# ANGORA GOAT AND MOHAIR PRODUCTION

*by*

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**Maurice Shelton**

## FOREWORD

The author, **Dr. Maurice Shelton,** has worked with Angora goats in Texas for 34 years while in the employ of the Texas Agricultural Experiment Station, The Texas A&M University System. This time was not devoted entirely to Angora goats, but also included other types of sheep and goats, and to a limited extent, other livestock species as well. During much of this time, there were relatively few people working with sheep and goats and a very broad general approach to research was undertaken in the belief that this was the best use of resources. As a result, the author has worked in all the broad subject matter areas discussed, but not necessarily in all details which are covered in this publication. The preparation of this book was undertaken as a form of a report to goat producers in this state, but hopefully, it may be found of interest to a broader audience. Much of the information presented comes from the author's own efforts and experience, but information is also included from the work of colleagues within the Texas Agricultural Experiment Station and the broader academic community as well. Where the data or information presented is based on the work of others, an attempt has been made to give appropriate credit. This has required the use of a somewhat scientific approach by citing many appropriate references. Although this publication is based largely on work conducted while in the employ of Texas A&M University, the book represents the author's own efforts, done on his own time, and the content or opinions, where expressed, do not necessarily carry the endorsement of Texas A&M University or the Texas Agricultural Experiment Station.

In several places throughout the text product names have been utilized in the interest of being helpful. However, this should not be interpreted as an endorsement of these products over others which might serve a similar role.

The amount of research information on Angora goats is somewhat limited, especially in respect to replication of studies under different conditions. The available information is presented and utilized to the extent possible in the preparation of this publication, but the producer must make the final judgement concerning the appropriate use of this material. In many respects, the text is wordy as compared to presenting simplistic solution to problems. For the most part, simplistic technical or final solutions to the problems of the industry do not exist, and producers need to consider all available information to make the most appropriate breeding and management decisions. A report or publication of this nature is never complete and new information or alternative interpretations of existing information become apparent within minutes after material is set in print, and this applies to this effort as well. The document was prepared without the services of professional editorial assistance, and it is hoped that readers will be tolerant of shortcomings in this respect.

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CHAPTER 1

# ORIGIN AND DOMESTICATION OF THE GOAT AND HISTORY OF THE ANGORA GOAT AND THE MOHAIR INDUSTRY

Goats are thought to have been among the first species of farm or ranch livestock to have been domesticated. Insofar as can be determined, only the dog predates the goat as an animal to have been tamed and brought into a symbiotic relationship with man. It is unlikely that domestication can be regarded as a single or specific event or that the total population of this or any species traces to a single instance of domestication. Thus, it is probably not logical to insist that domestication of any species totally predates that of another. It is generally conceded that the species; sheep, goats and dogs were among the first to be domesticated. It has been suggested that animals which have some type of social relationship with one another, such as the formation of flocks or herds, are more likely or are more easily domesticated and adapt to a long-term association with man.

The terms "taming" and "domestication" are used here somewhat interchangeably, but, in fact, they have quite different meanings according to Squires (1975). Taming would be generally defined as "the elimination of the tendency to flee from man," whereas, domestication often involves morphological, physiological and behavioral changes in the animal as the result of man's control of breeding, feeding and activity patterns. According to this definition, an individual wild animal might be tamed and made into a pet, but domestication would involve a large number of animals over many generations. Thus, it is impossible or inappropriate to be very specific as to the date, but domestication of the goat is thought to have occurred "at least by the eighth millennium B.C.," or, at least 10,000 years ago perhaps at more than one site in Asia or Africa. The reader should also be reminded of the close chronological relationship of domestication of the three species mentioned earlier to the transition of man from a nomadic hunter to one who actively managed the resources around him. Clearly, the domestication of the sheep and goat played an important role in placing man on the long road to civilization. Over the years, and even to this date, many people have been almost self-sufficient on the products obtained from sheep and goats. Both species produce, or have the capability to produce meat, milk, fiber and skins. At times, they are also kept for other purposes such as sport, beasts of burden or for their manure.

Goats belong to the order Artiodacgle, the family Bovidae, and subfamily Caprinae. Other animals comprising this subfamily are the antelope, sheep, chamois, Rocky Mountain goat (not a true goat), musk ox and aoudad. Within the genus Capra, to which the goat belongs, there are a number of related wild types. These include the Bezoars or Pesangs (Capra hircus), Markhor (Capra falconer^), Turs (Capra caucasica) and Ibex (Capra pyrenaica). These are not always easily distinguished from related genera such as Ovis (sheep), Hemitragus (tahr), Ammotragus (Barbary or aoudad) or Pseudosis(Bhara1). Within the wild types of Capra, the Ibex is most widespread, with a number of subtypes such as the Spanish Ibex, Alpine Ibex, Caucasian Ibex, Siberian Ibex, Nubian Ibex and Abyssinian Ibex. It is not known precisely which wild type contributed to the domestic goat, but the Bezoars (Capra aegagrus) are thought to have been the most important. The domestic goat (Capra hircus), especially the Angora, is sometimes referred as Capra hircus aegagrus. However, any type could have contributed, as they are all interfertile. True wild types such as the Ibex are most often found at higher elevations and in rough terrain. As a result, most are sure-footed and produce well-developed undercoats, thus contributing to their early exploitation as fiber producers. Most wild types are larger than domestic goats. So-called "wild goats" are found at many places in the world in relatively large numbers, but in general, these are more properly called "feral goats" or domestic goats which have reverted to the wild state.

The Capra genera apparently did not cross the Bering Strait in prehistoric times, as did wild sheep. As a result, there were no true indigenous wild goats in the Americas. The so-called Rocky Mountain Goat is not a goat, but is more closely related to the antelope. Several species of Ibex have been introduced to the U.S. in more recent times and have been intentionally crossed with domestic goats. In general, this crossing has been for reasons of science or novelty or to develop populations of wild types for hunting. Up to the present time, they have apparently not been seriously introduced into commercial types. Most types of Ibex are larger than domestic goats, but they are more difficult to control, late to mature sexually, and are very seasonal in breeding. This would suggest caution in crossing these into domestic goat populations.

Since time immemorial, man has attempted to separate the sheep from the goats. This is made more difficult, even for the scientist, when it is realized that there are many species, or subspecies, of each group and that various degrees of hybridization between some of these may occur.

Closely related to the efforts to separate the sheep from the goats are the attempts to mix them up again by crossing the two species. In general, these efforts have not been successful, but this statement requires some qualification. Matings between the two species occasionally occur under field conditions, and many specific cross-matings have been made by man. This may be done naturally, by selecting individual males which will mate with a female of the opposite species, or by artificial insemination. When a male goat is mated to a female sheep, conception does not, in general, occur. The apparent explanation is a failure of sperm transport due to immunological antagonism. If a male sheep is mated to a female goat, conception will occur in a large number of cases, but the conception rate of 30-50% is below that of intra-species mating. The normal result of mating a male sheep to a female goat is a hybrid embryo which dies in the 40-50 day range, with some surviving for a more extended time. Over the long period of history, many alleged viable hybrids have been reported, and in recent years, some have been verified as such by chromosome studies. The inability to successfully cross the two species was initially-attributed to the differences in chromosome number. However, this was not easily reconciled with the early growth of the embryo, followed later by death. As of this writing, an alternative theory is that of an allergic reaction in which the hybrid embryo is rejected by the maternal organism. Unconfirmed reports have suggested that hybrids have been carried to term when they are carried "in utero" with a nonhybrid of the same species as the dam.

The above discussion will appear to most as being of academic interest only. However, it is not without at least a minimal practical interest. For instance, if mating between the species did occur under field conditions, normal reproduction could be interfered with. This would more likely be the case where male sheep mate with female goats, where the resulting conception could at least delay normal within-species reproduction possible for a breeding season. The writer is aware of instances in which crossspecies matings have been observed to occur under field conditions. However, the long history and widespread practice of running the two species together would indicate that this is not normally a problem. It is more likely to be a problem where high-libido types of young male sheep are run with young replacement female goats.

## ORIGIN AND HISTORY OF THE ANGORA

There appears little doubt that Angora goats, as a breed, developed in the region known as Asia Minor. This area lies between the Black Sea and the Mediterranean within which Turkey is located.

Specifics of where they originally developed is largely speculation, but it is fairly certain that fiber producing goats have occupied the area of Asia Minor for at least 2,000 years. In the Bible, it is recorded that Moses directed that articles of goat's hair be brought to the tabernacle. Four separate references are made to articles of goat's hair in these passages. Although fiber-producing goats were originally found over a much wider area, it is accepted that the white fleeced animal we now recognize as the Angora evolved on the Anatalian Plains of Turkey near the city we now know as Ankara and from which the name "Angora" derives. The term "mohair" apparently derives from arabic (mukhayyar). In Turkey, it is known as "tiftik," but this term refers specifically to white goat hair, as other colors have different names.

The first recorded information about Angoras as a breed, in any detail, became available during the second half of the nineteenth century. Early books written by Hayes and Schreiner contain details gathered from reports and correspondence obtained from early importers of Angoras.

The Angora, in its native or homeland, was a small goat with long ringlets, very white in color and containing little oil in its fleece. These goats were found in the valleys and elevated plateaus around Angora (Ankara). The region is described as extending 80 miles east; 80 miles west, 100 miles south-and 150 miles north of Ankara.

The earliest Angoras were described as a small, refined, delicate animal of great beauty, clipping from 2 to 4 pounds (according to sex and age; kids considerably less). The fleece consisted of dazzling white, fine, soft, silky, very lustrous mohair, curling in ringlets from 8 to 10 inches long, based on a single annual shearing. The doe was smaller and finer than the male and had only one kid at a birth. It's delicacy was thought to be due mainly to inbreeding.

It should be pointed out that the Angora was not the only goat found in this region of Turkey and, no doubt, some mixing occurred from time to time. This point has significance to early attempts to establish a mohair industry in other parts of the world. This may also be a factor in the quality of mohair from Turkey at the present time.

Beginning as early as the sixteenth century, Angoras were taken from Turkey to a number of countries, mostly in Europe; attempting to establish a mohair industry in these areas. For a variety of reasons, these attempts were largely failures; leading to the belief that Angoras could not be produced outside the dry and cool plateaus of Turkey. Based on more recent experience, we now know that this is not true as Angora goats are being successfully reared in many European countries, although large-scale industries have not as yet developed in these areas. In general, it should probably be recognized that as the Angora is taken into higher-rainfall and colder areas a higher level of management (particularly in respect to disease and parasite control and shelter or protection) is required. The technology or resources to provide these inputs may have been largely unavailable in the earlier period.

Although it was inferred above that the Angora can be produced almost anywhere, major industries became established (outside of Turkey) only in South Africa and the U.S. (largely in areas on or adjacent to the Edwards Plateau of Texas). The uniqueness of these areas and their similarity to the Plains of Turkey warrants further attention.

**Importations to South Africa**

The first importation of Angoras to South Africa reportedly occurred in 1838. The one surviving fertile male from this shipment was bred to Boer goats, thus initiating the industry, at least partially, on a crossbred foundation. However, in the period from 1856 to 1896 it is reported that over 3,000 head were shipped from Turkey to South Africa including shipments as large as 500 and 700 head.

Some of these animals made their way to Basutoland (currently known as Lesotho), thus establishing the breed in this area, where it persists to date in numbers approximating one million head.

In this century, several exchanges of breeding stock occurred between the U.S. and South Africa. Two shipments, totaling 40 head, went from the U.S. to South Africa in 1961 and 1965.

**Establishing the Angora in the United States**

During the administration of President Polk, the Sultan of Turkey requested an expert come to Turkey to experiment in the production of cotton. President Polk sent Dr. James B, Davis of Columbia, South Carolina. Upon his return to the United States in 1849, Dr. Davis brought with him nine choice goats as a gift from the Sultan. These consisted of seven does and two bucks.

This first herd of Angoras were mistakenly thought to be Cashmere goats by Dr. Davis. He considered them thus until he sold the herd in 1853 to Colonel Richard Peters of Atlanta, Georgia. Colonel Peters thought the animals were Angoras and with technical help from agricultural authorities, was able to verify that this was the case.

Other importers of Angoras from Turkey were W.H. Stiles from Cartersville, Georgia; W.W. Chenery from Belmont, Massachusetts; and Israel S. Diehl with the U.S. Department of Agriculture.

Notes about Chenery's herd were recorded by John L. Hayes in this early book, *The Angora Goat, Its Origin, Culture and products*, written in 1882, who stated that:

"Of the recent importations of Angoras into this country the most considerable have been made by Mr. Winthrop W. Chenery, of Belmont, Mass., who arranged for four shipments consisting of two in 1861 and one each in 1866 and 1867, containing a total of approximately 300 animals."

Angoras from the Diehl importation, totaling 160 head, were sent to the farm of C.S. Brown of Newark, New Jersey, arriving late in 1867. Soon afterwards, they were relocated on the farm of C.P. Bailey of San Jose, California.

In 1863, Diehl reported "numerous herds of Angoras containing from 12 to 300 head being located on farms near Atlanta, Georgia; Nashville, Tennessee; Russellville, Frankfort, Paris and Georgetown in Kentucky; Greenville, Lebanon, Montgomery and Budyrus, Ohio; Green County, Indiana; Chicago, Decatur and Evanston, Illinois; St. Louis, Maramee and Fayette, Missouri; Baltimore, Maryland; Leavenworth, Kansas; Brownsville, Pittsburgh, Washington and Philadelphia, Pennsylvania; New York City; Boston and Belmont, Massachusetts; Austin, Texas, and in the states of Iowa, Michigan, Minnesota and California."

A significant early breeder was William Landrum of Laguna, Texas. Landrum was in California from 1850 to 1883 and while there, he received Angoras from Chenery and Peters. In 1872, Landnun purchased all the goats under 8 years of age from Colonel Peters. In 1883, he moved to Texas with his sons to continue raising Angoras. In 1901, Landrum imported two yearling bucks from South Africa. These two bucks were bred by R.C. Holmes, sired by his prized buck "Dick", which was the prize buck at the Port Elizabeth show in 1900. Mr. Landnun settled around Laguna, Texas, which was between Camp Wood and Uvalde. At one time, he and his partners had more goats than anyone in the country. His two sons, W.E. and Frank, carried on the goat interests in Texas. Frank later relocated above Barksdale near the Nueces River.

Later importations of Angoras from Turkey were made by John S. Harris, Hollister, California (10 does and 2 bucks in 1875), C.W. Jenks of Boston, Mass. (3 bucks in 1880), E.A. Shultz, Leon Springs, Texas (2 bucks in 1886) and W.C. Bailey of San Jose, Calif. (4 bucks in 1901). Some references also list a Eutichides importation in 1873.

In addition to the introductions from Turkey, introductions were made from South Africa, beginning as early as 1886. One of the most notable importations of Angoras from South Africa was made by G.A. Hoerle of Midland Park, New Jersey. Having been in South Africa in 1902, Mr. Hoerle had information that an export tariff of 100 pounds sterling would be placed on each Angora goat and this would be enacted during the next session of the South African Parliament. Mr. Hoerle petitioned the U.S. Department of Agriculture to approve a permit for him to bring into the U.S. 40 or 50 bucks and 120 does, with their kids, before the tariff went into effect. His reasons given for requesting approval of his permit cited higher fleece weights, more evenness of covering and greater density of the Cape Colony goats compared to those found in the U.S. at that time. Mr. Hoerle received approval for an importation and 148 South African goats were delivered to the New York port in 1904.

In so far as is known, the last importation from Turkey or South Africa occurred in 1925. On May 7, 1925, a shipment from South Africa of 117 head of goats to the U.S., accompanied by E. Cawood, arrived in New York. This shipment was consigned by South African breeders who desired to establish trade with breeders in the U.S. Following their quarantine, these animals were forwarded to Camp Wood, Texas, where they were sold at public auction. South African breeders with bucks in the sale were J.E. Hobson, C.J.L. Hobson, E.J.R. Cawood, P.E. Hobson, J.A. Fitzhenry and Sons, Robert Hobson, J.B. Grewar, W.G. Cawood, C.D. Cawood, James Kirkman, T.G. Theophilus, J.J. Cawood, J.H. Hobson and A.B. Hobson. Most of these breeders, along with many of the individual goats involved, were pictured in a Special Illustrated Supplement to *Mohair* in 1925.

From these importations of 600 - 700 head of Angora goats from Turkey and South Africa, the Angora population in the U.S. grew to a number of over 4 million head in 1968. The introduction and distribution of the 148 goats in 1904 and 117 males in 1925 from South Africa could not have failed to have had a major impact on the Angora population of this country, and thus as late as 1925, the Angora populations of the two countries would have had a similar genetic base. Divergence in genetic types since this time is due, at least in part, to different selection practices and production conditions in the two countries.

In recent years goats from both the U.S. and South Africa have been shipped to Turkey in an attempt to improve the quantity and quality of mohair produced by Turkish Angoras. The most recent or most extensive of these was approximately a dozen males shipped from Texas in 1983. The pure Texas males have had difficulty surviving under Turkish feed conditions, but crossbred offspring obtained from these have shown improved quantity and quality (less kemp) of mohair (Gunes, et al., 1992). It remains to be seen what long-term impact this exchange will have on the Turkish Angora goat industry. Angora goats have been shipped from the U.S. to many countries in Europe and Asia. In Asia, shipments have been made to India, Pakistan and China. A number of countries in Europe received goats during the 1980s. Shipments have also been made to both Australia and New Zealand. These animals were released from quarantine in Australia in 1992 and will be released in New Zealand in 1993, and can very well have a major impact on the genetic potential for mohair production in these areas.

In the late 180O's, Angora goats were found in limited numbers in the U.S. and were largely concentrated in the farm states. However, beginning around 1900, their numbers began to be concentrated in a few regions. These included the Southwest (Texas, New Mexico and Arizona), on the West Coast (Oregon and California), and the farm states of the upper South (Missouri, Arkansas and Tennessee). In 191 8, there were 1 12 members of the American Angora Goat Breeders Association, and 33.9% of these were in Texas and 32.1% were in Oregon. Only seven years later, in 1925, there were 177 members, of which 59% were in Texas and 17% in Oregon. Following this, numbers were further concentrated in Texas, more specifically in the Edwards Plateau, with approximately 95% of the goats and mohair production in the period 1940 to 1980. However, in the decade from 1980 to 1990, and during a period of reasonably favorable prices, there has been movement of Angoras back into a number of farm states. Angora herds are now found in most states in the U.S. Some of the greater concentrations in the farm states are in Oklahoma, Michigan and Minnesota. In addition, there has long been a concentration of Angora type goats in Arizona and New Mexico. In recent years, there has been some increase in commercial herds in both states, but in a large measure, production from these areas comes from the American Indian population in the "Four-Corners" regions of the states of Arizona, Colorado, New Mexico and Utah. Arizona alone shows more owners of Angora goats than Texas. However, the total mohair production from this region is low in both quantity and quality, and is declining. The decline in quantity is largely due to an adjustment in animal numbers to resources in the area: The four states involved have a great potential for goat production, but a large increase is not anticipated due-to fencing costs and predation problems; and in the case of Angoras, the difficulties of providing the required management inputs under extensive conditions.

## ORGANIZATIONS SUPPORTING THE ANGORA GOAT AND MOHAIR INDUSTRY

Most countries which have a significant mohair industry have one or more organizations supporting their industry. These may be concerned with maintaining pedigrees or herdbooks or supporting marketing or promotional efforts for both breeding animals and for mohair. For reasons of time and space, this discussion will relate primarily to those organizations which directly impact the Angora goat and mohair industry in the United States.

### The American Angora Goat Raisers Association

The first organization formed to further the interests of this industry was the American Angora Goat Breeders Association. This organization was incorporated in Kansas city, Missouri in 1900. The foundation animals admitted to registry at that time were chosen after inspection by a representative of the association. The original officers and directors represented the states of Kansas, Missouri, Iowa and Texas. A membership directory showed 146 members in 1918 and 178 in 1925 in the following states:

| State | 1918 | 1925 | State | 1918 | 1925 | State | 1918 | 1925 |
|---|---|---|---|---|---|---|---|---|
| Alabama | 1 | - | Kentucky | 3 | 4 | N. Carolina | 1 | - |
| Arkansas | 3 | 3 | Louisiana | 4 | - | Oklahoma | 1 | 1 |
| Arizona | 3 | 4 | Massachusetts | 2 | - | Oregon | 36 | 30 |
| California | 10 | 8 | Minnesota | - | 3 | Texas | 38 | 105 |
| Colorado | 2 | - | Missouri | 6 | 5 | Tennessee | 5 | - |
| Connecticut | 2 | - | Montana | 2 | 1 | Utah | 2 | 3 |
| Idaho | 1 | - | Mississippi | 1 | - | Virginia | 2 | 1 |
| Illinois | 3 | - | Nebraska | - | 1 | W. Virginia | - | 1 |
| Iowa | 2 | 2 | New Mexico | 5 | 3 | Washington | 1 | - |
| Indiana | - | 1 | New York | 3 | 1 | Wisconsin | 2 | 1 |
| Kansas | 4 | - | Nevada | 1 | - | **TOTAL** | **146** | **178** |

It can be seen that between the time the organization was formed on or around 1900 and 19 18, the industry had largely shifted to concentrations on the west coast (Oregon and California) and

Texas (and adjacent areas of New Mexico). In 1925, the Association had 178 members, of which 59% were in Texas and 80% were in Texas, Oregon and California.

In 1918, another association, the National Angora Record Association was formed and incorporated under the laws of Texas, with headquarters in Junction, Texas. The two record associations merged in 1924 and at that time the headquarters was moved to Rocksprings, Texas. In 1934, the association had 353 members, of which 266, or 75{3%, were in Texas. The primary responsibility of this association is to register goats and to maintain pedigrees. As of this writing (October, 1992) over 1 million goats have been registered by the association.

Another registry association has been organized (The Angora Goat Record and Registry of North America) in recent years in Michigan (1451 Sisson, Freeport, MI).

An organization known as the National Mohair Growers Association was organized in San Antonio, Texas in 1909. The purpose of the organization, which presumably operated as a cooperative, was to improve the marketing position of mohair growers. The services offered were warehouse facilities for storage, as well as for sorting, grading and marketing; along with cash advance payments of up to 75% of estimated conservative market value. In discussions relating to this organization, references are made that mohair sold for as much as 40# per lb in 1911, indicating that prices or value, have not always kept pace with inflation. Needless to say, producers were enthusiastic about Angoras at that time. Apparently this organization was supplanted by the warehouse system which now exists in Texas.

A number of individual state organizations have been formed (including Texas, Michigan, Oklahoma and Ohio) primarily for the purpose of facilitating and promoting animal sales. The largest, and perhaps one of the oldest is the Texas Angora Goat Raisers Association which was apparently formed in Uvalde, Texas in February, 1927. It functions largely as a mechanism to sponsor sales of registered breeding animals.

**The Mohair Council of America**

The Mohair Council of America was established in 1966 as the promotional organization for United States produced mohair. Dedicated to promoting the general welfare of the mohair industry, the Council's programs emphasize market surveys as well as research and development activities. To accomplish their objectives, Council representatives are in contact with firms engaged in the processing, spinning, knitting, weaving, distribution and sale of mohair.

The Mohair Council also cooperates with various state and federal agricultural agencies, textile and fashion schools, research and other related organizations in an effort to develop programs and projects beneficial to the industry. The Honorable Dolph Briscoe was active in establishing the Council and served as its first President.

The Council was created and has been sustained by mohair producers. It is funded by a "check-off' of funds paid to producers as a part of the U.S. Department of Agriculture incentive program in those years when a payment is made. At other times, the Council is funded by producer contributions. Sixty directors are elected each year from 10 Districts throughout the United States. From that number an Executive Committee and Officers are selected. The programs and projects of the Council are designed to serve both those who produce and use mohair.

The Executive offices of the Council are located in San Angelo, Texas (516 Norwest Bank Bldg., 36 W. Beauregard, P.O. Box 5337, San Angelo, TX 76902) at the edge of the primary mohair production area in the United States. Current Executive Director is Duery Menzies. Previous executive directors included Walter Pfluger, Ross McSwain, Fred Campbell, Bob Paschal and Dr.

Brian J. May. The current President of the Council is Jeffrey Sutton. Previous presidents included Dolph Briscoe, Noel Fry, Walter Pfluger, Sid Harkins, Bob Childress, Herman Moore, Robert Pfluger, Dr. Joe David Ross, Perry Bushong and Mark McLaughlin.

In addition to administrative support functions, the San Angelo office coordinates planning and implementation of travel, promotion, and marketing activities. Grower seminars, workshops and competitions are also administered by the San Angelo office. An office is also maintained in New York City (499 Seventh Avenue, 1200 North Tower) to conduct the promotions programs to all segments of the industry.

**The International Mohair Association (IIMA)**

The International Mohair Association was formed in response to a perceived need for international cooperation in marketing, promotion and more recently in protecting the integrity or purity of products made from mohair. Uys (1988) discussed the events leading to the formation of this organization. A preliminary meeting was held in Amsterdam in 1974 followed by a more formal conference in Zstanbul in July, 1975, where a constitution was formally accepted. The IMA is made up of representatives of producing countries and processing groups. The organization holds annual meetings in various countries, with the most recent in San Antonio, Texas in June, 1992. To date, the organization has had three chairmen, as follows:

Tom Hibbard, United Kingdom, 1975- 1980
Tony Hobson, South Africa, 1980-1986
Bob Childress, United States, 1986 - 1992.
Gielie Grobler, South Africa, 1992 - present.

The organization functions through its Director General, with headquarters in England (Mohair House, 68 The Grove, Ilkley, West Yorkshire, England), and a sub-office in Japan. Funding is through levies or subscriptions by participating countries or groups.

**World Centers and Trends in Mohair Production**

On a world basis, the three major producing countries have long been South Africa, U.S.A. and Turkey (Table 1-1). Other countries with a significant number of Angora goats or mohair production over time have been Argentina, Lesotho and the former Soviet Union. Statistics on the Soviet Union are generally unavailable. Mohair from Lesotho is usually marketed through South Africa, and thus the two are often lumped together in production statistics. Australia and Neg Zealand, and to a lesser extent, several other countries, have taken an interest in angora goats during the decade of the 80s when prices were reasonably favorable. Trends in major producing countries for the 12 year period (1980-1Q91) are shown in Table 1-1. From this, it can be seen that world production, derived largely from the U.S. and South Africa, increased until 1987 or 1988. Production in South Africa has dropped almost 45% from 1988 through 1992 due to low mohair prices and to a prolonged drouth in that country. Production in both Turkey and Argentina have trended downward during the entire period. Australia and New Zealand showed very marked increases in production until 1989, followed by downturns in both countries. It can be shown that trends in production are related to price and vice-versa. Apparently, the total world production of approximately 55 million lb. in 1987 and 1988 exceeded world demands at that time and contributed to a significant price break.

**Production in the U.S.**

As discussed in connection with the establishment of the industry in this country, Angora goats were initially located in farm states. They later became concentrated in the range states of Texas and the Southwest. As early as 1900, Black reported that 40% of the Angora goats were in Texas and New Mexico. In the decade of the 80s, there was some movement back into farm states. There appears to be some possible explanations for these shifts. The most significant of these is that this early period coincided with the period when forest lands were being converted to farm land, and goats were valued or almost indispensable to this effort to prevent re-encroachment of brush in newly established farm and pasture land. Writings in 1911, *An Oregon Farmer* (Springer, 1911) suggested that anyone with brush problems cannot do without goats, and that anyone without brush has no need for goats. The latter statement can be over-ridden by economic forces. Angoras were apparently preferred for this because they were easier to fence and produced a non-perishable sale product. In the period following 1925, in which the goat industry became largely-concentrated in Texas and adjacent range states, there was less activity in the conversion of timber to farm lands and also, there was extensive use of mechanical energy, herbicides or fire for brush control. In recent years these techniques have come under pressure from economic or environmental issues, with the result that the goat is being rediscovered in areas where its value was common knowledge 100 years ago. States developing a significant number of Angoras in recent years include Oklahoma and Michigan. Aside from the movement into or out of farm states, the primary variation in number of Angora goats in the U.S. is in the number on Texas ranges (see Figure 1-1) and this is largely a function of mohair prices (or vice-versa). During times of favorable prices, the numbers in grazing systems are maximized, whereas in periods of low prices, goats are minimized or Angoras are replaced by Spanish goats. These fluctuations are expected to continue.

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CHAPTER 2

# BIOLOGY OF MOHAIR GROWTH

Most land mammals produce some type of fiber which serves as protection from the elements, and in some cases, as sense organs. Fiber production from all animal species has a great deal in common, with the major differences deriving from the level of production and the quality (fineness) of the fibers. These differences depend in a large measure on whether man has selected the species for commercial exploitation for fiber.

The species which have been exploited for fiber along with some information on characteristics of the fiber and the amount produced are shown in Table 2-1. From this it can be seen that sheep dominate the scene as a producer of animal fibers (wool). By contrast, other fibers tend to be specialized fibers which generally sell at a high price because of their low level of production or are a by-product of animals exploited for other purposes.

The data presented refer to harvested fiber, but it must be realized that the large trade in pelts and furs are dependent on their fiber properties. Even mankind himself should not be exempt from an interest in the biology of fiber production due to the aesthetic values attached to hair care in women or the problem of balding in men.

In the natural state, the coat of essentially all mammals contain two types of fiber. These consist of an outer coat of coarse hair and an inner coat of fine hair, often called "down." This is still the natural, or normal, scheme; but natural or artificial selection (that imposed by man) has altered the situation in many types of animals to the extent that only one type of coat is evident. In general, tropically-adapted animals show only a reduced or vestigial outer coat of guard hair, which may be shed frequently. Types such as Merino sheep or Angora goat, which have been selected for fiber production, have a highly developed inner coat with the result that the outer coat is either absent or is masked by the highly developed inner coat. Other types which are sometimes exploited for fiber are those which naturally (often as a result of adaptation to cold climates) have a substantial inner coat of very fine hair which may, at times, be harvested. Examples of this are the Cashmere goat and Asiatic camel.

Animal fibers are derived from follicles which arise from the inner layers of the skin. These follicles normally consist of two types known as "primary" and "secondary." The relationship of these types of follicles are shown in Figure 2-1. These two types of follicles exist in reasonably well-defined follicle bundles. The coarse or outer coat derives from the primary follicles. The down or inner coat develops from the secondary follicles. The ratio of secondary to primary follicles (S/P) in these bundles may vary widely. The values reported represent the number of secondary follicles per single primary. The primary follicles may vary from a low of 5 or 6 to numbers greater than 25 per primary follicle. The latter value represents the most highly developed fiber producers such as the more productive types of Merino sheep. In the Angora, the S/P ratio is on the order of 7 to 10 to 1. The contrast of these values with values above 20 for some Merino sheep must hold interest for goat breeders. In both the Merino and the Angora, the fleece consists largely of fibers derived from the secondary follicles. In the case of the Merino, fleece is much denser and the fibers are finer (18-20 µm compared to over 30 µm for most adult Angoras). This suggests that if finer mohair is to be produced without a substantial loss in fleece weight, fleece must be denser.

**Follicle Development**

Follicle development begins at approximately 60 days of gestation with the initiation of "central primary" follicles, followed a few days later by pairs of "lateral primary" follicles to make up the trio grouping. Each primary follicle possesses a complete set of accessory structures (sebaceous gland, sudoriferous gland and arrector pili muscle). The initiation of secondary follicles begins 14 to 20 days later and reaches a peak just prior to birth. Secondary follicles possess only a sebaceous gland as an accessory structure, and in some cases this may be lacking. In some species, no doubt including the Angora, some secondary follicles will produce more than onefiber.

It is generally considered that the goat will be born with all of the follicles, primary and secondary, that it will ever have, but that many of the secondary follicles will not be producing fibers at the time of birth. Thus, the kid at birth will be hairy in appearance with the visible fibers coming largely from the primary follicles. There appears to be two peaks of maturation of secondary follicles, one just prior to birth and the other at about 35 days after birth, with all the secondaries producing fibers by 12 weeks after birth. At weaning, most of the fleece will consist of fibers derived from secondary follicles, but still the kid at five or six months of age will appear more kempy than as an adult.

Total fleece production is influenced by both the number of follicles present in the skin (number of follicle bundles and S/P ratio) and the number of follicles actually producing fibers. It has been shown withsheep, and is probably true of goats as well, that level of nutrition of the dam in late pregnancy influences birth weight and subsequent mature weight of their offspring and this also affects follicle population and consequently fleece production. This is probably a mechanical situation in that the greater body growth as a result of better nutrition gives a greater surface area and better nutritional support for follicle development. Thus, pre-natal and early post-natal nutrition can be a factor in the maturation of secondary follicles. A low plane of nutrition during the first few months after birth can have the effect of reducing fleece production by delaying maturation of secondary follicles and may permanently impair the capacity of some follicles to produce fiber. The influence of nutrition on fiber production capability is probably minor, but may still warrant concern, particularly since improved management will favorably affect other factors as well.

Fleece density is influenced by follicle population or number of follicle bundles per unit skin area and S/P ratio both of which are under genetic control. The functioning of the follicles is often cyclical in nature. Much of the study of skin biology has been on a confined animal such as the laboratory rat. In these animals, the follicle goes through a functional or resting state in which the fibers are shed in as little as six weeks. Many other animals, such as cattle, tend to shed seasonally. One result of selection for fiber production has been a markedly reduced tendency to shed, making it possible for man to harvest these fibers on a controlled basis. The better wool-producing sheep show little evidence of shedding suggesting that the follicles function on a continuing basis, but with Angora goats spring shedding can be a problem. The degree to which shedding is a problem has been markedly reduced through selection.

Another point of interest is that some follicles simply become non-functional with age. This is the primary explanation for the reduced fleece weight and deteriorating quality (increased fiber diameter) of mohair with increasing age. It is almost certain that this trait can be changed through selection, but progress is likely to be slow. Male selection, where most genetic progress is made, is usually done at an early age, and this does not necessarily favorably impact age trends. Culling breeding stock which show deteriorating fleeces with advancing age, while keeping those which hold their fleece will likely give the emphasis this trait deserves in a selection program. However, it is important to insure that selection against reproductive rate. For this reason, selection of females should be done at the spring shearing, or from among animals known to have raised a kid.

**Kemp**

Another factor which deserves our attention, but derives from a biological consideration, is the problem of kemp or medullated fibers. As stated earlier, the fibers arising from the primary follicles, especially the central primary, tend to be coarse. These may show up as kemp fibers which have different processing and dyeing properties to that of the bulk of the fleece.

Kemp fibers are medullated fibers in which the diameter of the medulla (hollow air space or "cellular marrow") is 60%, or more, of the diameter of the fiber. As a result, the fiber is less strong, less elastic and appears as a chalky, white fiber in the undyed state (Figure 2-2.). After dyeing, the fiber still shows up visually because of the differential light reflection and refraction as a result of the hollow area. Many fibers may be partially (less than 60%) medullated and not present the same problem to the textile processor if medullation is present in only a small part of the fiber. These fibers with intermediate or intermittent level of medullation are often called "med," heterotype or "gare" fibers. Kemp and med fibers are considered to represent different degrees of the same problem (Lupton et al., 1991). Thus, although the presence of med fibers may not present the same problem to the textile processor, the presence of med fibers should be discriminated

It has been stated earlier that primary follicles are always present, yet it has been shown that the problem of kemp can be reduced and maintained at low levels by visual selection. It is not known exactly how this selection operates but the following can be suggested:

1. An increase in the number of secondary follicles reduces the ratio of primaries, and thus the proportion of potential kemp fibers in the fleece.

2. Compaction resulting from increased fiber density causes the fibers arising from the primaries (especially the lateral primaries.) to be finer and thus less distinguishable as kemp or med fibers. It is known that an increase in the S/P ratio is related to a decrease in primary follicle density, primary and secondary fiber diameter and a reduction in medullated fiber content.

3. The primary follicles may function on a cyclical basis resulting in the fibers produced by them being shed from the fleece or they may become totally non-functional with age or season. One study suggests that total medullation is greater in fall-shorn fleeces.

The mechanism involved could be elucidated with well-planned research, but this may well be of academic interest only since it has been shown that kemp can be reduced through selection.

It seems likely that because of compaction in skin or other factors, the central primary follicle is the major source of kemp fibers. If one assumes an S/P ratio of 10:1 and that all the secondary follicles are functioning and that the central primary (and only the central primary) always produces a kemp fiber, which is not necessarily true, theoretically 3% of the fibers would be kemp. In practice, the percentage of kemp in highly selected Angoras is much lower than this. For instance, for 1100 young males completing the performance test conducted by the Texas Agricultural Experiment Station at Sonora, the mean kemp content was 0.4 % (Table 2-2), but some individual animals were much higher than this. There is even a suggestion from these data that the amount of kemp is being reduced even in this short period of time. This low level of kemp suggests that even the central primary does not always produce kemp or that it does not always remain in the fleece. It is known from work with cashmere goats that the growth cycles for primary and secondary follicles are not the same.

It would appear that the optimum level of kemp would be zero. Individual fleeces or entire clips of mohair which are visibly kempy typically show 2-3% kemp. Clips with this level of kemp are usually found in areas where the mohair industry is being initially developed or has not benefitted from effective selection programs. In the performance testing program mentioned above, a kemp level above .5% is recommended as a culling level for stud breeding males. However, this level was somewhat arbitrarily chosen. These data appear to show that among herds being used for the production of breeding males, or those associated with this testing program, the kemp level is very low. Yet mohair buyers or processors complain about the kemp content of U.S. mohair. Either this complaint is invalid or the kempy mohair is coming from herds which have not benefitted from selection against this problem. Visual selection can be effective to eliminate high levels of kemp, but the process should be made more efficient by the use of laboratory values such as those available from the performance testing program. Only laboratory results provide a basis for selection against med fibers. In any case, producers would be advised to cull breeding animals (especially males) with visible levels of kemp. Any animal with visible kemp should be sorted prior to shearing in order that the fleeces can be kept separate, and the animals can be culled after shearing or at the first opportunity. Breeding animals are available which are relatively free of kemp. These should be used to reduce kemp level below the level required by processors.

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CHAPTER 3

# MOHAIR: PROPERTIES, EVALUATION, USES, PREPARATION, MARKETING[1]

## INTRODUCTION

Mohair is the white, lustrous fiber produced by Angora goats. The Angora is considered a single-coated animal since fibers produced by the primary and secondary follicles are of comparable dimensions. As a result of selection, Angora goats have a reduced tendency to shed their fleece, but this can still result in significant fiber loss if they are not shorn in the spring. If goats are shorn only once per year, as is true in some countries (i.e., Argentina, Lesotho and Turkey), it is necessary that this shearing be in the spring. It is apparent that there are genetic differences or degrees of genetic control in the tendency to shed, as the present population has evolved from an ancestral type in which complete shedding of the fleece occurred. Most Angora goats are shorn twice a year after the fibers have attained a length of about 4 inches or more. Each animal produces from 1.5 lb (6-mo kid) to 25 Ib (mature male) of grease mohair per clip with the typical mature female shearing in the range 3.5 - 9.0 lb. Some of the effects of age on mohair production and other important traits are shown in Table 3-1.

In South Africa, shorn fleeces are assigned to several of 189 classes prior to sale. In this system, mohair is classed according to animal age, average fineness, length, style, character and degree of contamination and requires minimal or no further preparation prior to scouring. In contrast, much of the U.S. clip is packaged in "original bag" (OB) form with little or no removal of inferior fleece portions (e.g., stained and heavily contaminated mohair) prior to packaging. This mohair is usually classed and/or sorted at the warehouse or by the first buyer prior to processing. However, the Texas industry has recently adopted a set of guidelines for marketing mohair and it is anticipated that this will result in more mohair being sorted and classed prior to sale.

## MOHAIR CHARACTERISTICS

Important characteristics of mohair are listed in Table 3- 1. The surface of mohair resembles that of wool of corresponding fineness. However, the epidermal scales of mohair tend to protrude and overlap less than those of wool thus contributing to a relatively smooth handle. Light is reflected from the surface of scoured mohair fibers to a greater extent than from cashmere and wool providing mohair's characteristic luster. The cross-section of mohair has a high degree of circularity with the ratio of major to minor diameters rarely exceeding 1 :1.2. However, heavily medullated, coarse mohair fibers (kemp) contain a collapsed medulla and thus appear markedly elliptical.

As with other animal fibers, mohair is contaminated, to varying degrees, with dirt and vegetable impurities, the latter generally being described in the U.S. as low (1.0 - 1.9%), medium (2.0 - 4.0%) and high (>4.0%). Although most forms of dirt are readily removed in scouring, several types of plant material persist throughout textile processing, which in extreme cases, necessitates carbonization. Since contaminated mohair is discounted, producers take measures to avoid vegetable defect whenever possible. The actual grease content of mohair ranges from 5 - 15%. The bulk of material removed in the scouring process is sand and dirt together with varying amounts of suint, dried skin and vegetable matter.

[1] Prepared by C.J. Lupton, Texas Agricultural Experiment Station,
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Mohair is produced in a broad range of average fiber diameters. Fineness values smaller than 28 µm are common for animals less than one year old while diameters greater than 40 µm would not be uncommon for mature males under well-fed conditions. However, much of the commercially available mohair is grown by mature breeding does and falls into the range of 34-38 µm. Angora wethers (muttons, in Texas) constitute another important source of mohair which will normally be somewhat coarser than that from does. Fineness is the dominant dimensional characteristic affecting manufacturing value and, therefore, price. Average diameter and standard deviation are the sole basis for assignment of grade to mohair in the U.S. (ASTM, D3991).

Mohair grows in long, uniform locks. Commonly used lock descriptions in the U.S. are ringlet, flat and intermediate between ringlet or flat. Ringlet hair is favored by much of the textile industry because of its association with fineness and it is also claimed to contain less variability in fiber length. For this reason, South African and to a lesser extent, U.S. breeders have tended to emphasize this trait in their Angora goat selection programs. For satisfactory processing on the worsted system, the staple length of mohair should be greater than 4 inches but less than 6 inches. In a good growing season, this is not a difficult specification to meet. However, drought and illness can result in less than 4 in. of growth in a 6-month period.

Kemp is an extreme form of medullated fiber which is usually visible to the naked eye as a chalky white fiber in both the natural and dyed states. Kemp fibers create problems in textile fabrics since they differ in appearance from the majority of unmedullated fibers. The undesirability of kemp and other medullated fibers in mohair is well documented. This trait is selected against by Angora goat raisers in most producing countries. Kemp production does not appear to be affected to a significant degree by environmental factors such as nutrition and season.

The surface of an Angora goat fleece usually appears gray or brown. Opening or shearing the fleece reveals the clean fiber below the level of dirt penetration. The predominant features in this area of the staple and in mohair that has been scoured are extreme whiteness and a high degree of luster. These features combine to produce a unique fiber that is substantially different in appearance from other fibers.

Chemically, mohair, wool and cashmere are almost identical. The common parent protein is keratin but considerable variability, particularly in sulfur content, does exist among individual animals, species and production locations. The cortex of most wool contains ortho and para cortical cells arranged in a bilateral manner. This factor is responsible for the characteristic crimp of wool. In contrast, the cortex of mohair is composed almost entirely of ortho cells. Hence, the low levels of crimp normally found in mohair. Para cells have been observed in mohair in which case they appeared in a radial type of cortical asymmetry. A similar arrangement is observed in luster wools. Since ortho cells are less resistant to chemicals and heat than para cells, mohair is more sensitive to heat and light degradation and discoloration than wool. Thus, wool procedures and formulations should not be applied directly to mohair. Attention must be paid to scouring and dyeing recipes and dyeing temperatures and times to avoid destruction of luster, yellowing or damaging the fibers in other ways.

## CHARACTERIZATION OF MOHAIR

### Objective Characterization

Physical characteristics of mohair are summarized in Table 3-1. Most of these fiber properties can be measured objectively while others are assessed subjectively. An objective measurement is an assessment made without distortion by personal impressions or prejudices. It is the opposite of subjective assessment which is an evaluation made by human judgment using the senses of sight and touch. By necessity, therefore, an objective measurement is obtained using a machine or instrument.

Mohair may be tested to ensure that processors purchase and producers sell fiber based on its actual characteristics and to assist goat breeders to identify superior animals. Objective measurements are necessary in such appraisals because visual appraisal of animal fiber characteristics is less accurate.

Physical characteristics of primary interest to producers and textile manufacturers are summarized in Table 3-2. Generally, the processor is concerned with sampling and testing relatively large lots of fiber. Often, producers are more concerned with establishing characteristics of individual fleeces of candidate breeding animals or classed lots or entire clips. Standard test methods do not exist for five of the characteristics listed in Table 3-2. In these cases, current subjective assessments will be summarized.

**Sampling for yield and diameter**

Detailed procedures for sampling lots of different sizes of animal fibers are summarized in American Society for Testing and Materials (ASTM) Standard Practice D1060. International Wool Textile Organization (IWTO) Core Test Regulations were developed for sampling bales of wool but can also be applied to bales of mohair. Portable, electric coring tools having two-inch or half-inch diameter tubes are commonly used in the U.S. Typically, two-inch coring tools are used to sample bags or bales of raw fiber at the warehouse and mill. Subsequently, the two-inch cores are normally subsampled using a coring machine fitted with half-inch tubes at the testing lab. This same machine is often used to sample single fleeces. The half-inch core samples are then used in yield and diameter determinations. Overseas storage complexes and textile mills throughout the world are now using specially designed coring machines for sampling mohair bales. This form of sampling can only be used on relatively large accumulans of fiber. For comparison between individual goats, the sample submitted for testing is normally taken from the mid-side. Since variation in diameter and yield does exist between different body areas, other sampling points that may be considered are the neck, back and britch. However, if the fleece is shorn, by far the best way to sample a whole fleece is to spread it out and take samples with the assistance of a grid. This insures impartiality on behalf of the person doing the sampling and the sample thus taken has the potential to provide accurate yield, diameter and staple length data representative of the whole fleece.

When samples are taken to evaluate an individual goat, it is very important that the age of the animal be recorded at the time of sampling since Angora goats produce progressively coarser fibers with increasing age.

**Scoured yield**

Standard methods for determining yield (ASTM, D584; IWTO, 19-85-E) have changed little since their introduction. Basically, the methods involve scouring samples in hot, soapy water followed by determination of residual grease, inorganic ash and vegetable matter content (ASTM, Dl113) on the dried, scoured fiber. Subsequently, "Mohair Base" (pure, oven-dry fiber) is converted to a value known as "Clean Mohair Fiber Present" by dividing a factor of .86 (in the case of the U.S. method). This is the factor required to adjust the mohair base to a moisture content of 12%, an allowable alcohol-extractives content of 1.5% and a mineral matter content of 0.5%.

**Diameter**

A microprojection technique for determining average diameter has been the international industry standard for many years. In ASTM (D2130) and IWTO (8-61-E) standard methods short longitudinal sections are projected onto a screen using standard magnification of 500X. The widths of the projected images are measured using a standard wedge card or ruler. These methods allow for calculation of both an average and a measure of variability of diameter, either the standard deviation or coefficient of variation of diameter. Using the wedge card technique, a competen technician can measure 200 fibers in about 20 minutes. Fiber diameter measurements are often summarized in the form of a histogram.

Several U.S. institutions are experimenting with digitizing device (Blakeman et al., 1988) that can replace the wedge card or ruler and allow for more rapid measurement. At this time, none of the innovative techniques have been incorporated into standard methods. For many years, there has been a need for an instrument capable of rapid and accurate measurement of fiber diameter and distribution. This need was met to a large extent by the introduction of the Commonwealth Scientific and Industrial Research Organization (CSIRO) Fiber Fineness Distribution Analyzer (Lynch and Michie, 1973) and its commercial counterpart, the Peyer Texlab FDA 200 System. These instruments represent the most innovative concept for determining animal fiber fineness parameters since the introduction of projection microscopy for this purpose. Commercially, the instrument is used to measure mohair in Australia, New Zealand and South Africa as well as wool samples in these countries and in Europe. The electro-optical technique is capable of measuring 1000 fibers, calculating a mean, standard deviation and coefficient of variation and printing this information together with a histogram all in the space of three minutes (See Figure 3-1). Probably because of the high price (currently approximately U.S. $100,000) only four of these instruments are in use in the U.S. in 1992. Approximately 50 of the instruments are operating throughout the world. The Peyer Texlab FDA 200 System is programmed to measure individual fiber diameters in the range of 6 - 80 µm. Thus, it is not capable of measuring mohair coarser than about 45 µm (mean value) since such samples typically contain fibers coarser than 80 µm. This is not only a software deficiency. A physical limitation is also present since coarse fibers cause blockages in the glass measuring cell.

Image analysis techniques have been used for measuring the diameter of wool, with varying degrees of success. ASTM (D3515) describes a technique utilizing a PiMc Particle Measurement Computer system. This instrument is now obsolete and the method was discontinued. Nevertheless, several research groups (Marler and McNally, 1987; Blakeman, et al., 1991) are further developing image analysis techniques. This technology shows distinct promise both for enhancing the speed with which fiber diameter can be measured and the range of fiber diameters that can be accommodated. SGS Wool Testing Services of Australia recently announced an instrument based on image analysis technology. It is called the Optical Fiber Diameter Analyser.

For some purposes, a knowledge of the variability of diameter is not required. In such cases, air flow instruments have made a tremendous contribution in the wool sector (ASTM, D1282; IWTO, 28-82-E). Three versions have been used in the U.S. (Micronaire, Port-Ar and WIRA) and at least one type (Port-Ar) is calibrated and used on a regular basis to measure mohair in scoured and top forms. The airflow measurement takes less than a minute to perform. Sample preparation takes much longer.

**Lock/staple/fiber length**

Commercially, mean fiber length determines the system on which the fiber will be spun (worsted or woolen) and the type of product into which the fiber will be manufactured. The standard U.S. technique for determining staple length (ASTM, D1234) is simple, accurate but slow and requires only a ruler for measurement and a pencil for recording. This method can easily be adapted for direct measurements on the live animal. The ASTM procedure calls for "relaxed" staple length to be recorded. This technique sometimes modified in the case of mohair staples, and straightened or stretched staple lengths are measured. Provided the report specifies the configuration of the staple at the time of measurement, there should not be a problem with this practice.

State-of-the-art instrumentation for measurement of staple length (predominantly for wool) is the CSIRO ATLAS (Automatic Tester for Length and Strength; Whiteley, 1984). Several of these instruments are currently being used in Australian Wool Testing Authority facilities to provide (mainly) pre-sale data for wool buyers.

**Staple strength and position of break**

Staple strength is rarely a limiting factor in the production of mohair yarns. However, on the occasions when weakness occurs in the staple, this can have a serious effect on the efficiency and quality of yarn production. Thus, in some circumstances it may become desirable to use an objective measure of staple strength. A range of instruments are available for this purpose and include the unsophisticated manual strength tester produced by Agritest (Agritest, 1988) at one extreme and the automated CSIRO ATLAS instrument at the other end of the spectrum.

**Medullation**

Projection microscopy is used in the two standard methods (ASTM, D2968; IWTO, 12-64-E) for determining the percentage of medullated fibers in mohair. Fibers are prepared in exactly the same manner as for diameter determination. However, only a cursory inspection of the projected fibers is required in order to designate individual fibers either medullated or unmedullated. The ASTM standard defines two types of medullated fiber, med and kemp. A medullated fiber in which the diameter of the medulla is less than 60% of the diameter of the fiber is a med. When the medulla is greater than 60% of the fiber diameter, the fiber is referred to as a kemp. Research with mohair has shown that most kemp fibers appear chalky white after dyeing when most med fibers appear to have been dyed normally.

The SAWTRI Medullameter (Smuts et al., 1983) was developed specifically for determining total medullation of mohair samples. The instrument is quite capable of performing this function but appears to be incapable of accurately predicting percentages of med and kemp.

Image analysis promises to be a faster method of measuring med and kemp. However, the specifics for doing this have yet to be established. An alternative method of identifying the proportion of mohair fibers capable of causing dyeing problems is currently being investigated by the International Mohair Association. The new method may involve dyeing a scoured sample of fiber with a mixture of dyes followed by a visual evaluation and accurate count of undyed fibers.

Most mohair is converted into yarn using the worsted processing system. In this system, short mohair fibers are removed in the combing process. Short kemp fibers are also removed in combing. Thus, the most undesirable type of kemps are those having length comparable to the bulk of the normal fibers. This is why length of medullated fibers is an important characteristic of mohair.

## Subjective characterization

### Style and Character

Style is the twist in a staple and character is the crimp or wave. No current ASTM method addresses the measurement of style or crimp. Nevertheless, style and crimp of relaxed mohair staples can be (painstakingly) quantified using a felt board and a ruler. Visual appraisal of style and fiber wave or crimp frequency and definition form an important part of purchasing strategy. A technique involving automatic image analysis is currently being developed to measure crimp in wool. When available this method could conceivably be applied to mohair.

### Luster

Luster, perhaps the most prized characteristic of mohair, is routinely and subjectively assessed in the marketing process. There is no approved objective method for determining luster on greasy animal fibers. However, appears likely that photometric techniques will be developed for estimating this elusive characteristic. A goniophotometer was used to establish luster values for scoured and chemically treated mohair (Van Rensburg and Maasdorp, 1985). As for color, luster is affected by the amounts of grease and dirt surrounding the fiber. Thus, scoured fibers required for accurate determination of luster. As unlikely as it may sec the bulk or resistance to compression of luster wools (and perhaps mohair) is related to luster (Elliott, 1986) which may provide an indirect method to quantify this characteristic.

### Color

Scoured color is a reproducible, measurable characteristic of wool. The New Zealand and Australian Standards Organizations both have published methods for specifying the color of scoured wool. Purchasers of white wool are actually more concerned with lack of color or whiteness. Nevertheless, the same instrument, a colorimeter, could be used to accurately specify the color of scoured mohair. In the case of wool, whiteness (or yellowness) of the greasy product is not a very good indicator of the whiteness of the scoured product. Such would also be the case with mohair.

### Matted/felted fleeces

This problem sometimes occurs in kid Angoras and mature animals growing mohair of poor style or character and perhaps low grease content. The problem is more likely to be observed in goats which have been doing poorly from the standpoint of nutrition, disease or parasite load. Because matted fleeces result in broken, short fibers in mechanical processing, it is important that this problem be avoided or minimized.

### Weathered tips

Exposure of unprotected fiber tips to the sun and other elements results in degraded protein that will not accept dyestuff in the normal manner and which is brittle. This can be a problem in mohair, particularly in fleece containing excessively low grease levels. There is little the producer can do about this except to maintain animals with adequate grease in the fleece and a well-defined lock formation.

## END USES OF MOHAIR

In earlier times, mohair was used primarily in textiles that were required to be highly durable. The high resistance to wear of mohair was thus used to advantage in heavyweight, upholstery pile fabrics such as those common in public vehicles. As the fiber evolved into a luxury item, this particular end-use declined although its use in luxury plush and pile fabrics is still common (Table 3-3). In blends with wool, finer grades of mohair are used to produce lightweight (tropical) suitings. Mohair has the capability of being dyed to very bright shades while retaining its natural luster. These attributes, in particular, are used to produce attractive dress materials, shawls, stoles, plushes, astrakhans and various types of womenswear coatings composed typically of velour fabrics but also novelty fabrics containing bouclés and worsted yarns. Mohair is also used to produce smooth, high quality linings for suits, curtains, drapes and table coverings. A small amount of mohair is used to produce highly resilient carpets, rugs and paint rollers.

The major use for mohair in the recent past was in hand-knitting yarnsin which the natural luster and brightness of mohair combined with its smooth handle, warmth and tendency to resist dirt, creasing and felting provide distinct advantages over synthetic fibers and even wool. The bulk of these yarns are knitted into sweaters and other ladieswear accessories. Brushed yarns and fabrics composed of adult mohair and mohair-rich blends often dominate the sweater market when the fashion pendulum swings in this particular direction. At the time of this writing (Winter 1992),the percentage of mohair being used in hand knitting yarns is below the 65% shown in Table 3-3 and this has had an adverse impact on demand and price.

Most of the U.S.-produced mohair is exported. Traditional import or consuming countries have been England, Spain, Italy, Belgium and Japan. However, currently developing markets, particularly for the coarser grades of fiber, are China, Taiwan, India and the former Soviet Union.

## MOHAIR PREPARATION, GRADING AND MARKETING

Much has been written about preparation and marketing of U.S. wool (e.g., Lupton et al., 1989). In comparison, little information exists in theU.S. literature concerning optimization of the value of grease mohair through preparation and marketing.

Production and marketing of a good mohair clip begins with the breeding program. Much of the genetic progress is realized through selection of breeding males. Ideally, these should be selected utilizing some type of performance data. Nannies should be selected for fleece weight, length, diameter, style and character (breed and lock). Goats with excessively coarse necks and/or britches or short staple mohair over certain parts of their bodies should be culled. Mean fiber diameter should be well within the expected range for a specific age group (see Table 3-4). In so far as numbers permit, older animals should be culled before the fleece weight deteriorates or the hair becomes straight or overly coarse.

Angora goat management is also a mohair preparation activity since itcan greatly affect the quantity and quality of fiber production. Poor nutrition results in relatively lightweight fleeces containing short, dull (but fine) hair. External parasites, especially lice, undermine the appearance of fleeces. However, data from a recent experiment indicate that the effects ofshort-term lice infestation on objectively measured mohair properties may have been exaggerated (Lupton et al., 1988). Angora goats should be managed to minimize plant (vegetative) contamination of fleeces.

The next important component of clip preparation is adequate working facilities including pens, shearing floors and sheds. These areas should be clean, free of mud and dust and well lit. Many producers prefer a concrete shearing floor which is easy to keep clean but can be hard on shearing equipment. A sheet of plywood laid over the concrete makes for a more efficient and comfortable work station. Shearers should develop the skill to remove the bulk of the fleece in one piece since this greatly assists in sorting/grading. Shearing of Angora goats is similar to sheep except that in the final move they are sheared with a stroke of the shearing head from the belly to the back, starting at the rear of the animal. This permits the shearing head to move against the way the locks are presented and thus to reduce double cuts. Shearers should be provided with clean oil for their shears. Burnt motor oil is difficult to scour out of mohair. Specific responsibilities of growers and shearers in preparation for and during shearing are listed in the American Sheep Industry Code of Practice for Preparation of Wool Clips in the U.S. (American Sheep Industry Association,1990) and are equally applicable to goat raisers as sheep producers. Similar information is well documented in the Proceedings of the Mohair Preparation Seminar that is conducted annually under the auspices of the Mohair Council of America, Texas Agricultural Experiment Station and the Texas Agricultural Extension Service.

Typically, animals are separated by age prior to shearing. This permits the producer to shear and package kid, yearling and adult hair separately. Gate or chute-cutting may be used not only for separation of age groups, but can also be used to separate the adult flock into broad quality groups. The next level of preparation is removal from individual fleeces of all stained fibers. Mohair fleeces differ in most measurable characteristics; fineness, yield, vegetable matter type and content, length, strength, color, etc. When individual fleeces are subdivided according to any or all of these characteristics, the process is called sorting (or classing, particularly in South Africa). Sorting is probably the ultimate form of clip preparation since it results in matchings that may be scoured and utilized directly by the textile industry. When fleeces having a small range of fiber diameter are packaged together for marketing purposes, the process is known as grading.

Theoretically, any degree of clip preparation can be conducted at the ranch. In practice, gate-cutting a flock of goats into age groups followed by a second division of each group into "fine" and "coarse" sub-groups, for example, is as much clip preparation as some producers can organize or justify. In contrast, some conscientious mohair producers are currently delivering fully-prepared mohair matchings directly to the warehouse. In many instances, it is probably more convenient for producers to pay formohair to be sorted at the warehouse than to attempt this task on the ranch where time and skill are often inadequate to do a reliable job. In this context, it is important to note that a mediocre sorting job is virtually useless in terms of adding value to the clip. To obtain compensation for clip preparation and sorting, it is essential that all defective (e.g. short, stained kempy) mohair be removed from the main lines and that different grades be kept completely separate. In short, if ranch clip preparation is to be rewarded, it must be done properly.

Mohair grading and sorting have been marketing tools in Texas since at least 1940. However, until recently, only a few warehouses have provided this service. A Texas Agricultural Extension Service report (Gray and Groff, 1971) estimated the financial return for grading mohair at the warehouse. The same article attempts to identify conditions under which a clip should not be graded due to fleeces containing no fine and/or a high proportion of stained mohair. The economics of sorting or classing mohair will be highly variable between years (and flocks) and is greatly dependent on the premium received for superior types.

For over 16 years, South African producers have sorted and classed the11 mohair prior to sale. Cape Mohair Classing Standards incorporate 18 separate classes, mohair being differentiated by such variables as animal a! and breeding (kid, adult, crossbred, etc.), length, style and character fineness, kemp content, vegetable contamination and stain. To some degree, these 189 classes represent description as contrasted to the product of sorting or matching. Prior to sale by auction at a central location, small lots are consolidated into larger ones, thus dispensing with the disadvantages associated with marketing small lots. These practices, in conjunction with higher clean yields, have resulted in South African mohair prices being consistently higher than those of similar types in the U.S. Tradition and opportunity also appear to play a part in this price differential. The observed differences between the prices in the U.S. and R.S.A. have caused numerous U.S. ranchers and warehousemen to pay more attention to mohair preparation. It has been claimed that such practices have resulted in comparatively higher selling prices. Intuitively, these claims seem reasonable. However, because of the short-term volatility of the mohair market, it is difficult to fully substantiate all claims. Furthermore, because of the extra time or manpower requirement of the intensive preparation methods it is often difficult to demonstrate cost-effectiveness even when superior prices are realized.

With this background, a multi-year experiment was designed to study the technical and economic consequences of ranch-preparing mohair at shearing time (Pfeiffer et al., 1990). The economic results of the first two and a half years of the study may be summarized as follows. Selling mohair that had been graded at the ranch according to fiber diameter did not result in significant economic advantage compared to selling comparable hair using the conventional original bag methods. Mohair from this study was sold in a declining (fall, 1987) and sluggish (1988-89) mohair market. It was not possible to sell all the mohair from a particular clip at one time. Thus, a truly valid comparison and interpretation of the economic data were not possible. The report does not address the questions: how would preparation affect mohair prices when demand is, high; what would have been the result of a similar experiment if the grading and sorting had been conducted according to South African standards; what would the economic effects of moving stain and grading mohair if all U.S. producers used such a system, a marketing tool? Obviously, answers to the broader questions have yet to be found. Even without answers to all these questions producers are encouraged to sort into age groups, remove defect and stain and to be alert for opportunities to gain financial advantage from a system of better preparation. They would also be advised to consult with their warehouseoperators or with others in the process of mohair marketing on a regular basis.

There are currently (Winter, 1992) thought to be 29 warehouses operating in 22 cities in Texas and New Mexico which are actively involved in marketing mohair. One of these should be in traveling range of most Texas and New Mexico producers but access to marketing facilities may present problems for producers in some other states.

In general, mohair is packaged and sewed into special 6-foot long jute bags (see Figure 3-2) and transported to a warehouse. A small quantity of mohair is sold to buyers "at the farm gate." Some warehouses purchase mohair from producers. Most warehouses operate on a commission basis. Some marketing agencies specialize in selling OB mohair. Others have adopted the marketing strategy of offering mainly matchings. In the latter case, classing or grading of the mohair in the warehouse is normally a prerequisite of sale since it permits warehouse personnel to control quality. This is achieved semi-continuously on a belt or batchwise over a table. However, some ranch-graded hair is accepted from producers with established grading expertise and/or when warehouse personnel were present and supervised grading at shearing time.

Some U.S. mohair is core-sampled and tested prior to sale but most is only subjectively assessed by prospective buyers. Most of the U.S. clip is sold in sealed-bid sales or by private treaty in contrast to the public auction system most commonly used in other countries.

**Marketing Philosophy**

South African mohair is prepared and classed to a much higher degree than most U.S. hair. Type for type, buyers generally pay more for South African hair, even on a clean basis. The question arises, "Is South African mohair superior in quality to U.S. mohair?" The author believes this not to be the case. Rather, mohair buyers are willing to pay higher prices for (relatively) large lots of uniform (length, diameter, style, character, etc.) mohair when offered through the South African Marketing System. Recognizing this, in 1990 the Texas Sheep and Goat Raisers Association adopted guidelines for marketing graded mohair (Table 3-4) and several Texas warehouses are currently using these or very similar guidelines in their marketing strategies.

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CHAPTER 4

# REPRODUCTION

**Importance of Reproductive Efficiency**

A high reproductive rate is a major contributing factor to efficient meat production since only animals which are surplus over replacement needs are available for slaughter. Since meat production is of less importance for the Angora, the relationship between reproduction and efficiency is less direct. However, there are a number of reasons where reproductive rate is important with this animal as well. The most direct of these to the individual producer is that he will have more surplus animals for sale as replacements to other breeders. This is not a net gain to the overall industry, but represents a transfer of funds between producers. However, there are a number of advantages to the industry as a whole:

1. A moderate level of reproduction is necessary to maintain producer herds or national populations,

2. A high level of reproduction permits the industry to respond more rapidly in times of favorable prices or demand for mohair,

3. It contributes to genetic improvement through providing a greater selection differential to an individual producer or to the industry through allowing more animals to be culled,

4. A high reproductive rate contributes to improved mohair production from both a qualitative and quantitative standpoint by reducing or permitting a reduction in the mean age of the flock or population.

It should be obvious that successful reproduction is necessary to maintain numbers, but this may be more important than is immediately apparent. With the Angora, castrated animals ("muttons," in Texas) are kept for mohair production. If it is assumed that one-half of the kids born are males, and that most of these are kept for fiber production, then up to one-half of individual or national herds could be males (including castrates). If culling age for the two sexes are similar, the actual percentage of males could theoretically be higher due to a higher loss rate of breeding females. Thus, the net kid crop raised, when expressed as a function of the total adult population, would be approximately one-half the value obtained when expressed as a function of the breeding-age does. Actually, it could be less than this when young or replacement animals are included in the total. Under these conditions, a net kid crop raised of at least 40% of the breeding age does would be required to maintain numbers. A 10% increase in kid crop reared would provide for only approximately 1.5% increase in total numbers. This explains the problems encountered in increasing numbers of Angora goats at times of favorable prices. Angora goat numbers may go down at a rapid rate, but they cannot increase at a rapid rate. Good statistics on the kid crop raised are not generally available from mohair-producing areas, but poor reproductive efficiency is known to be a problem. A look at time trends in goats clipped in the United States (see Figure 1-1) indicates that in times of favorable prices, numbers often increase at about the maximum rate possible. Rapid changes in goat numbers can occur (over the short term) only as a-result of delayed culling, or rapid sell-off of excess animals (especially muttons) for slaughter. Increases in numbers occurred in the periods 1924- 1934,1952- 1965, and in the decade of the 80's. The rates of increase during the earlier periods were greater than in the decade of the 80's, when prices were considered favorable. One of the more logical explanations for this is that the reproduction rate was greater in these earlier periods. This could very well be explained by a greater labor supply to provide more intense management, and that Angora goats at that time were less highly bred (in respect to fleece cover), and therefore had higher reproductive rates. In the earlier period (1924-34), no doubt some crossbred types were involved, which would have contributed to higher reproductive rates. Losses due to predation were probably less during this period.

In addition to permitting an increase in numbers, a high level of reproduction would also contribute to long-term genetic improvement through providing a larger number from which to select future breeding stock. Most of the true genetic improvement will come from male selection, and a larger number of male kids will provide for greater selection options.

A high level of reproduction can contribute to improved quantity and quality of fiber produced in a more direct and more important manner than through its influence on genetic progress. Young animals produce a finer quality mohair. They also produce more mohair, except during the first 2 shearings, or at least produce more fiber per unit of body weight maintained, and thus, produce fiber more efficiently (Figure 4-1). In a similar manner, castrated animals produce more fiber than does. Thus, in a stable population, the percentage of the herd which may be made up of castrates and the age at which both castrates and females can be culled directly influences quantity and quality of mohair produced, which, in turn, is directly related to the rate at which replacements are produced.

The sale price of surplus Angora stock is closely related to mohair prices and trends in numbers. This provides a mechanism for producers to gain a reward from improved management practices and to increase kid crop reared during periods of favorable prices. An increased reproductive rate will always tend to increase total income per doe when expressed on a "per head" basis, but marked increases in income per unit of land area or per unit of cost will occur only when mohair prices and the demand for replacements are reasonably favorable. The difference between the two is based on the assumption that larger sized does and, in many cases, a reduced stocking rate and increased feed and labor input are associated with increased kid crops. There have been times in the past, and likely will be in the future as well, in which low prices for surplus animals did not justify these inputs. The major factors contributing to improved kid crops largely result from management. Thus, in tinies of favorable prices these inputs can be maximized, and in times of less favorable prices, these inputs might be reduced. However, in some cases, such as developing young replacement stock, there will be a time-delay before reproduction is affected. Relaxed selection for high fiber production, especially that resulting from extreme covering including the face, will contribute to improved reproductive rate.

**Basic Reproductive Phenomena**

An understanding ofthe basic reproductive phenomena of Angora goats is necessary for a discussion of reproductive efficiency, or for that matter for overall herd management. The basic reproductive phenomena of the Angora appears to be essentially the same as goats in general. Exceptions to this are their greater seasonality, and the greater stress placed on this breed as a result of the high nutritional demands associated with fiber production. Reproduction in the Angora is a problem area, whereas, many other types of goats are noted for a high level of reproduction.

**Age of Puberty**

Age of puberty is the initial or minimal age at which the animal becomes reproductively active, i.e., does start ovulating and males start to rut. Angora goats are highly seasonal. They either reach puberty during their first season, at six to eight months, or one year later at approximately 18 months. Individual well-developed kids will reach sexual maturity their first season, but under range conditions, this is often not the case. Even if they do reach puberty, it is not generally recommended that they be bred or used for breeding their first season under range conditions. Individual male kids may be used for light breeding if they are observed to be rutting their first season. No consideration should be given to breeding doe kids unless they are to be raised under unusually good conditions. There is a risk that breeding as kids may result in abortions, which can become habitual. To prevent the occasional breeding of doe kids, they should be separated from male kids or from mature animals during the breeding season. In fact, since kids require or deserve special treatment, they should preferably be managed separately from other age groups throughout their development phase. Under poor range conditions, many does will not breed satisfactorily even as yearlings to kid at two years of age; but this failure is more a result of lack of condition or development and should be viewed as a fault of management.

**The Breeding Season**

Angora females belong to a group of animals which are referred to as being seasonally polyestrous; that is, they are seasonal breeders, and the females have re-occurring estrual periods during the breeding season if they are not bred. The phenomenon of seasonal breeding is known as photoperiodism, or response to the day/night ratio, as is true of many plants and animals. With Angora goats, the number of hours of darkness appears to be the controlling factor; they start to cycle with reduced day lengths. The goat, especially the Angora, is somewhat unique for domestic animals in that both the males and females are seasonal. The mating season of the male is easily detected by the characteristic odor and rutting activities. Occasionally, individual males may fail to rut even during the normal breeding season. This is usually explained by their being too young or in poor condition. If this is not the cause of failure to rut, they may be induced to initiate breeding activity by placing them with other rutting males, or with females in estrus. If they continue to show low or minimal interest in breeding, which is not explained by poor condition, they should culled. Goats, including Angora, are also somewhat unique in that the females do not normally start cycling until they are stimulated by the presence of the male. Later in the season, other stimuli can serve this same purpose. The goat is not totally unique in respect to the male effect, but they show this phenomenon to a greater degree, and in a somewhat different manner than other species. Another unique feature is that the females do not all exhibit a silent estrus (ovulation without showing estrus) as do most other ruminants, or if they do, they recycle again within five to seven days instead of one estrous cycle later.

The most extensive study of breeding season was done in South Africa (Marincowitz, 1962), which showed does cycling October to February (U.S. equivalent dates) with September as a transitional period. In this country, satisfactory results can usually be obtained from matings starting as early as September, and individual breeders often obtain kids from matings earlier than this. This is greatly influenced by shearing date. Summer kids will occasionally be seen in herds, resulting from winter matings following an early abortion.

**Length of Estrous Cycle**

The length of estrous is reasonably well documented. Typical estrous cycles of individual does are 19, 20 or 21 days. Two research studies (Shelton, 1961 and van Rensburg, 1970) found estrous cycle lengths of 19.5 and 20.6 days, respectively.

**Length of Estrus Period**

The length of estrus, or the length of time does are in heat, has not been extensively studied in Angora does. However, van Rensburg (1970) arrived at an average length of 22.3 hours, which is shorter than in other species, such as sheep. The duration and intensity of estrus will be longer at estrual periods subsequent to the first and for mature does. This information would be primarily of interest to those persons practicing hand mating or artificial insemination.

**Gestation Length**

The gestation length of Angora does is well documented, with Shelton (1961) reporting an average of 149.2 days, and van Rensburg (1970) reporting 149.4 days. Ranges as much as 143 to 153 days are reported, but it is difficult to determine if the extreme values should be considered normal. Twin kids are normally dropped approximately one day earlier than singles.

**Ovulation or Kidding Rate**

Ovulation refers to the release of an egg, or ovum, from the ovary, and sets the upper limit in the number of kids which may be conceived from matings at a given estrus period. An individual doe may ovulate 0, 1,2 or more ovum. The important contrast in Angora goats is between does which raise one kid or those that raise none, but the potential for "twinning" is rather high. Except for the possibility of identical twins, the ovulation of two ova is necessary for twinning to occur, but does not insure twin births as one of the pair of ova may not be fertilized or the resulting embryo may not survive to term. Identical twinning has not been demonstrated or documented with Angora goats; if it occurs, it is of very low frequency. With other species, such as the sheep, ovulation rate is largely determined by breeding (differences between breeds or strains within breeds), season of the year, and size or conditions of the female. Season of the year is not a particularly important consideration with Angoras, since they are not normally bred outside the fall season, and if breeders wish to do otherwise, this would not be highly successful without the use of hormones or light modification. The expense of doing this would not be warranted for commercial herds. Ovulation rates for the various months from September through December have not been studied, but it is known that the ovulation rate at the second true estrus period of the season is higher than the first (Shelton, 1961). Mating at this second estrus would be expected to result in some increase in level of twinning. Mating at the second estrus may be insured by using sterile males in advance of putting out fertile breeding males or, in some cases, by simply delaying the breeding season until later in the year.

Size and development of the doe seem to be the major source of variation in ovulation and kidding rate. In a study by Shelton and Stewart (1973), 244 does were slaughtered following the breeding season and the ovulation rate recorded. Of this number, 25 (10.2%) had not ovulated, 170 (69.7%) had single ovulations and 49 (20.1%) had ovulated two eggs. However, the ovulation rate varied greatly between groups of does. The relationship of ovulation rate to size is shown in Figure 4-2. The ovulation rate indicates the potential kidding rate, but in practice, the kidding will always be below the ovulation rate.

Given good conditions, the ovulation rate of the Angora may be reasonably high. This may be somewhat dependent on conditions under which the herd has evolved. For instance, limited data from less-developed areas indicate the goats have very low twinning rates. Generally poor feed conditions would not favor a high level of multiple births, and therefore animals developed or maintained under these conditions would not be expected to show a high twinning rate. A low twinning rate of Turkish Angora appears to indicate this. It's the writer's opinion that it is not advisable to actively select for multiple births in Angora goats to be run under range conditions. Stud herd or herds run under farm conditions may well benefit from twinning, but it should be remembered that the target population are those run under commercial conditions. If conditions favor a high level of twinning in the herd, or population, selection for this trait will be automatic. Under adverse range conditions, the contrast is primarily between does which raise 0 or 1 kid. Thus, it appears to be more logical to discriminate against does which fail to raise one kid by reason of abortion or failure to conceive. As applied to a single season, this is automatic, but it is conceivable that producers might find themselves keeping a breeding male out of a doe which raised only one kid in her lifetime. This would almost certainly be a mistake. It is unlikely that failure to reproduce is due directly to specific individual genes, as such genes would be eliminated from the population by natural selection. However, over-emphasis on other traits such as face cover and grease fleece weight (high oil content) which are genetic in origin can adversely influence reproductive rate in an indirect manner. Improvement of reproductive efficiency, including twinning, I should be largely through management practices at times when prices are favorable, and when the additional costs can be justified.

**Fetal Development and Birth Weight**

In one study, Angora does were sacrificed at various stages of gestation (30-141 days). Fetal weight and crown-rump length (body length from the crown of the head to tail setting) were recorded. The crown-rump lengths are essentially linear (Figure 4-3). From this relationship, fetal age can be determined either by approximation from the graph, or more accurately by calculation.

Fetal weight is highly correlated with age, but this relationship is curvilinear, instead of linear as with fetal length. Actually, the increase in fetal weight is geometric in nature, being very similar to the theoretical curve, assuming a constant and unlimited rate of cell division. If these values are plotted, the rate of growth closely approximates the theoretical until near the end of the gestation period when nutrition or uterine capacity begins to limit growth. The accelerated growth rate of the fetus around 90-100 days indicates increased nutrient demands and coincides with the time that abortions may begin to occur. Normal birth weights for kids are in the range of 5 to 7 Ibs., and kids below this range have low survival rates (Table 4-1).

**Sources of Loss in Reproductive Efficiency**

Kid crops range from 0 to highs of at least 150%. The latter will be limited to small farm herds or intensely managed stud herds. The normal range for commercial herds in Texas tends to be in the range of 40 to 80%. These values are distinctly below that for other types of goats, and can almost certainly be explained by Angoras having been successfully selected for a high level of mohair production, resulting in a situation in which fiber production takes precedence over other body functions such as growth and reproduction.

As applied to an individual doe, or even to a herd, a breakdown in reproduction must occur at a specific point as a result of a failure of some process. Thus, it should be useful to investigate the points at which this 1 loss can occur. These may be outlined as follows: (1) a failure to ovulate and/or show estrus, (2) failure of conception, (3) failure of embryo survival resulting in abortion or resorption of the fetus, (4) death losses of kids at or subsequent to birth. It is possible to determine, or document, where losses are occurring, but it may not be feasible for an individual producer to do this. In any case, the results would differ greatly, based on conditions. Data of this nature were tabulated in one study (Shelton and Stewart, 1973). In this study, the average ovulation rate per doe ovulating was 1.22, suggesting a potential kid crop in this study of 122%. This is not a true estimate of the potential kid crop, as this value was based on does ovulating. In this particular study, the net kid crop raised was 56.4%, which is thought to be indicative of problem herds on the range. In this study 10.7% of the does did not cycle, 12.5% failed to settle, 8.9% lost the fetus(s) and 22.0% lost their kids. Losses at each point were closely related to body weight (Table 4-2). It should be pointed out that these data represent problem herds maintained under commercial conditions during the early 70's, when mohair prices were poor and goats received little care. Almost all the indicated losses can be corrected with improved weight and condition of the doe or more intense management during gestation and kidding. Kid crops of at least 100% are theoretically possible under range conditions.

Failure to ovulate or cycle is almost totally explained by lack of size and development. This is the case if they are being bred at the appropriate season (fall) and they are sexually mature (at least yearlings). There is simply no alternative to good size and development if good breeding results are to be obtained (Figure 4-4). This figure is based on all does in the herd. This is influenced somewhat by age of the doe. Body weights of yearling does will be concentrated more at the lower range, resulting in few of them having twin ovulations. Also, the yearlings may breed more readily at a somewhat lower weight than mature does. For reasonable breeding results, yearling does should weigh at least 65 lbs (shorn body weights in the fall) and mature does should weigh 85 lbs. The enormity of the problem is apparent when it is realized that mean body weight of range does is only approximately 65 lbs. The solution is difficult. The high level of mohair production of the Angora goat ensures that this animal is almost always in nutritional stress under typical range conditions. Management practices which contribute to better development are proper stocking rate and other range management practices, parasite control and supplemental feeding. Good management during the post weaning period is often critical for doe kids and can influence lifetime reproductive performance. If optimizing management practices fail to result in an adequate level of reproduction, it may be necessary to relax somewhat the selection for extreme mohair cover or fleece weight. Perhaps the best way to accomplish this is to select for the animal which performs well including raising a good kid crop under the conditions in which the animals are to be maintained.

**Failure to Conceive**

Lack of conception was implicated in failure of 12.5% of the does or 19.9% of the ovum ovulated. These values were somewhat higher than expected, and the research itself does not directly suggest the reason. Both does and males should be shorn before the breeding season, but cold stress during the breeding season could well interfere with conception. The difference between the percentage of does that do not conceive and the percentage of unfertilized ovum suggests that the loss is higher in twin ovulations. A portion of this is obviously due to chance, since if one of the two ovum were fertilized the doe would not return to estrus. Other factors probably contributing to a failure of conception are a lack of libido, or mating vigor, of the male. Sterility is not a major problem among Angora 'males that are strong and have sufficient mating vigor and libido. However, lack of strength is a distinct problem in poorly nourished, unthrifty or under-developed males. This can be overcome by using stronger males or using more males. Extreme under-nutrition of the doe may also result in failure of conception or early loss of the embryo.

Some apparent cases of failure to conceive may be attributed to early abortions. For this and other reasons, it may be desirable to cull dry does. This will usually improve kid crops in subsequent years. However, the desirability of doing this may be based on a number of factors. Some knowledge of why the does failed to raise a kid would be useful in making this decision. If does were simply in poor condition at breeding as a result of a dry year, they might actually raise a better kid crop the following season due to improved condition. In one study, 10% fewer dry does kidded the following year than does which raised a kid. If one assumes that the dry does constituted 25% of the herd, culling the dry does would result in only a 2.5% increase in the percent of does kidding in the following year.

Abortion, or loss of the fetus, represented 8-9% of the does or 12.2% of the potential kid crop. Abortion can be confmed by observing the abortus or blood stains on the mohair around the vulva. However, some additional losses will occur through early resorption of the fetus or through unobserved abortions. Essentially all herds of Angoras will suffer some losses of this nature. In observed experimental herds, identified aborting does generally range from 0-3%. In one problem year, 16% of a group of experimental does were observed to have aborted. In one producer-owned problem herd, annual abortions on the order of 16% were documented over a period of years. Losses as high as 60% have been reported in South Africa (van Heerden, 1964). In the past, this problem has been more serious in South Africa than in this country, but it is also likely that much higher losses (greater than 16%) have occurred in this country as well.

In general, goats (all goats) abort more readily than other ruminant species, such as the sheep or the cow. There appears to be a physiological explanation for this. A hormone known as progesterone serves a role of preventing uterine contractions and preserves the fetus. The initial source of this hormone is the Corpus luteum (CL) on the ovary, but in the sheep or the cow the placenta takes over the role of producing progesterone. However, in the goat the placenta does not assume this role, and thus, in the absence of a CL on the ovary, abortion will occur. Thus, the goat is known as a Corpus luteum dependent species and anything which interferes with the CL will result in abortion. Although abortions are frequently observed with all types of goats, the Angora seems to be more susceptible to this problem. This seems to be predisposed by their high level of fiber production, and this high metabolic priority for fiber production predisposes them to nutritional and other forms of stress.

A number of infectious agents are known to be able to cause abortion in goats. These include Brucellosis (Bruceflamelitensisin the goat), Chlamydia, Listeriosis, Salmonellosis, etc., and a much larger number of infectious agents could predispose abortion by contributing to ill thrift on the part of the animal. In specific conditions, and on a worldwide basis, infection may be an explanation for abortion, but this does not appear to be the case with Angora goats under range conditions.

Most instances of observed abortion will occur in the range of 85 to 120 days of gestation. It seems clear that most abortions are concentrated in this period, but it should be pointed out that losses prior to this date may not be identified and losses in late gestation may not be classified as abortions.

Research has been conducted on this problem in the U.S. (Shelton, 1985) and South Africa (van Heerden, 1964; van Rensburg, 1970; and Wentzel, 1982). Initially, the results from the two countries appeared to be in disagreement, but this has subsequently been explained by the occurrence of two types of abortion. These are known as stress aborter and habitual aborter. Most of the losses in Texas are from the "stress aborter," often occurring as "abortion storms" in which a number of goats abort in a short period of time (1 to 5 days). This appears to suggest the introduction of an infectious agent, but this apparently is not the case. Stress abortions tend to be concentrated in small or undernourished does, and the fetus will often be alive at expulsion. The occurrence of synchronized abortions, or abortion storms, appear to be explained by one of two phenomena. One of these is that the does were (collectively) subjected to some form of stress. This may not always be obvious, but is usually associated with interrupted feeding or watering (from a variety of causes) or from movement (hauling, driving long distances or molestation by predators). Abortion will usually occur within 1-3 days following such stress. Another potential explanation for synchronized abortion is that matings are often synchronized and the susceptible does reach the critical age at approximately the same time. The first precaution is to prevent these conditions (small size or poor condition) which predispose abortion. The second precaution is to prevent those acute forms of stress which trigger abortion storms.

The habitual abortions appear on the surface to be quite different to stress aborter. They often occur among the larger does in the herd; they do not occur in a synchronized manner, and the abortus is usually dead and often edematous when observed. As indicated in the term, habitual aborters tend to repeat each year and as a result, the does often become large since they are not producing kids. There appear to be other physiological differences which are either the result of, or the cause of abortion. These animals often have a distinctive appearance. The link between the two types of abortion is not clear, but it appears likely that some stress aborters eventually become habitual aborters. The number of habitual aborters in the herd tends to increase with age. In well managed herds, the number of habitual aborters will be low (1-3%), but these can build up with age. Thus, any animal identified as a habitual aborter should be culled. The possibility (unconfirmed) that stress aborters develop into repeat aborters suggests again that they be considered for culling, but this depends somewhat upon the percentage of these in the flock, and that replacements are available. A large percent of abortions suggests that there is a management or environmental problem which should be corrected. If they are present in small numbers for which there is not an obvious explanation, they should probably be culled.

Research work from South Africa (Wentze1,1982) has provided a primary explanation for stress abortion in that poor nutrition (low blood glucose) of the dam results in low levels of glucose (the only energy source) to the fetus. The latter results in stress of the embryo, elevating steroid output from the fetal adrenal which induces abortion. There are appropriate explanations as to why the major loss tends to be restricted to the 90-120 day period. One contributing factor is that it is about 90 days when the nutrient demands of the fetus becomes significantly greater (Figure 4-3). Regardless of the physiological explanation for stress abortion, it can be almost totally prevented by; (a) culling repeat aborter, (b) insuring that the does have adequate size, (c) insuring that pregnant does receive an adequate level of energy and (d) attempt to insure that they are not off feed or severely stressed for even a short period. A very small doe can be stressed by a fetus regardless of the ration she is receiving. Does can be induced to abort by holding them off feed for a brief period of time, but does which were previously being well fed can withstand a short period of feed deprivation with little loss. An energy feed, such as corn, fed on the range is a good feed for pregnant does. Culling is the only apparent solution for the habitual aborter. One overlooked possible explanation for abortion in goats is that they may have been mated to a ram (male sheep) which will invariably result in fetal loss (often through abortion) in the range of 50 days gestation.

<u>Death loss of kids</u> was the single greatest source of loss in the study reported earlier, and is generally considered to be the greatest source of loss under commercial conditions. In the study reported earlier, 22.0% of the does lost 32.1% of the kid crop. In general, the cause of these losses is known or can be ascertained and prevented, but often at substantial cost.

Major sources of loss are predatory animals, cold stress and starvation. The latter factors are predisposed by management, weak kids, poor mothering and bad udders on the does.

Angora kids are among the most susceptible to predation, as they may be killed by both small and large carnivores, as well as by certain flesh-eating birds. There seem to be only two avenues of preventing this predation; either removal of the predator or protection of the kids. If the kids are afforded protection for the first few days, they may resist attacks by the small predators such as raccoons, foxes or vultures, with assistance from the doe. However, the larger predators such as the bobcat or coyote will continue to kill, with the latter readily taking adult animals. For this reason, removal of the offending predator appears to be the most suitable alternative.

Chill or cold stress is a major source of loss among does kidding on the range. Choice of kidding date or provision for some protection are suggested to eliminate this problem. The kid is likely to be lost from cold stress for only a short period until they are dried off and full of milk. Protection may consist of shelter or a pasture with substantial natural protection for kidding. As the season advances, the likelihood of kids being lost due to cold stress decreases and thus, later kidding will often increase the kid crop weaned.

One underlying cause of death losses of kids is the problem of weight and vigor of the kid at birth. Factors affecting birth weight are primarily number of kids born (twins vs. singles) size of the doe and nutrition during late gestation (Table 4- 1). In cases of critical need, such as a pregnant doe subsisting on poor quality forage, the addition of supplemental protein and energy will usually provide a response in birth weight and kid survival. When green forage is available to the doe, protein need may not be limiting.

A second and major underlying cause of loss of kids is found in the tendency of does to bed down (hide) their kids and graze off from them. A direct result of this is that without the doe, the kid is much more subject to predation by small predators. Another, and often more important factor, is that the doe fails to return to claim the kid, with the result that they are abandoned and starve to death. This source of loss is greatly increased if either the doe or her kid is disturbed. Losses from this source may be minimized by the choice of kidding systems.

**Kidding Systems**

Kid losses or kid survival is a major contributing factor to kid crop reared, and management during kidding has amajor impact on kid survival. Each producer will have their own unique kidding system or management system during kidding. However, there are three general kidding systems. These are:

a) confinement kidding,

b) kidding in traps, i.e., "small camp kidding",

c) kidding on the range.

During periods of favorable prices there is a tendency for an increase in confinement kidding. It seems likely that this approach will tend to be restricted to farm flocks, stud flocks or small commercial flocks. However, at times or under some conditions this system can be justified for larger flocks. It is important that confinement kidding be well done or it is possible to end up with no more kids than other systems (Figure 4-5 and Figure 4-6). Space does not permit a detailed discussion of management I during confinement kidding. If this system is to be practiced, it is assumed that kidding would coincide with a period of protection following spring shearing.

One system of very intense kidding which was used in earlier years was known as "kidding on the stake," in which the kid was tied to a stake near a box for protection. The does would be returned to the boxes in order that the kid could nurse. This system is very labor intensive, and is largely unused at this time.

A second option is kidding in small numbers in small traps or pastures. In South Africa this is often referred to as "Small Camp Kidding." This system has a number of advantages. One of these is that the does are split up into smaller groups. A large number of does in a group has a distinct adverse effect on several aspects of reproduction. One of these is that it often interferes with pairing, or bonding, of dam and offspring and can result in doggie or dead kids. This is more critical at the time of birth, but may lead to some problems throughout the early life of the kid. A second advantage is that the does cannot stray very far from their kids and this will reduce the number of kids which are lost for a variety of reasons, such as abandonment. Also, both does and kids may be kept in close proximity to shelter in critical times. Finally, when does are managed in a small group, the owner may be able to intervene in specific problem situations, whereas he would not be able to do so in large pastures. The problem with this system is that few ranchers have the number of small pastures or traps which are needed. However, most producers will have at least some traps, and one or more of these may lead to a shed or barn. Consideration might be given to constructing additional small pastures. These should be useful at various times during the year, but in order to maximize their value for kidding, they should be rested for a time prior to their use for this purpose. In this kidding system, the producer has several options in response to cold stress. One of these is to shear approximately 30 days prior to kidding and protect a larger group of does in large sheds, and as kidding approaches turn the does into traps for kidding. Kidding in large groups, even though they are in sheds, often results in heavy death losses of kids. A second choice is to shear immediately prior to kidding in small traps. In this case, the does should be cape shorn or they should be provided protection in the traps. It is important to remember that inexpensive shelter can often be provided. It is also important to remember that a fresh-shorn doe is under greater stress from cold weather than is the kid except for the few hours immediately following birth. The use of "small camp kidding" system should be utilized more extensively in this country. The question is often asked, " What is the optimum size of pastures or number of does in this system?'There is no definitive answer to this question, but any reduction is likely to prove advantageous.

Finally, producers with a significant number of goats should realize that it is not necessary that all animals be managed in the same way or kidded at the same time. It may be desirable to split the odds by utilizing more than one shearing or kidding method or date. This would not only spread the odds from the standpoint of weather, but would give the producer more opportunities to exercise management skills or to obtain greater use of limited facilities or labor.

A third kidding system is kidding on the pasture or range. This is the most frequently practiced approach, and can lead to heavy death losses. These losses can range from near zero (a lower limit of 10% is more realistic) to 100%. There are some precautions which can be useful. The first of these is to try to minimize the predators present in the pasture. This problem is too involved to attempt to treat at this point. A second suggestion is to consider that some pastures are better suited to kidding than others. This may have to do with the amount of natural and artificial protection. Predation problems may be less in one pasture than another. Shape or location of the pasture may be a factor in respect to prevailing wind direction. Another important consideration is to minimize disruption or movement of animals. If the does are likely to run to or from a vehicle in the pasture, traffic in the pasture should be minimized during kidding. Throughout much of the year feed, water, salt, shelter or wind direction is used in distribution of grazing in the pasture. However, at kidding time it is often preferable to minimize movement by concentrating these practices at one point. In the writer's opinion it is often desirable to self-feed the animals (such as a salt-limited protein-energy supplement) near water and shelter to hold them near this point for much of the time during the kidding season.

One research study was conducted in this country comparing these kidding systems (Figure 4-6). Confinement kidding resulted in the greatest number of kids raised, but "small camp kidding" appeared to give the most economic results. This was assuming that the construction of the smaller pastures was not charged to this one use. The differences shown (Figure 4-6) are considered to be minimal, and greater differences might often be expected. A better job of confinement kidding or more severe conditions on the range would likely have resulted in a much wider spread in kid crop reared in the various experimental groups.

**Increasing the Potential Kid Crop**

Data presented earlier clearly indicated that the major factor affecting kid crop is in the area of reproductive wastage, such as conception failure, abortion or fetal loss and death loss of kids. These factors deserve or demand attention if a good kid crop weaned is to result. However, factors which affect or have the potential to increase the kid crop, such as percent of does showing estrus and ovulation and kidding rate, also deserve attention. This is especially true for producers who have resolved much of the other problems such as abortion and death loss of kids. Some approaches which might be taken are selection, flushing, use of male stimulation and the use of hormones.

As discussed earlier, selection for reproduction, particularly for multiple births, is probably not indicated. Nature will favor a higher reproductive rate if production conditions permit, and man does not intervene. However, it is important to remember that many of the problems in reproduction are associated with lack of size and development, which is related to the high nutrient demands for fiber production. Thus, producers may wish to plan their selection programs with reproduction in mind. In general, they need to select to maximize fiber production and plan to feed their animals for size and reproduction, or alternately, relax somewhat the emphasis on fiber production in order that the goats may survive and reproduce on a lower level of management or resource inputs (Easy Care Animals). It is the writer's belief that more producers (under arid range conditions) should pursue this latter approach. This will almost certainly be the case if it becomes necessary for the industry to survive at lower mohair prices. Since producers seldom know what the future holds, they may wish to pursue breeding practices consistent with their estimate of future conditions, or choose some intermediate position or course of action. Selection practices which have the greatest negative impact on reproduction are covering of the body, especially in the face, and a high grease content of the fleece. Excess oil in the fleece requires a great deal of feed energy to produce. Beyond these two items which have a specific relationship to reproduction, the level of fiber production may need to be relaxed somewhat since at time of nutritional stress these two nutrient demands (reproduction and fiber production) are in direct competition. Only lactation has been shown to take precedence over fiber production. At high levels of nutrition, which infrequently occurs under range conditions, the competition between fiber growth and body development is much less evident and may not present a problem.

The term flushing will be recognized and is at times used by producers. It implies a period of feeding immediately prior to and during breeding to improve the reproductive rate. Angora does will respond to flushing, but whether it is a desirable practice will depend on other factors. Flushing is generally used to increase the twinning rate, which may not, in fact, be desirable under range conditions. Another potential response to the flushing is that thin or small does will be induced to breed and settle when they may not have otherwise done so. This provides the most favorable response to flushing. However, it can be shown that many does which are induced to breed as a result of feeding at mating, will often lose their kids through abortion or death loss of the kids unless forage conditions improve or unless feeding is continued. For best results from flushing, feeding should be initiated sufficiently in advance of the breeding season that an improvement in weight or condition can be obtained. Hand feeding of corn or 20% range cubes at 0.5 to 1.0 lb daily might be suggested. Hand feeding may disrupt normal feeding or grazing patterns for the does. For this reason the use of blocks (high protein blocks if used on dry ranges), complete feeds (i.e., sun-cured alfalfa pellets), or salt limited supplements may be alternatives.

One suggested approach might be to sort the does at or prior to the breeding season into a strong group and a weaker or thinner group, which might not otherwise be expected to breed. Only the latter should be placed on feed, and this group could then be continued on feed for a longer period of time. The level of feeding, and how long they should be on feed, must depend on condition of the range and of the does involved.

Another suggested approach to enhance reproductive efficiency is to make use of the male effect. It was pointed out earlier that within season males provide the normal stimulus to start the females cycling. If done in a controlled manner, this can have the effect of providing a high degree of synchronization of mating and kidding. This may or may not be desirable. Synchronized mating may result in overuse of males and thus have an undesirable effect. If the animals are to be kidded in the barn, it may be desirable to get the job over with quickly or to have kidding occur more slowly in order that better care can be provided. If the does are to be kidded "on the range", synchronized kidding in times of bad weather could be disastrous, whereas if kidding occurred in good weather, the reverse would be true.

Irrespective of the question of synchronization, it has been shown that ovulation rate will be higher (more twinning) at the second, as compared to the first estrus (Figure 4-7). This can be made to occur as a result of male synchronization. If a sterile male is placed with the does for not less than 10, or not more than 20 days, followed by the release of the fertile males, all matings should occur on the second cycle. This practice has not been widely used by the industry, and for it to work a number of conditions must have been met. For instance, the does must not have been around males for a few months prior to the breeding season, but conditions must otherwise be suitable for breeding (male stimulation) to occur. Also conditions should be such that the overall kid crop would be benefitted by an increase in twinning rate.

**New or High Technology and Reproduction in Goats**

Although not necessarily new, there is technology that may be regarded as new or "high tech" to the producer. Some practices which might fit into this category are fertility testing of the males, artificial insemination (AI), the use of frozen semen, use of hormones to control or stimulate reproduction, embryo transfer and ultrasonic pregnancy diagnosis. All of these practices can be successfully carried out with Angora goats at the present time, but space does not permit a detailed treatment of each of these practices in this discussion. Most of them could, with the possible exception of embryo transfer, be carried out at the producer level. However, it is the writers opinion that cost or the cost-benefit ratio of these practices preclude the extensive use of any of these practices with goats at the commercial level. In many cases, the cost of these practices exceed the value of the animal. Individual producers may disagree with this assessment and the stud or purebred flocks and the export interest may justify a different conclusion. Of the various practices listed, only

AI has found widespread use in the livestock industry, especially the commercial industry, and this is in dairy cattle which can support a substantially higher cost than Angora goats. Ultrasonic pregnancy diagnosis or detection of ewes or does carrying twins is the most economical practice to apply and is finding some use by the sheep industry. This practice will also work well with goats, but it is often possible to look at freshly shorn does and determine which will kid.

It is not unusual to receive inquiries about the possibility of using hormones to increase the reproductive rate of Angora goats or to stimulate out of season breeding. It is possible to do this, but it is far from being practical on commercial (non-pedigreed) animals. One of the problems in stimulating out of season breeding, is that with the,Angora, both the male and the female are seasonal. There is a great deal of research and information on control of reproduction in the female, but very little on the male, as the Angora is about the only domestic animal in which there would be a need. Although the information is available to synchronize or stimulate reproduction in the female, the drugs required are not generally available to the U.S. producer and if they were, the cost would be prohibitive in terms of their commercial value. For these reasons this approach has not been extensively used. Still, there will be individuals, specifically those interested in artificial insemination or embryo transfer, who may wish to control reproduction in the female. The first step to do this is to synchronize ovulation or estrus. This is accomplished by use of progesterone or synthetic progestin (materials having progesterone properties). For an individual or a few animals, this might be accomplished by giving daily injections of 10 mg. of progesterone but, it is most commonly accomplished by use of intravaginal suppositories (pessaries or CIDR devices) or subcutaneous implants of silastic material with imbedded progestin. This use of progesterone is necessary for both the cycling and the non-cycling animal in order to have all animals in a known physiological state and to insure that they respond with an active estrus. Typically, the progesterone exposure periods are for 14 days, although it can vary from this for one or two days. During the breeding season, the animals should cycle in 2-3 days following termination of progesterone treatment. However, to insure ovulation or to increase the ovulation rate (especially for embryo transfer), some type of gonadotrophin administration should be considered. This most typically is PMSG (pregnant mare serum gonadotrophin) at levels up to 500 I.U., FSH (follicle stimulating hormone) or HCG (human chorionic gonadotrophin) or combination of these. HCG used alone does not give satisfactory results. These materials can be purchased, but they are expensive. A lower level of PMSG is usually recommended for synchronized AI matings to insure a better response.

Artificial insemination could be carried out on any farm or in any flock, but total costs would likely run to several dollars per head. The first problem is to identify a sire with sufficient merit or superiority over others available to justify the expense. Following this, the male must be trained to the extent that semen can be collected by means of an artificial vagina. Electro-ejaculation can be utilized but it is less satisfactory. The time required to train males to serve an artificial vagina can vary from a few minutes (for gentle, high libido males) to infinity (some males never adapt to this type of semen collection). If a producer is prepared to use fresh semen, the next task is to identify the doe in estrus and carry out insemination. To identify the doe in estrus requires the use of a sterile (vasectomized) male to check for does in estrus twice per day. This will largely preclude extensive use of this practice in commercial flocks or on any substantial scale. Fixed time insemination (approximately 56 hours after progesterone removal) might be used with less favorable results.

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# CHAPTER 5

## NUTRITION AND FEEDING

Both magic and mystery are sometimes attributed to the goat in respect to nutrition or feeding habits. Actually the animal is merely a small ruminant, and except for size, it functions much as any other ruminant. The same basic principles of nutrition apply to the goat as other ruminant species, and these principles will be reviewed only briefly in this discussion. However, the goat in general, and especially the Angora, does have some unique aspects which warrant mention. Many perceive the goat to be a scavenging or "tin can" eating animal which can survive on almost anything. By contrast research has shown the Angora to have a high nutritive requirement relative to other domestic ruminants. At the same time it has been reported that the goat has a superior ability to digest poor quality forages. Likewise different breeds of goats have been reported to have a low or a high requirement for protein. Clearly some of these contradictions need to be resolved before a logical treatment of the subject on the nutrition of the goat can proceed.

The apparent controversy relating to the digestive ability of the goat appears to be explainable. The ability of a ruminant species to digest forages is greatly influenced by the time these materials remain in the digestive tract. In animals with a large rumen capacity, such as a beef cow, the feedstuffs remains in the tract for a longer period of time than some other animals such as a deer and certain types of goats which have a low volume of the digestive system. The latter apparently make up for this by being more selective grazers thus consuming a higher quality diet and in some cases passing ingested material through the digestive system at a more rapid rate. Thus they often consume a larger amount of material relative to body weight (Huston, 1978). This can have the effect of showing the animal to have a reduced ability to digest structural carbohydrates, but to work to the animal's overall advantage.

Goats are known to be both more able and more willing than some species to select and consume a wider variety of material and to select those plants or plant parts having higher nutritive value. Problems tend to be encountered when the ability of the goat to be selective is restricted such as a monoculture or a restricted variety of plant species which does not meet their nutrient requirement. The apparent inconsistency relating to protein requirements appears to be explained in that at maintenance or subsistence levels goats appear to be able to maximize the recycling of nitrogen (urea or ammonia) and thus to survive on a low level of protein. However, the protein requirements for production of meat, milk or fiber does not appear to be less for the goat than for other species and may actually be higher. This is almost certainly true of the Angora. The apparent ability of the goat to recycle nitrogen (Cronje, 1992) suggests that this animal may have a superior ability to utilize nonprotein nitrogen. Some studies suggest that this is the case, but this is not currently being exploited by the industry. Other unique aspects of the Angora have to do with the demands associated with fiber production. The Angora goat is an animal breeding success story in that they produce a high level of fiber relative to body size and feed consumed. Selection for high fiber production has certainly elevated their requirements for protein, energy, and possibly other nutrients. On a world basis, large differences exist within the Angora in inherent levels of mohair production. Thus, one would expect differences in nutrient requirements related to different levels of fiber production. Observations strongly suggest that the goats found in some areas such as Turkey and Lesotho normally receive a lower quality of ration, but at the same time have a lower genetic potential. Apparently the Angora found in the U.S. has the highest genetic potential for fiber production and the problems rising from this. Most of the discussion to follow will be based on data and experience obtained under Texas conditions. Although the Angora goats in Texas may well have unusually high nutritive requirements, they are often run on ranges which after long use by goats do not have the quality or nutrient content to meet their requirements. The result is a goat which is almost perennially undernourished unless they are appropriately supplemented. It has been estimated that the normal weight for mature Angora does is on the order of 85 pounds, whereas, many does found in market channels tend to weigh on the order of 65 pounds. It may be argued that these are culled animals, and that herd does are larger, but it is obvious that only a small percentage of the does ever reach optimum size. The first result of under-development is reduced reproductive performance. In addition death losses among these underdeveloped does may increase due to nutritional, parasitic or climatic stress. Although reduced by poor nutrition, fiber production will continue until the animal dies of starvation and the quality, or more properly fineness, of the fiber will improve under conditions of poor nutrition. However, this statement applies to diameter only as length and weight will be reduced and the fleece will often be matted and difficult to shear or process.

## Required Nutrients

The type of nutrients required by all animals is essentially the same and these are energy (carbohydrates, fat), protein, minerals, vitamins and water. Although fat is shown here as an energy source there does appear to be a limited requirement for fat itself, but this is not considered to represent a problem. These nutrients provide the raw materials or resources for body maintenance, muscular activity, growth (meat production), reproduction as well as milk and fiber production. Nutrients interact to serve different functions which will be reviewed briefly.

**Energy** is obtained from dietary carbohydrates (sugars, starch and fiber) and fats. The Angora goat is a ruminant with a large microbial population in the rumen. The microbial population requires carbohydrates for growth. They ferment both fibrous and grain based diets into compounds called volatile fatty acids (acetate, propionate and butyrate) that are readily absorbed through the rumen wall to be utilized by the host animal for energy. Grain based diets are more readily fermented in the rumen than fibrous based diets and thus tend to produce more energy. The fiber in immature plants is more readily fermented than mature plants. Thus, most grazing animals go through an annual cycle of weight loss and weight gain associated with season-based changes in maturity and availability of forages. They exhibit a cycle of depositing excess energy in the form of body fat during the spring season and gradually mobilize their stored fat during the fall and winter when feed supplies are scarce. Unfortunately, Angora goats store relatively little body fat, and for this reason the Angora is more susceptible to nutritional stress at the time of unfavorable feed conditions. This does not mean that Angoras will not fatten, but that due to their high nutrient requirements a higher quality diet is required to permit fat deposition.

Fats are a concentrated form of energy (2¼ times energy of carbohydrates) and therefore, adding fats to the ration is a very efficient way of increasing caloric density of the diet; however, there are some adverse affects of fat addition. Polyunsaturated fatty acids are apparently inhibitory to microbial growth, resulting in reduced fermentation of fiber in the rumen. Not more than 3 to 5% unprotected dietary fat appears to be well tolerated by ruminal micro-organisms. Whole cottonseed (20% fat) has been used successfully as an energy supplement for Angora goats, but high levels may cause a reduction in fiber digestibility. It is recommended that whole cottonseed be limited to no more than ¼ the total diet.

**Protein** is the nutrient which might be considered the second most limiting for both fiber and milk production in the Angora goat. Proteins are made up of amino acids. The animal's tissue level requirement is for individual amino acids. The two main sources of amino acid supplies to the animal are; microbial protein synthesized in the rumen and dietary proteins and amino acids which escape ruminal degradation. If energy is not limiting, rumen micro-organisms appear to provide sufficient protein for maintenance, slow growth, and early pregnancy. Animal fibers (wool, mohair, etc.) are pure protein. Thus, a high-producing Angora goat has a high protein requirement, compared to other ruminant species, and will respond to increased dietary protein with increasing fiber production up to 20% of the ration. However, it may not always be desirable to feed for maximum fiber production. Thus, the choice of level of protein in the ration or in the supplement is an economic as well as nutritional consideration. Complete rations are seldom formulated to contain more than 16% protein, but in commercial practice goats are seldom fed complete rations. Most feeding is in the form of energy or protein fed as a supplement to range forage, and under these conditions, protein concentrates of 20 to 40% are generally used.

The kind or quality of protein consumed by ruminants, including the Angora, is not considered to be particularly important. This is a general statement to which there are some exceptions. The very young kid may function as a pre-ruminant and thus respond to good quality protein. Animal fibers such as mohair contain a higher percent of the sulfur containing amino acids (methionine and cystine) than other body tissues, and the availability of these amino acids at the tissue level frequently limit fiber production. Unfortunately, if these are fed in the ration they are normally broken down in the rumen and do not reach the tissue level where they might be directly used as building blocks for fiber synthesis. Mohair production appears to be dependent on and limited by the rate of synthesis of these sulfur containing amino acids. It is important that goat rations contain an adequate level of available sulfur. The term available is important. In most cases browse makes up an important part of the diet of the goat. Many of these plants contain tannic acid, or other compounds such as lignin, which tie up much of the protein, rendering it somewhat indigestible. The result may be not only a protein insufficiency, but a deficiency of sulfur as well if the sulfur is unavailable. If goats are fed nonprotein nitrogen (such as urea) then the need for sulfur for protein or fiber synthesis is obviously important. The recommended level of sulfur is usually expressed as a ratio of nitrogen to sulfur. This is normally stated as something on the order of 15:1, but there is reason to believe this should be no higher than 12:1 for fiber producing animals. In the case of goat feeds it should be this high or above. Qi, *et al*. (1992), estimated that the total ration should contain .23-.29% sulfur. The preferred source of sulfur would likely be in the form of s-containing amino acids, elemental sulfur or in the sulfate form such as ammonium,potassium, calcium or sodium sulfate. In the normal scheme, amino acids presented at the tissue level for meat, milk and fiber production are derived mainly from microbial protein synthesized in the rumen and dietary protein that has escaped degradation in the rumen. Production efficiency would potentially be improved if a significant proportion of these feed proteins could get through the rumen without being degraded. This would be especially true with respect to mohair production if the protein feeds used were made up of high quality protein, rich in limiting amino acids such as methionine. It is more important that these sulfur containing amino acids are fed in a form which prevents rumen degradation. It has been shown that fiber production (wool or mohair) can be increased by as much as 20% through the use of rumen by-pass proteins (see Figure 5-1). At present there are methods of coating amino acids or protecting proteins to increase the amount which escape ruminal degradation. Although this can be done on a laboratory scale, it has not yet been used extensively in practice. Some proteins found in nature tend to be slowly digestible, and a portion of these tend to get through the rumen intact. This is true of some of the browse (tannic acid containing forages) species utilized by goats with the result that the browsing goat may produce more mohair than a non-browser. Unfortunately many of these proteins are poorly digested and thus may not become available even past the rumen. The end result is that some browse species or protein supplements may stimulate fiber production, without beneficially affecting other body functions. Thus it may not be desirable to attempt to stimulate additional fiber production by this route unless overall nutrition is satisfactory. Some protein concentrates (blood meal, fish meal, meat meal or feather meal) are poorly or slowly digestible and thus have some rumen escape properties. Fish meal not only has escape value, but is also high in the sulfur containing amino acids and has been shown to be useful to increase fiber production. Since a small amount of readily soluble protein is necessary for microbial digestion of fibrous materials in the rumen it may often be desirable to provide at least a low level of readily available protein to stimulate ruminal action even when protein is available
from other sources such as browse. Another option to increase fiber production can apparently result from a high level of protein feeding. This would not only supply any protein or amino acid needs, but may result in some spill over from the rumen thus providing a form of ruminal by-pass.

Although a response from feeding a high level of protein or a high level of bypass protein can be expected it may not always be economic. In general it is more financially remunerative to use the most economical source of natural protein. Where protein supplements are comparable in price a mixed protein supplement might be preferable. There appears to be an opportunity to make greater use of non-protein nitrogen (NPN) with goats than is being done at the present time. This statement is based on economic consideration and it is not meant to imply that the animals will actually do better on NPN sources.

**Vitamins** are a group of compounds which are required in minor amounts. Generally these are grouped as the fat soluble vitamins (A, D, E and K) or the water soluble vitamins (C and the B complex group). Ruminants are thought to be able to synthesize all except the fat soluble vitamins. Vitamin D is produced by the action of the sunlight on plant or animal tissues. A and E are widely present in plant or forage materials. Thus, vitamin deficiencies are unlikely with goats under normal grazing conditions. Vitamin A is the one most likely to prove limiting, but this will occur only under extreme conditions such as in young animals which have not experienced a growing season when green forage was available. Because of the remote possibility of a deficiency it is probably advisable to include Vitamin A in feed supplements for goats at the rate of 5000 I.U. or more per pound of ration. The cost is normally negligible. Where producers have knowledge of, or suspect that, a Vitamin A deficiency exists or where past history has shown a response to this nutrient, injections of Vitamin A would provide a quick response. A limited number of tests under Texas range conditions have not shown a response to injections of Vitamin A.

**Minerals** are required by all animal species, and certainly the angora goat is no exception. A number of mineral elements are required in relatively small amounts and deficiencies of almost any mineral can be serious. It is a mistake in management to allow mineral deficiencies to limit production since these can usually be provided at low cost. Very little research has been conducted on the mineral requirements of Angora goats, and even if this was not the case, results would tend to be area specific. The minerals which are considered essential for animals fall into two categories known as "macrominerals" (calcium, phosphorus, potassium, etc.) or those required in relatively large amounts and "microminerals" which are required in small amounts. There are a large number in the latter class which are considered essential. These are often required in such small amounts that they are difficult to study. Micromineral requirements are too complex to attempt to discuss at this point. Generally producers should be concerned about the minor elements only if they live in an area which is known to be low in specific elements such as iodine, selenium, etc. On the other hand many producers will choose to use a broad spectrum trace mineral mixture as a form of insurance. A large amount of research or experience might be required to conclusively confirm or deny that a response to some mineral elements might be obtained. When goats are managed on range or pasture the only major (macromineral) element with much likelihood of being deficient is phosphorus, but goats, like sheep, appear to have the ability to conserve phosphorus. A limited amount of research indicates that they are less likely to respond to supplemental phosphorus than are cattle. However, most dry range forages, especially grasses, are at least borderline in their phosphorus content for goats. When this is compounded with soil or moisture conditions which contribute to low phosphorus content, a deficiency of phosphorus for Angora is a real possibility or even probability. Thus provision of supplemental phosphorus could be recommended under many conditions. Many browse plants are high in mineral content and this, compounded by a habit of highly selective grazing, provides goats with some protection against mineral deficiencies. Fortunately most protein supplements contain a significant level of phosphorus or if this is not the case phosphorus should be added in the formulation of supplements. Still the provision of additional phosphorus during the non-growing season (for forage) should be considered good insurance. Two common sources of phosphorus are bonemeal and di- or monocalcium phosphate.

The other mineral that might deserve special mention in connection with Angora goat nutrition is that of sulfur. This was discussed earlier in connection with protein. However, it is probably desirable that any mineral fed to goats should contain sulfur.

Although information on the mineral requirements of the Angora goat is sketchy there is little evidence that mineral deficiency is a major problem or explains poor performance with this animal. In fact, it would be good news if we could identify a mineral element which when offered to the goat would markedly improve performance.

**Water** is also a critical nutrient which should not be ignored. Goats can live with low intakes of water, especially when consuming green forage. However, they perform better when given access to clean and safe water. Still it may occasionally be possible or desirable to run goats in areas where water supply is restricted. This can be more easily done with goats than with other species such as cattle. It may be possible to run non-lactating goats on green forage without water, and even for lactating goats hauling water may not be a major chore. Goats are often less willing to drink from foul or contaminated water sources such as earthen tanks. When Angora goats are forced to drink from earthen tanks they should be observed carefully for bogging. They are more likely to become trapped than other species especially when they have a full clip of mohair which may become weighted with mud or water.

**Feeding Practices**

This discussion will deal largely with the commercial goat which is run under range or pasture conditions to the maximum extent possible. This is the only basis on which the industry is likely to persist over a long period. Alternatives to maximizing the use of forage consist of heavy feeding on pasture or confining to dry lot. The latter may be practiced during confinement kidding, developing show animals, performance recording, research purposes, or on those rare occasions in which mohair or breeding stock is sufficiently high in price to warrant intensification. It will be assumed that these latter situations represent a small part of the industry, and that the major concern is with supplementing the grazing animal to optimize or maximize performance or income.

An effective or efficient job of supplemental feeding requires (a) a knowledge or awareness of the animal's needs and (b) an estimate of what the animal is obtaining from the range. The difference between these represent the kind and amount of feed which should ideally be provided as a supplement. However, in these cases the availability of the appropriate feedstuffs, methods of administration, and lastly cost, may impose limitations on the ability to feed according to need.

Some information relating to requirements is presented in Table 5-1. These data were adapted from a report by Huston, Shelton and Ellis (1971), and should be considered only as guidelines. Observations by the author suggest that under diverse conditions the animal's requirements may differ significantly from those reported. For instance animals with a low genetic capability for fiber production may do well on rations which do not meet the indicated needs. On the other hand animals which have an unusually high genetic potential for fiber production, especially those which produce an oily or greasy fleece and which may have suffered from "ill thrift" early in life will not develop properly even when provided with the indicated requirements. Thus producers should utilize experience in feeding under a given situation (i.e., type of animal or type of range) and condition of the animals as additional guides.

A knowledge of what the animal is obtaining from the range or pasture is difficult to attain. This is generally possible only in the case of animals grazing a monoculture or a single plant species (such as cereal grains) in a uniform stage of growth. Under range conditions (which is normally characterized by numerous plant species) this is made difficult by the tendency of the goat to be a highly selective grazer. This means that the animal may not only be selective between plant species, but of different plant parts (i.e., new growth, seed heads, etc.) of the same plant species. Although the goats do not understand nutrition, there is a distinct tendency for them to choose those forages which are more nutritious or more useful to them. Producers should attempt to become familiar with plant species found on their range, their preference order by the goat and their nutritive qualities. It is not feasible to attempt to deal with this subject in detail in this discussion because of the extreme variety of plant species in different areas where Angora goats are grown. For this reason it will be treated by broad classes of plant species such as grasses, forbs and browse or woody species.

**Grass** is usually the dominant forage in grazing lands and may be the most important for cattle or sheep, but this should not generally be true for goats since they are often included in the grazing program because of their tendency to utilize forbs or browse. Goats readily, and heavily, utilize grasses when their preference order or food value is above that of the other plant species available. In their early growth stages grasses are usually high in nutritional value (adequate protein and high digestibility) but become relatively poor feed for the goat as they mature. The vegetative portion of many mature grasses are almost totally unutilized by goats if other choices exist. If forced to consume only mature dry grasses over a long period of time Angora goats may not survive, and certainly will not perform satisfactorily. Survival can be ensured by protein, mineral (phosphorus) and vitamin (A) supplementation. However, a high level of energy supplementation is required in order for them to perform well. Grasses only occasionally cause problems of toxicity, but some species such as klein grass (*Panicum coloratum*) and winter cereals such as oats or wheat can cause photosensitization. Goats should not graze extensively on klein grass. Producers should freely use small grain for grazing when available,but the animals should be observed closely for evidence of photosensitization. Goats prefer to graze at a higher level from the ground than sheep, and this gives them some advantage in respect to parasitism. However, this is not always true since the superior nutritive value of regrowth or new growth forage near ground level may encourage them to alter their grazing habit and thus may increase the ingestion of parasite larva. This is especially true of prostrate growing warm season grasses which are often low in feeding value. Bermuda grass (*Cynodon dactylon*) is a prime example of this, but other species such as curly mesquite (*Hilaria belangeri*) may be put into the same category. It is difficult, and probably undesirable, to run goats in areas where these types of plants are the only or predominant forage resources. Goats often selectively forage on seed heads of grass. This would generally represent good feed quality, but may adversely affect reseeding of desirable grass species. Goats should rarely be included in the grazing system in pure stands of grass, but may be utilized effectively if forbs or browse are present as invading species and the goats can be made to utilize or control these. There may be times when goats or mohair are sufficiently valuable that it will be desirable or economically possible to produce them on cultivated or established pastures consisting largely of grass species.

**Browse** is a term used to refer to the woody shrubs or trees. This is an important forage source for the goat in that goats are normally kept in areas where browse is available to be controlled or utilized. The concepts of control or utilization can be quite different or can grade into each other. Control implies using goats to remove or suppress browse or woody species with a view that the land can be made more productive or made more suitable for other animal species such as sheep or cattle. If this is the primary goal, Spanish goats may prove more useful than Angoras because they are somewhat more vigorous browsers, and may require less facilities or management skills. Utilization may be thought of as management for sustained production from browse species or to balance competition between animal or plant species to maintain productivity of the range. Decisions as to these goals are important in choice of stocking rates, combination of livestock, and perhaps grazing management, but are only indirectly related to the question of nutrition. Browse species are highly variable in respect to palatability, nutritive qualities and toxicity. Goats and browse species tend to be concentrated in the more arid regions as contrasted to forests or cultivated farmland in temperate zones. Many plant species which develop in arid environments possess properties (stickers or spines) or constituents (tannins, resins, etc.) which tend to reduce animal use and/or moisture loss. But in some complex vegetative areas highly palatable and highly digestible species may be intermingled with others which are either toxic or totally unacceptable by the animal. Some species are very valuable to the goat in small amounts, but become toxic when consumed in large amounts.

A typical example of this in Southwest Texas is the plant known as guajillo (*Acacia berlandieri*). Some of the most commonly utilized browse plants such as various species of oak, are toxic under some conditions such as when they constitute the sole diet. In the case of the oak, it is the high tannic acid content which may cause problems. This is infrequently observed with goats, but can be a severe problem with cattle at certain stages of growth. As a group, browse plants are highly variable in their nutritive value. Leguminous browse plants such as the acacia and prosophis (mesquite) are usually high in protein but may present problems in respect to palatability and digestibility. Thus, each plant species must be evaluated on its own merits. For instance, oak species are relatively low in food value for most of the season but because of their prevalence they represent an important food source for goats. Information relative to plant species and toxicity can be found in reports by James, et al (1980), Hoffman and Ragsdale (1962), Gould (1975) and Rowell (Undated). Some data on the nutritive values of some range plants are reported by Huston, et al. (1981). Taylor (1992) discussed some desirable forbs. An attempt has been made to characterize some potential forage species available to Angora goats in Texas (Table 5-2). It will be noted that there are some marked differences between plant species and plant types. One of the most important considerations to remember is that for most plants early or new growth is much higher in nutrient value than more mature plant parts. There are possible exceptions to this with some browse species in that the tannic acid content of some plants may decrease with maturity and thus the digestibility or palatability may improve.

**Forbs**, sometimes called weeds, is a general term used to characterize broadleaf plants which do not fit into the other two groups (grass or browse). Forbs may be annual, bi-annual or perennial. If they are palatable and nontoxic, forbs generally represent some of the more nutritious forage available to goats. In mixed species grazing, goats would generally be in direct competition with both sheep and deer for these feed sources. In the early stages of growth, many forbs have high protein content (up to 20%) and digestibility (up to 70%). Forbs tend to retain their feeding value into maturity better than do grasses. Leguminous plants such as alfalfas and clovers when found in the range are classified as forbs. It might be noted that goats do not search out legumes such as alfalfa and clover, and often preferentially consume grasses or browse. Some examples of high quality forbs for goats in Texas are tallow weed (*Plantago hookeriana*) and filaree (*Erodium texanum*). No doubt similar plants exist in other grazing areas. The above comments appear to suggest that goats should be produced on a diet of forbs, but life is not so simple. As mentioned earlier, many such plants are either toxic or are unpalatable due to taste (bitterweed or broomweed) or to the presence of spines on the leaves (thistles). Goats appear to be more able to selectively graze only plants or plant parts that are safe than are sheep and cattle. Still problems of toxicity occur. The most serious limitation to utilization of forbs by goats is one of availability of desirable forbs. Many are seasonal (fall or spring) and grow only if moisture is adequate at this time. Also it is almost inescapable that grazing, especially continuous grazing, will adversely affect the more palatable species at the expense of others. It is very difficult to manage a range to favor plant species which make up a small part of the total plant community or are sporadic in their occurrence and which are utilized by one or more animal species. This can be approached through variation of stocking rate, combinations of livestock and rotation systems. In arid grazing lands stocking rates are critical and combination grazing (more than one animal species) and rotation grazing generally yield favorable results. Goats are often not included in the grazing program to utilize forbs if one or both sheep and deer are present as both these utilize forbs extensively. Deer are generally not under man's control and may not provide a manageable option. Sheep may or may not be better income producers than goats depending on the price received for lamb, wool or mohair and the suitability of the resources to produce good market lambs.

**Supplemental Feeding**

The well bred and high producing Angora goat will benefit from some form of supplemental feeding under many or most conditions. The nature, level and manner of supplemental feeding will be highly variable depending on forage availability and the economic outlook. The individual or national herd may be generally divided into the following classes:

Developing young breeding stock (kids and yearlings),
Breeding does,
Castrates (muttons) run for fiber production,
Breeding males.

It will be obvious to readers that the level of feeding and care will vary widely depending on the age or sex class involved. In the case of breeding does the needs would be highly variable depending on the stage of pregnancy and lactation. The requirements for lactation are greatest, but late gestation is critical because of the threat of abortion.

Decisions concerning supplemental feeding may be based on experience in a given area or on attempts at a scientific approach. Of the two, experience may well be the best teacher or the most useful, but experience may take a lifetime to acquire and is difficult to transfer from person to person or to another set of conditions. For these reasons the scientific approach is the only one which can be dealt with in terms of numbers. Also the two combined may contribute to improved production over either used alone. As stated earlier the scientific approach would consist of estimating the requirements (see Table 5-1), estimating what the animal is getting from the range (Tables 5-2) with the difference between these being that which is needed in the way of supplemental feeding. The next step consists of determining the most economical way of meeting these needs, and to determine if the expected response will equal or exceed the costs involved. Composition data for some common feedstuffs are shown in Table 5-3. Feeding to maintain or increase body weight or to improve mohair production or reproduction may or may not be economic and would be highly dependent on the ratio of feed cost to the value of the increased production expected. It would be highly desirable that feed response ratios could be provided. Unfortunately information is not available to provide a good basis for doing this. Limited research indicates that the minimum amount of feed required to produce a pound of mohair is on the order of 40-50 pounds of a high quality ration, and generally this ratio would be expected only for high producing animals fed to permit them to perform satisfactorily. Under a wider range of conditions the response ratio would likely be less favorable. With feed and mohair prices in effect at this writing, feeding for mohair alone would not be economically feasible and this would often be the case. If specific limiting nutrients, especially those required in smaller amounts, can be identified and provided as a supplement a more favorable response would be expected. In essentially all cases in which an increase in mohair production can be expected some body weight advantage (more gain or less loss) will also occur. This weight advantage can have an effect of increased sale weight, perhaps increased mohair production in subsequent seasons, better survival in times of stress such as cold weather "off-shear losses" and more especially, improved reproduction. Thus, feed resources would be better invested at those occasions in which the body weight as well as mohair response would be expected. In most cases this will be the breeding female either during their development phase or during the breeding and kidding season.

**Feeding Wethers**

Castrates which would be run only for fiber production would be expected to receive the lowest level of supplemental feeding. This would generally be limited to providing protein and minerals (phosphorus) as needed to make up for deficiencies in these elements and providing energy feeds or concentrate grains only to maintain adequate size and vigor to prevent death losses. More specifically this would be on the order of .20 to .25 lbs. of a protein concentrate (25%+ CP) when the animals are living on dry grass or similar low value forage. This may be provided on an infrequent basis, such as 2 or 3 times per week, or provided as a lick or block. A limited amount of protein and energy may stimulate improved fiber digestion, and thus provide a benefit over and above the nutrients provided. If a higher level of energy feeding becomes necessary this should be done based on the condition of the animal, and would more likely be necessary or desirable for the young growing wether. It will often prove advisable to sell (following shearing) aged wethers when a significant amount of feeding becomes necessary. The 20% cube is a good compromise type feed as both energy and protein are provided, but either corn or a higher protein supplement (approximately 30%) may work as well. Producers who use significant amount of range cubes may benefit from formulating their own cube, and obtaining competitive bids. Commercial formulations are legally required to provide only the protein content on the label, and competition may encourage the use of lower value ingredients in the formulation. Excess protein will also serve as an energy source, but if used in this manner it will usually be more expensive than feed grains. Feed grains, such as corn, are a good energy supplement but will usually be below the optimum level of protein. Since supplemental protein can be stored within the animal system for several days it is quite feasible to periodically, for instance once per week, substitute a higher protein concentrate for the corn. Whole cottonseed is currently being used by some producers as it provides both protein and energy. Since it is digested slowly, this material works well for infrequent feeding.

**Feeding Breeding Males**

Although most producers will find this difficult to do, selection of breeding males should preferably be made from among those which do well under normal production conditions (i.e., minimal or limited feeding). This will reduce the tendency to develop a population of animals which are poorly adapted to the production conditions under which they are expected to perform. However, once they have been selected for breeding they should be fed well to maintain them in good condition to maintain mating vigor. This would require almost routine protein and energy supplementation, and in times of stress or poor conditions, especially before the breeding season, they may benefit from being fed a complete ration containing up to 15% protein. Although selection under production conditions is advisable, few producers of sale bucks will actually do this since the animals will not present a good appearance at sale time. Many feeding regimes can be used to correct this. The approximate ration used in the Angora goat performance testing program is as follows:

| | |
|---|---|
| ground alfalfa 30%; | cottonseed hulls 30%; |
| cottonseed meal 16%; | molasses 5.5%; |
| sorghum grain or corn 17%; | T.M. salt .5%; |
| calcium carbonate .5%; | ammonium chloride .5%; |
| Vitamin A, 2000 I.U./lb; | Rumesin, 15 gm./ton. |

Many producers use a ration with a lower protein content than that used with the performance testing program in order to produce a finer fleece. The above ration was not designed to maximize performance, but to develop the animal and minimize the tendency to become overly fat.

**Developing Young Breeding Stock**

Under commercial conditions developing the young breeding stock, especially the doe, is one of the important phases of successful Angora goat production. This might start pre-weaning by creep feeding, but it is difficult to design a creep feeder for goats which will exclude the does. For this reason this practice is not widely used. If the goats are doing very poorly it may be better to feed the entire herd or if the kids are as much as three and one-half or four months old they might be weaned with the result that they can be independently fed according to their own needs. Thus development of future breeding stock usually starts with weaning at four to six months of age. Weaning is a very critical time for Angora kids, and significant death losses can be encountered. The kids would normally be weaned in late summer when feed conditions are often poor and internal and external parasites are likely to be a problem. Except under the best of conditions, producers should practice some feeding at this time (see Table 5-4). A good practice is to hold them in small traps or pastures where they can be fed and watch them for a period of time following shearing (protection from rain). If this is done they may need to be fed a complete ration or a (salt) limited protein and energy source. Producers will generally find it necessary or desirable to formulate their own salt limited supplement. A typical ration of this type might be:

| | |
|---|---|
| sorghum grain or corn 53%; | cottonseed meal 18%; |
| salt 20%; | dehydrated alfalfa 5%; |
| di- or mono- calcium phosphate 2%; | Vitamin A, 5000 I.U. per lb.; |
| urea (or ammonium sulfate) 2%. | |

The salt level may be varied to control intake. Ingredients and levels may be changed as conditions dictate. This ration contains approximately 18.5% protein as fed or approximately 22% on a salt free basis.

As an alternative to feeding on pasture, some producers confine the weaned kids to drylot for a period of time. This type of intense management practice following weaning was common during the early 80's when prices for mohair and breeding stock were favorable. Unfortunately, the concentration of animals into feed lots and traps led to severe outbreaks of coccidiosis for which the young kid has little resistance and resulted in heavy death losses. Fortunately, this also led to the discovery that the incorporation of a low level coccidiostat (especially rumensin) into the feed gave excellent control of coccidiosis. Rumesin was used at the level of 15 grams per ton in a complete ration, or double this level in supplements. A number of other effective coccidiostats are available. Presently, it is rare that producers practice confinement feeding of weaned kids.

**Breeding Females**

The breeding female constitutes a major part of the population and a very important one so far as the well being of the industry is concerned. If the does were not used for breeding, feeding recommendations would be essentially the same as for wethers. However, it will be assumed that essentially all does past one year will be used for breeding or that attempts will be made to breed them.

Generally, the breeding doe is busy carrying out reproductive process (mating, gestation, lactation) throughout most of the year and the only time of the year in which they may not be directly concerned with reproduction is that period of time (approximately 2 months) between weaning of one kid crop and the initiation of breeding for the next kid crop. If flushing is to be practiced this would be the time of the year which this is to be done, as discussed in Chapter 4. Angora goats respond well to flushing. Feeding at breeding (flushing) may do one of two things. One of these is to cause some young, underweight does to breed that might not otherwise do so or it might increase the ovulation and twinning rate of more mature does. Nutritional management at breeding should preferably be a part of the overall management program. If adequate forage is available, but it is of low quality, low level protein supplementation (one-fourth to one-third pound per day) may improve the utilization of this type of forage and give a favorable response. If forage is in short supply or especially poor quality or the does are in poor condition then energy supplementation (one-half to one pound daily) would be required to make much change over a short period of time as defined as flushing. This may be hand fed as grain or cubes on the ground or by self limited free choice feeding. Whole cottonseed might also be considered as a short term flushing ration since it contains fat.

For the first three months of gestation, breeding does may be fed a maintenance ration. From 90 to 120 days the fetus begins to develop more rapidly (see Figure 4-3) and will represent a nutrient drain on the mother. This also coincides with the period of time in which the doe is susceptible to abortion, and management during this period of time may be a critical factor in raising a good kid crop. Abortion appears to be explained by undernutrition of the embryo, but since the fetus gets its nutrients from the dam, abortion is often explained by lack of development or poor nutrition of the doe. Abortion was discussed more fully in the section on reproduction. Does may need to be supplemented during mid-gestation, depending on conditions, but most should be fed during the last 30-40 days of gestation. If the doe is to be well nourished during this latter period, she should receive a total of 4-5 lbs. (dry matter) of feed daily of a 50-58%+ TDN ration containing at least 10% protein. This level represents the total feed intake and should be provided only to does being maintained in dry lot as might be the case in confinement kidding. Under range conditions it is near impossible to know what the doe is receiving from the range. Unless range conditions are good the does might well be fed up to 1.0 pound of a high energy supplement per day. This is the case in which corn (or other grains) might be used, but corn would be below the optimum level of protein. An increase in the protein intake might be achieved through alternate feeding of higher protein supplements or whole cottonseed.

The requirements of the lactating doe (during the early stage) is sufficiently high that it is difficult to feed her to meet her needs under practical conditions. Somewhat surprisingly lactation (at least in the early stages) is the one body function that takes precedence over fiber production in the Angora. This can be confirmed by observing how slowly a lactating doe puts on fiber following shearing. A complete ration during this period of time would require over 5 lbs. of a 50% roughage ration with up to 12% protein. Fortunately if the doe is in moderate condition and receiving a moderate level of feed intake she will produce sufficient milk to raise her kid until the kid can begin to forage for itself. If a producer is fortunate and kidding occurs at a time the spring forage growth occurs they may be turned to pasture with no supplemental feed. However, if ranges are dry and no green feed is available they should ideally be well fed on a complete feed or an energy protein supplement. Up to two pounds per day of supplement would be sufficient for best performance, but the doe and kid will usually survive at levels of up to one pound per day.

**Methods of Feeding Goats on Range or Pasture**

In areas where Angora goats are raised it is seldom convenient or economically feasible to hand feed or to feed a complete ration. The result is that low level feeding of high energy and/or high protein concentrates are most commonly used. For reasons of economy as well as preventing overeating it is important that the intake of these feeds be controlled, and that an attempt be made to insure that all animals have access to the feed. Neither of these are easily accomplished. Where a small number of animals are run in small enclosures it may be possible to hand feed daily a controlled amount in a manner that all animals can have access to the feed at the same time. This option seldom occurs under commercial scale conditions, and some of the various alternatives will be reviewed briefly.

**Licks or blocks**

The use of licks or blocks is a frequently used method of administration of nutrients at low level. The term lick would generally apply to hard blocks which are primarily used to administer salt and other minerals. This is an efficient method of administration of minerals at low level. The animals usually have difficulty obtaining sufficient amounts of salt to fulfill their desires, but they can easily fulfill their needs in this manner. A deficiency of salt is extremely rare. There may be some concern that the animals spend a large amount of time licking this block when they could be out grazing, but this concern should be minor. Softer blocks on which the animals may use their teeth can be used to administer a low level of intake of protein and sometimes energy. This is a good way to administer low level intake of high protein such as one-fourth pound daily. In this case it may be necessary to control the intake by the amount put out, but it will usually provide a chance for most animals to get access to the feed. Unfortunately these types of feed are usually more expensive than salt limited or hand fed grains, but labor costs from this type of feeding are low. In South Africa some producers make their own licks or supplements (i.e., chocolate mealies). The same type of feed is not available on the U.S. market and labor costs plus the unavailability (to the producer) of certain ingredients tend to preclude the use of this particular product in the U.S., but this general approach should hold interest. The use of licks or blocks may well be the most commonly used method of feeding muttons. Salt content of the block (along with hardness) may be used to control (increase or decrease) intake of the block. For this reason, it may not be desirable to use free choice salt or salt limited feeds when blocks are being used as a source of supplemental feeds.

**Hand Feeding of Cake (Oilmeal Cube), Cubes or Grain**

The traditional method of feeding animals on the range has been to hand feed a controlled amount of something such as oilmeal cake, cubes or corn on the ground. When this is fed daily at low levels there are a number of disadvantages. One of these is that the strong animals get more than their share of the feed while the weaker animals, which need it most, get little if any. Another problem is the labor and energy cost which comes from the rancher making each pasture every day. Another disadvantage is that it disrupts the animals' grazing pattern resulting in their spending a large amount of time near gates or the entrance to the pasture looking for the feed truck or that they chase any vehicle entering the pasture. These disadvantages can be partially overcome by feeding the animals a larger amount two or three times per week at an irregular time and place. This is probably the most useful approach, but it also has some disadvantages. One of these is that it is difficult to practice any type of hand feeding during kidding on the range. This may cause many does to abandon or to become separated from their kids. This practice works well for does which are to be kidded in confinement, as feeding on the range will be terminated during kidding. Another disadvantage of hand feeding is that, except for the use of corn, producers are generally prevented from mixing their own rations as they would not be able to pellet them. As has been previously mentioned corn is a good feed for use in this way, particularly for pregnant does, but it has less protein than would be desired in rations for goats. If it is desired to use corn it might be alternated with the use of a high protein pellet as protein can be maintained in various reserves in the body for several days. Feeding three times per week with one feeding consisting of a higher protein supplement is a possible compromise. Either 20 or 30% cubes or cottonseed meal cake (cubes) are reasonable alternatives to corn.

**The Use of Feed Limiters**

Another approach to controlling feed intake is the use of feed limiters. Using this approach it may be possible to continue supplementation throughout the year. The most common of these is salt, but others which have been used or tried at various times are gypsum (calcium sulfate), fat, antibiotics or lowly palatable feeds such as feathermeal or bloodmeal. The use of antibiotics for this purpose is definitely not recommended. The use of fat or lowly palatable feedstuffs holds possibilities which individual producers may wish to pursue. Extensive experience and a limited amount of research provides a basis to discuss the use of salt as a limiter. Salt can be and is used extensively for this purpose, although it does have some undesirable attributes. It is difficult to predict the reaction or level of intake of salt control feeds by goats. Generally salt levels in the range of 10 to 20% are used. It must be used with ground feeds as it cannot be mixed with whole grains, and pelleting of salt control rations tends to reduce the effectiveness of salt as a limiter. Thus, these types of rations should not be pelleted. If goats overeat on feeds with salt at the levels indicated, the salt content may be increased or the amount of feed offered may be limited to provide the desired intake. Hopefully the level of salt used would slow down the rate of intake sufficient that all animals would have access to the feed. One precaution in using this approach is that if new feed is provided after the feeders have been empty for a time losses can occur as a result of overeating or overcrowding and trampling at the trough. Additionally, the high intake of salt will cause the animal to drink a lot of water. In cold weather a lot of energy will be required to bring this cold water to body temperature. More importantly, the animal may spend a lot of time and energy traveling from feed to water. In normal times this might be used to distribute grazing about the pastures. As discussed previously, feed and water should be placed together during kidding to reduce movement. If salt feed is fed near water, clean water troughs regularly as thirsty animals drop large amounts of the salt feed into the water and it quickly becomes foul and may reduce water intake. If does spend a lot of time around feed and water troughs, these may become a hazard to the kids, and appropriate precautions should be taken.

In case of frozen water, or if water is unavailable for other reasons, the animal normally will not consume the salty feed, but if they did it could theoretically have an adverse effect on the animal. The recommendation in this respect is to keep fresh water available or to revert to an alternate method of feeding, such as hand feeding concentrates, when access to water is limited. Also it has been shown that a high level of water intake and urine output can result in some increase in nitrogen (protein) loss through the urine, but this is apparently a minor concern. There is some increase in by-pass protein, or rumen escape, with salt limited feeds due to the greater liquid content or the large fluid volume in the gastro-intestinal tract, but this is apparently of limited consequence.

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CHAPTER 6

# GENETICS AND SELECTION

The Angora goat is the only breed of goat utilized for the production of mohair, and thus breed policy and industry goals should be the same or at least similar. The majority of the income obtained from the Angora goat industry is from the sale of mohair. The only other income is from the sale of cull (usually aged) or surplus animals for meat. The split in income from the two commodities is often estimated at 85 and 15%, but in fact this is highly variable, depending on trends in numbers and relative price of the two products. If prices are favorable and numbers are being increased, very few animals are culled for slaughter, but in the reverse case, a relatively large number may be culled for slaughter. If a large number of castrate animals (wethers or "muttons," in Texas) are being culled for slaughter, the proportion of income from meat could be well above the 15% figure. Although most of the income to the industry is from mohair sales, this is often not true to the individual producers. For instance, stud breeders may receive a large portion of their income from the sale of pedigreed animals. Understandably, their goals may be to maximize the benefit to them, which may not be the same as maximizing the benefit to the industry. Also, commercial producers who run primarily doe flocks may receive a significant portion of their income from the sale of surplus animals to other mohair producers. This could conceivably result in genetic or management programs emphasizing numbers as contrasted to optimizing mohair production or quality. Breeding programs to produce superior muttons could conceivably be different to that designed to produce does. Sales of breeding or replacement stock represent exchanges within the industry, whereas, the sale of mohair and meat represent the only income to the industry. These two segments of the industry have a big influence on the genetics of the total population, and there is a potential for their goals to be somewhat different than the welfare of the industry as a whole.

The Angora goat may be considered a success story in animal breeding. The average fleece weight produced per head has gone up almost every year since the industry was established in the U.S. (See Figure 6-1). There may have been a slight tendency for this trend to level off in recent years. If this is the case, it may be a reflection of a trend to finer fiber, or an indication that the industry is reaching a plateau in respect to the level of production which can be supported under existing conditions. The Angora in the U.S. produces fiber at a more rapid rate (linear growth or length) and greater efficiency (per unit of body weight or per unit of feed consumed) than any type of sheep (or other fiber producing animals) with which they have been compared (See Figure 6-2) There are large differences in quantity and quality of fiber produced among centers of production (countries) and between areas, flocks and individual animals within countries. This indicates two things, i.e., that the type of product offered on the world market and the level of production are not uniform, and that this variability offers opportunity for change or improvement. It also indicates that the populations have responded well to selection. Although this might be debatable, the writer looks on the variability as positive from the standpoint of marketing (provides a variety of product quality) and breeding. These differences are, no doubt, due in a large measure to inheritance and confirm both the need and opportunity (genetic variation) for continued emphasis on improvement programs. The fact that the majority of the income to the industry comes from mohair suggests that breeding policy for this animal should be simple, but in fact, it has proven difficult to design a simple or single most effective breeding program. This traces to the fact that there are both qualitative and quantitative aspects of mohair production and a number of traits contributing to these, and that there are serious "trade offs" which are required in the selection programs. Also, as with most types of livestock, there is at least a tendency to emphasize certain aspects of visual appearance which have little basis in productivity or utility and for the industry to make only limited use of weights or measures in selection.

One of the most serious conflicts or "trade offs" is that as the level of mohair production is increased, the nutrient requirements increase and the adaptability or fitness of the animal decreases. This may result in reduced growth or reproduction or an increased susceptibility to various types of stress. This can be a significant problem, especially with Angoras managed under range conditions where the animals are often expected to survive and to serve a role under adverse conditions. A consistent increase in fleece weight over years can be documented (Figure 6-1). Over the same period of time, a decrease in kid crop raised or an increase in the difficulty of raising a good kid crop is believed to have occurred. The consistent progress realized in selection for fleece weight, based largely on visual evaluation, is encouraging, but this has occurred over a time scale which would be unacceptable in the present day. Also, this approach has not dealt effectively with the complex and often negative relationships involved.

**Types of inheritance**

**Qualitative**

Inheritance or genetic expression in farm animals is considered to be of two types known as qualitative or quantitative in nature. Qualitative, sometimes known as Mendelian inheritance, represents those traits which are discrete or traits which are controlled by one or a few pair of genes and which segregate according to discernable ratios. By contrast, quantitative inheritance represents traits which are influenced by many genes, with the result that their expression cannot be categorized into discrete units. Most of the important production traits in domestic livestock are inherited in a quantitative manner. There are relatively few Mendelian traits which have been identified in Angora goats, and some of these represent defects. Hereditary defects which are specific and identifiable and which are lethal, or are recognized as undesirable, tend to be recessive in nature. Otherwise, they would have been bred out of the population by natural or artificial, man-imposed, selection. There are relatively few such conditions existing in goats, since natural forces have played a major role in the evolution of the goat population. Some of the conditions which have been recognized or which might be encountered in Angora goats will be discussed.

**Peromelia (amputated)** , a condition in which one or more of the legs are missing, has been reported in Angora in Denmark (Nielsen and Arnbjerg, 1992). The hind leg is more commonly affected, and in cases where more than one leg is defective, the condition would likely be lethal. Although the condition has only been reported in Denmark among goats imported from New Zealand, goats with defective limbs have been observed in the United States. A similar condition has been reported in other species of farm livestock. The condition appears to be inherited as a simple recessive.

**Earless (or variable ear length)** is widespread in goats, but the writer has not observed this in Angoras. It could occur in cases where Angoras have been graded up from a non-Angora foundation. The inheritance of this condition is Mendelian in nature, with incomplete dominance and possibly several alleles. There is an earless breed in the U.S. known as the La Mancha.

**Wattles** or the appendages which are often found on or about the necks of many types of animals are frequently found on non-Angora goats. They will occasionally be observed in Angoras, likely those recently graded up from non-Angoras. The function or origin of these appendages is not known. They apparently serve no physiological role as they can be removed with no apparent impairment of the animal. This condition appears to be inherited as a dominant.

**Cryptorchid** (ridgling, torunas or retained testicles) is present in most populations of goats including the Angora. The frequency is relatively low in Angoras in the U.S. but is high in some populations such as in Australia and New Zealand. These tend to be inbred populations. This condition is inherited in a rather simple manner. Two pairs of genes are thought to be involved. The bilateral cryptorchid (both testicles retained) is sterile, but will exhibit libido or male characteristics. Unilateral cryptorchids (only one testicle retained) will have near normal fertility, but should not be used for breeding as this will propagate the condition. Cryptorchids should be culled, even as muttons, as they will be a source of disturbance in the flock.

**Horns** (polled, or the absence of horns) is inherited as a single gene trait in goats with the polled condition being dominant. Having horns, with both sexes being horned, is the normal situation in goats, but hornless animals occur in essentially all breeds or types. However, the absence of horns is linked to intersexes (hermaphroditism) in all types of goats which have been studied. In the homozygous, or pure form, essentially all, or at least a high percentage, of the hornless females are infertile. These are the individuals which appear as intersexes in which genetic females are often classified as males. Attempts have been made to develop polled strains of Angora goats, but most such efforts have been discontinued because of fertility problems. The intersex problem normally does not occur in the heterozygote polled animal (a single copy of the gene), and thus it is possible to maintain largely polled populations by consistently making only polled-to-horned matings. A high degree of heterozygosity, and thus freedom from this problem, can be realized in this manner. Interest in polled Angoras would likely derive from the problem of horned animals becoming hung in the fence (Figure 6-5), but this has apparently not been deemed of sufficient importance to justify the efforts to secure and maintain polled flocks.

**Color** in goats is no doubt inherited in a Mendelian (qualitative) manner, but throughout the species there are many colors, shades and spotting patterns; with the result that the manner in which all these variations are inherited is not understood at present. Pure Angoras are considered to be white although shading is sometimes observed. This suggests a dominant inhibitor gene, segregating as a single gene, for which essentially all Angoras are homozygous. This prevents the expression of other genes for color which the animal may possess and which may show up with further crossing. Some individual goat owners have attempted to breed color or color shades into the Angora for the handicraft trade. These efforts have met with some success, but the exact mode of inheritance of the shading is not known.

**Mouth** - The characteristic overshot or undershot jaw is relatively rare in Angora goats, though no doubt will be observed from time to time. This problem is present in almost all species. To the extent that this is an "all or none" trait, it must certainly be inherited in a qualitative manner, but it has not been identified in the Angora as conforming to a simple Mendelian ratio. Animals showing this defect should be culled. In addition to the simple undershot or overshot mouths, there are two other conditions relating to the mouth of the Angora that warrant mention. One of these is the situation in which the incisor teeth fail to intersect the dental pad by a small amount. This is often blamed on the type of feeding program, but the writer has observed instances in which this appears to be genetic in origin. There is currently no basis to suggest that this is inherited in a simple Mendelian manner. Minor inequalities in the jaw are not likely to interfere with animal performance, but the condition could presumably become exaggerated and should be guarded against. The second condition has to do with deterioration of the teeth with aging. Many goats, especially muttons, will show a tendency for the lower jaw to become longer with age. This is related to the fact that the long bones, particularly in castrate animals, tend to continue to grow with age. This may result in a poor match of the incisor teeth and the dental pad. Along with this, the incisor teeth will often become slanted forward with age, as is known to be the case with the horse (Figure 6-3). The end result may well be an animal which forages with poor efficiency and can be a cause of poor-doing animals. Both these conditions may be related, at least to some extent, to inheritance and should receive some emphasis in selection or culling. However, since the condition occurs with aging, it will not be easy to deal with. It is suggested that when animals are being worked, such as drenching, they might be observed and removed for this condition. This can have the effect of improving the performance of the current generation and influencing the future generations as well.

**Sheepy fleece** - This condition is well known to Angora goat breeders in this country. It may well be of more concern to purebred than commercial breeders. This condition is characterized by short staple with exaggerated crimp (kinky) as compared to normal mohair (Figure 6-4). The exact manner of inheritance of this condition is not known, but it does not appear to segregate as a single gene trait and certainly not as a simple recessive. The condition is not an "all or none" trait but is listed in this group for discussion purposes since it can often be categorized in discrete units. The animals may appear normal at one observation and sheepy at another. This more frequently takes the form of being normal in early life and changing at later ages. Rarely will the animal observed as sheepy return to normal at a later date. Some animals may be observed to have a sheepy tendency or sheepy spots which are not readily observed at a later date. The sheepy spots most frequently are observed along the back, or topline. This type of trait is often referred to as having "incomplete penetrance" or incomplete expression. This condition is almost certainly explained by inheritance, but it apparently can be influenced by environment. The condition appears to occur more frequently in purebred flocks where the animals are pushed on a higher plane of nutrition. Young males on the

Angora goat performance test are observed to revert to the sheepy condition more often than animals managed less intensively. The persistence of the problem in the Angora goat population suggests that it is a correlated response to something that producers are selecting for, as few would knowingly or intentionally use this type of animal for breeding. One possible explanation is that this condition is a correlated response to selection for increased weight through the medium of increased density. At some point, the increased density may break over into the sheepy condition, as the sheepy fleece appears more dense. As proof that the condition is primarily explained by inheritance, the writer has on more than one occasion intentionally used sheepy males in comparison with those with normal fleeces. In all cases, the sheep-fleeced males sired more sheepy types than normal males used for comparison although both normal and abnormal fleeces occurred in both groups. In another study, the percentage of sheepy offspring was recorded for different sires used on the same doe flock. In one experimental flock, this information was recorded for four consecutive years. The females were the same each year, but the males used each year were different. Similar observations were made in one private flock. The results are shown in Table 6-1. These data indicate that large sire differences existed in the number of sheepy offspring, indicating a genetic link for this trait.

The high percentage among certain sire groups indicated a reason for concern about this problem. It should be pointed out that the animals classified as sheepy may only have had a sheepy tendency or sheepy spot. In the above studies, as well as in others, attempts were made to relate the percentage of sheepy offspring to performance traits of the sires without a great deal of success. In one study, does which produced sheepy kids had a tendency to be heavier shearing but have shorter-staple than those producing normal kids, but the differences were small and not statistically significant. However, this should reinforce a need to emphasize staple length in selection.

**Quantitative**

As indicated earlier, most economically important traits of the Angora are inherited in a quantitative manner, and the development of a breeding program relates largely to dealing with these traits. A theoretical or scientific approach to the development of a selection program requires a knowledge or an estimate of the economic importance of each trait, the variability in each trait, the heritability or degree of hereditary control over each trait, and the relationships between the traits. Highly definitive information on these points is seldom available, but a reasonable consensus can be obtained.

**Traits to be considered in selection**

Essentially all traits or features of domestic livestock are to some degree under hereditary control and are thus subject to change. Throughout history the greatest mistakes in animal breeding have been in the choice of goals or traits to be emphasized in selection and not in the success with which the goals have been accomplished. This may be less true with the Angora than with some other species.

As pointed out earlier, the majority of the income to the industry comes from the sale of mohair, and thus it would appear that a selection program for the Angora is simple and that selection would be devoted largely to increased fleece weight. In practice, the development of improvement programs for Angora goats is much more complex. Some of the major difficulties derive from the fact that, historically, mohair markets have been erratic, both in terms of the prices received for the basic product, and the premium paid for such quality traits as fiber diameter, fiber length, lock type, character, luster, etc. This, in turn, derives from the fact that mohair is largely a luxury fiber and the demand and end use (quality requirements) may fluctuate widely based on fashion and general economic conditions. There is also a general lack of research to show how such traits as length, character, luster, etc. contribute to value in the manufacturing process or the finished product.

Generally, one might divide the traits of interest into those concerned with fleece and with body development and reproduction:

**Body development and reproduction:**

Size or rate of growth
Conformation
Soundness
Number of kids dropped or raised

**Fleece traits:**

Fleece weight (grease weight, clean weight and/or yield)
Fiber diameter
Fiber or lock length
Lock type
Character, luster, handle, etc.
Defects

**Others**: Face, neck and belly covering, horn shape, etc.

Each of these will be discussed briefly.

**Body size or rate of growth** are highly related and contribute to income in a small but direct way through weight at slaughter. Adequate size and development is more important as it relates to the environmental or production conditions under which the animal is raised. It contributes directly to improved reproductive rate, including reduced losses to abortion, (Figures 4-2 and 4-4 and Table 4-2) and to improved survival in times of stress (low temperature stress, internal parasites, etc.) and may contribute to increased fleece weight. Most Angora does run under range conditions are below the optimum in respect to body weight (Table 6-4). The above factors combine to suggest that selection for body size or development should be a major concern with Angora goats. In reality, it is unlikely that breeding efforts should be directed to development of a large versus a small Angora goat. Instead, this should be viewed as selecting for a goat that is sufficiently adapted or functional that they are able to grow (obtain optimum weights) and survive under existing production conditions. Size or growth is perhaps the best measure of fitness so long as this trait is not allowed to function to the detriment of fleece weight or quality (i.e., don't select for a big goat with no mohair) or reproduction.

**Conformation** was listed in this tabulation because it often comes up in discussions on selection. However, the writer considers conformation, except as it contributes to body size and development or soundness, to be of minor importance. This statement will be controversial within the industry. There is likely some logic favoring a more "meaty" type of conformation, but this may be a luxury this industry cannot justify unless or until a market or mechanism is established to exploit the Angora to a greater degree as a meat animal. There appears to be some possibilities for doing this which should be explored.

**Soundness** is important primarily from the standpoint of weeding out defective animals. Anatomical features of interest include feet and legs, mouth and back. Animals with a defective mouth (inequalities of the jaws) obviously should be culled (Figure 6-3). Caution should be exercised in over-emphasis on feet, legs and back as animals seldom really break down, and a large portion of the options in selection can be dissipated in searching for perfection in these points.

Two other traits which might warrant discussion are **udder soundness** in the female and **split scrotum** in the male. Angora does which have experienced one or more good seasons or high level of feed during lactation will often have damaged udders. The number of these may exceed 15% of the flock. Normally, these should be culled, especially if both teats are involved, unless their maintenance can be justified for mohair production alone. In the U.S., producers have traditionally discriminated against males with a divided scrotum. Biologically, there is a slight advantage for some separation in the scrotum as a result of improved cooling. This is a highly inherited trait, and perhaps there should be some discrimination against a completely divided scrotum. Instances have been observed in which each testicle was independent and that it was difficult for the animal to walk (Figure 6-6). In some programs, such as the Performance program, those with a division of more than ½ the testes length are sifted from sale as a stud animal. It would be difficult to justify this action for commercial animals in which males are not to be kept. Some producers believe that a divided scrotum is related to udder shape in the does, but limited studies (Shelton, 1966) have not confirmed this.

**Number of kids** dropped or raised, preferably the latter, is the ultimate measure of **reproductive efficiency** which is often a problem with the Angora. It can be well established that this is due in a large measure to the high metabolic priority for mohair production and the resultant lack of body development, size or condition. Thus, selection for size and development under production conditions is almost a direct selection for reproduction. Culling of the doe flock to eliminate habitual aborters, does which are dry for more than one season, damaged udders, etc., should also contribute to increased kid crop raised. Beyond this, selection for twinning or for early sexual maturity (to kid at one year of age) is probably not justified for the industry as a whole but may be advantageous to some individual producers.

**Fleece traits**

Historically, the most important factor affecting total income to the Angora goat industry is the wide fluctuations which have occurred in mohair price. Price not only affects the value of the fleece, but will greatly affect the sale value of replacement animals as well. After price, the next major factor is the level of production obtained. Among individuals or even flocks, the mean mohair production for breeding-age females tends to range from 2.5 to 7.5 lbs for a six-month shearing. The heritability of mohair production is at least moderately high and thus selection for fleece weight must be a high priority in any breeding program. The producer sells grease weight. Theoretically the prices paid reflect differences in yield, but this may be debatable. In any case, the yield of mohair is high, and there is a high correlation between grease and clean weight. Low yields are usually associated with a high oil content. The energy cost of producing the oil is equal or greater per unit of weight than for fiber. Thus, assuming producers are paid for mohair based on yield, they would be advised not to emphasize a high oil content of the clip. However, very high yielding mohair (90% or above) should perhaps also be viewed with disfavor. Unless the clip is sold based on a laboratory-determined yield, producers are not likely to be paid for this high yield. The high-yielding fleeces tend to pick up defect to a much greater degree than those with some oil. Also, a high-yielding fleece will tend to have a less well-defined lock and a lower character rating and possibly a greater amount of environmental degradation of the fiber. Thus, a target yield for mohair might be in the range of 85-90% assuming the loss in yield is associated with oil and not a high level of vegetable matter contamination. High levels of mud, manure or of plant material should generally be viewed as management problems, and adjustments for this should be made in evaluating the animal for breeding.

The simplest approach to selecting for fleece weight is to weigh the fleece of prospective breeding males or does in stud flocks from which breeding males are to be kept. Ideally, this should be clean fleece weight at least for the males, but major differences in yield can be ascertained with a fair degree of accuracy by visual inspection. In commercial programs or where the producer is not able or willing to collect fleece weights, differences among animals can be predicted with fair accuracy from length and density of the fleece, size of the animals and completeness of covering on the neck and belly.

In visually selecting (or more appropriately, culling) of females in commercial flocks, fleece weight estimates may be based largely on staple length (including uniformity of length), size of the doe and neck cover. Diameter and oil content are important components of grease fleece weight as well, but since both of these can carry negative connotations in the breeding program, it may not be desirable to favor these in estimating weight. Caution should be exercised in visually selecting for fleece weight in breeding age females, as the end result may be a discrimination against does which have raised kids.

**Fiber diameter**

As shown in Figure 6-7, the trait of mohair which makes the greatest contribution to price is fiber diameter, but this can very well vary with market conditions or year. Also, it should not be assumed that all the variation shown in Figure 6-7 as being associated with fiber diameter represent genetic differences. Fiber diameter is greatly affected by age with finer hair from kid goats and the coarser mohair from adult animals (see Figure 4-1). Fiber diameter will vary over different parts of the fleece or body. The neck and britch tend to be coarser than other parts of the fleece. This means that for fiber determination, three different parts should be sampled or that all animals should be sampled at the same place or that core samples should be taken from the entire fleece. Many breeders place great emphasis on uniformity of the fleece over different parts of the body. This would be valuable in that in sorting or classing all the fleece could go into one line. However, this difference over various parts of the body appears to be associated with the physiology of the animal and will be difficult to change and attempts to obtain a uniform fleece should not be overemphasized. There is normally variation in fiber diameter within ages and the breeder may wish to consider this in selection. However, the amount of emphasis to be placed on diameter should be based on what the individual producer perceives the future to hold in respect to price premium based on diameter. In higher priced markets, such as that used for clothing, it seems likely that there will continue to be a significant premium for finer hair. At times of low prices, such as the present, there is less premium based on diameter. The positive relationship between fiber diameter (coarser) and fleece weight presents a problem. Presumably, in time this could be overcome somewhat by selection for increased density or length. There is no good way to measure density, and also, there is some concern that density may be related to the sheepy problem.

**Staple length** (fiber or lock length) also has an impact on price received as well as on fleece weight and should receive emphasis in selection. Uniformity of length is also a frequent problem, with much shorter hair on the rear quarters. As shown in Figure 6-7, a significant price break occurred for hair under 4" in length. This may, in fact, vary with quality or end use of the hair and also with years and demand. Short staple is a frequent problem with mohair under range conditions in hard years. For this reason, selection efforts should be directed at producing mohair at least 4" in length, and this may require selecting breeding animals (sires) which have well above four inches in length.

The amount of emphasis to be placed on such traits as **style, character, luster** and **lock type** of the fleece is unclear. It is not known to what extent these traits contribute to value in processing or in the finished product. However, little definitive research has been conducted on these traits as related to processing. At any rate, buyers are in the driver's seat, and their opinions must be considered by the industry. As shown in Figure 6-7, buyers are showing a slight preference for character traits in the purchase of mohair, but, in fact, this may be influenced by its usual relationship to fineness. In the writer's opinion, producers should continue to place moderate emphasis on character and style in the fleece, as the development of a goat with a simple straight fleece is likely to detract from the uniqueness or luxury nature of the fiber, if not the actual processing qualities. Style and character in the fleece are not easily defined, and these are also somewhat related to **lock type** (see Figure 6-8 and 6-9). Two distinct lock types (ringlet and flat) are recognized (See Figure 6-8) or recognizable, but only a small portion of the U.S. goat population fit totally or clearly into either type. Intermediate types are sometimes referred to as webb lock. The writer refers to these intermediate types as R&F or F&R if one seems to predominate over the other. Another problem of classification is that the animal will be ringlet over part of the body (usually fore quarters) and another type of lock on the rear quarters. Also, many, or most, goats will be a ringlet at a young age (kid) and will revert to another lock type later. Ringlet fleeces are usually finer and are considered to show more character, but generally have lower fleece weight (Table 6-2). In reality the industry might be advised to select for the basic features of weight, length, diameter and character of mohair as opposed to selecting for lock type as an expression of these. Still, buyers may be influenced by lock type. The data in Table 6-2 suggest that an intermediate type of lock might be acceptable or preferable from a producer standpoint. In addition, there are some abnormal types. The most noted of these is known as "sheepy" or simple straight unclassifiable locks. Rather than being considered as an undesirable kind of lock, the latter might be considered as poor character.

**Neck and belly covering** are useful in visual selection for fleece weight. If actual weights are utilized, theoretically the neck and belly covering could be ignored. In practice, there is some logic to selection for both weight and covering. The two (neck and belly covering) are highly correlated, and since neck covering is much more easily observed, emphasis on neck cover alone is generally adequate. Therefore, there is little need to be concerned with looking at the belly, at least in commercial programs.

**Hair cover on the face**, at least to the extent that vision is impaired, is a serious problem with the Angora (Shelton, 1960). Thus, clearly selection should be practiced for less cover on the face. There is a correlation between face cover and that of neck and belly, but it now seems well established that it is possible to develop open-faced goats with good cover at other points. When feed conditions are good, such as under performance test conditions, there will often be a low, but positive, correlation between face cover and fleece weight, but this will not be true under pasture conditions where vision impairment is a factor. If hair on the face is adequate to interfere with vision, this constitutes a serious problem (See Figure 6-10) with development and reproductive rate being most seriously affected. The adverse effects of face cover not only reflects vision problems, but likely also a higher genetic potential for fiber production. Thus, in theory, covered-faced does should shear more mohair. In fact, this is not necessarily the case, as the larger size of the open-faced does results in comparable fleece weights. At the present time in Texas, excessive face covering is a problem with only a relatively small percentage of the goats. In other areas where mohair is produced, labor is often available where the mohair can be clipped from the face. If clipping the face is practiced, the emphasis to be placed on face covering would be reduced, but not totally eliminated. Care should be exercised that stud breeders do not allow their animals to carry a significant amount of hair in their face and expect these to serve commercial producers best interest. There is a tendency for some breeders to select for an intermediate amount of face cover which does not interfere with vision. It is likely to be difficult to fix the trait at this level, and there may be some segregation resulting in a few animals with vision problems. Selection for open-faced goats is not as simple as was the case with sheep due to the fact that one is concerned with both pattern of growth and overhang of the locks. Totally bare-faced goats are frequently lightly covered on the neck and thus have a reduced level of fiber production. On the other hand, some males may have open or bare faces because the fiber has been shed or rubbed off and actually have good neck covering.

**Variation in economic traits**

It is generally a safe assumption that significant or meaningful variation exists for all traits of interest in domestic livestock, and there is no reason to assume this is not true for Angora as well. Available data confirms significant variation in all traits studied.

**Heritability of traits of interest**

The term "heritability" refers to an estimate of the extent to which a given trait is under genetic, as contrasted to environmental influence or control. It is calculated by measuring the tendency for related animals to perform or to appear similar as contrasted to unrelated animals. Attempts have been made to calculate estimates of genetic parameters for Angoras in the U.S. (Shelton and Bassett, 1970; Shelton and Snowder, 1983), in Turkey (Yalcin, *et al*., 1979), South Africa (Delport, 1987 and Poggenpoel and Turner, 1983) and more recently, in Australia (Gifford, *et al*., 1992) and New Zealand (Nicoll *et al*., 1989). The Turkish data appear to be the most valid, but the estimates obtained in the U.S. are substantially higher than those obtained in Turkey. A possible explanation of this is that feed conditions and level of production in the U.S. are higher than those in Turkey, thus permitting genetic differences to be more fully expressed. Since a large amount of space would be required to report data from all of the above cited studies, only consensus values will be given. These are grouped in outline form below:

| | |
|---|---|
| Highly heritable traits - (above 25%) | Staple or lock length<br>Yield<br>Yearling or mature weight<br>Face, neck and belly covering<br>Secondary-primary follicle ratio<br>Scrotal division |

| | |
|---|---|
| Moderately heritable traits - (15-25%) | Fleece weight (grease or clean)<br>Fleece density<br>Fiber diameter<br>Kemp<br>Weaning weight |
| Lowly heritable traits - (below 15%) | Reproductive rate<br>Longevity<br>Adaptability |
| No information - (These traits are no doubt reasonably highly inherited, but are difficult to study because they cannot be measured or converted to numbers) | Character<br>Style<br>Lock type |

The above information suggests that most of the traits one might find of interest about the Angora are at least moderately highly inherited and thus subject to change through selection. This is especially true of fiber traits and the great success in selecting for fiber production confirm this to be the case. Reproduction and fitness traits are generally considered to be low in heritability. However, in the case of the Angora goat these fitness traits may be more easily influenced through selection, at least in a negative manner, by the amount of emphasis on fleece weight and body cover.

If all the traits listed above are emphasized in a selection program, the progress in any one of them will be very slow. Thus, the challenge is to identify and emphasize the most important traits, and these may differ between producers or producer outlook or segments of the industry. When we consider that selection only impacts the future the individual who is most successful in predicting what the future holds may well meet with the greatest success.

**Correlation between traits**

Correlations between traits are or should be a major cause for concern in Angora goats. The correlations may exist at the phenotypic (as observed) or genotypic level. Phenotypic correlations represent a composite of genetic and environmental influences which may be in opposite directions. It is the genotypic correlations which should be of concern in the design of genetic improvement programs, but the producer observes only phenotypic correlations. This may lead to erroneous conclusions. Only phenotypic correlations can be measured directly. It should be remembered that each animal has its own individual environment. Genotypic correlations can only be estimated in an indirect manner by measuring the tendency of related animals to perform similarly, and thus such values are highly variable or often erratic. An environmental correlation merely means that a given set of conditions affect more than one trait in the same or opposite direction. As an example of this, a favorable environment will increase body weight, fleece weight, staple length, fiber diameter, etc., whereas, the genetic correlations between some of these traits may, in fact, be in the opposite direction. Some phenotypic correlations calculated for Angora males on performance tests are shown in Table 6-3. Most of these appear favorable, with the exception that size or rate of growth and fleece weight (better feed conditions) are related to coarser fiber diameter.

It is the genotypic correlations that are of greater concern in selection programs, and these appear to present some problems. Only limited attempts have been made to calculate these parameters for the Angora. One Turkish study (Yalcin, 1982) and two Texas studies (Shelton and Bassett, 1970; Shelton and Snowder, 1983) report values for genetic correlations. Since these values are highly variable and to some extent contradictory, the author's interpretations from these reports are presented in narrative form instead of an attempt to report mathematical values. This discussion will concentrate primarily on those which represent problems to the industry and what might be done about these.

There is a positive genetic correlation between fiber diameter and fleece weight since diameter is a component of weight. It is not possible to eliminate this relationship, but it may be possible to circumvent it through increased length, density, body cover or size.

There is almost certainly a negative relationship between fleece weight, or genetic potential for fleece weight, and size or growth rate, adaptability to adverse nutritional conditions and reproduction. Under highly favorable price conditions, selection for fleece weight would be indicated while improving the environment or management to provide for growth and development and reproduction. Under conditions of less favorable prices, some intermediate position (relative to selection) would be indicated. Since no one knows what the future holds, each producer needs to make his own assessment.

There is a positive correlation (both genetic and environmental) between size or rate of growth and development with reproductive rate and reduced death losses or resistance to stressing conditions.

There is a positive relationship (phenotypically and genetically) between various measures of fleece weight (grease and clean) and with staple length (low). Yield tends to be positively related to clean weight but has a (low) negative relationship to grease weight.

Neck and belly cover are positively related, and in general, only neck cover needs to be emphasized. Some gain will be realized in discriminating against lightly covered necks, even though fleece weights are being used in selection.

Face cover tends to be positively related to cover at other points and to genetic potential for fiber production, but negatively related to growth and reproduction. It does not appear to be positively related to fleece weight under range grazing conditions. The relationship of face cover to cover at other points can likely be separated through selection.

The Turkish study shows fiber density and the Secondary to Primary (S/P) ratio is positively related to fleece weight and to reduced fiber diameter. Unfortunately, in that study it was also related to shorter staple length. These data suggest that it should be possible to select for fleece weight and finer fiber through increased density. However, it may be easier to do this through selection for fleece weight and reduced diameter directly since these traits are more easily measured than fiber density and S/P ratios. There is also some concern that increased fleece density may contribute to the problem of sheepy fleece. Thus, selection against this problem may be an added burden.

**Kemp**

The amount of kemp in the fleece is generally negatively related to most traits of interest, indicating no problems in selection for a reduction or absence of kemp. A slight positive relationship of kemp and body weight has been reported. This may be explained in a number of ways. One of these is that larger animals may have been fed more heavily, resulting in a coarser fleece with the result that a few fibers will appear medullated. Also, as observed across populations, larger animals are more likely to show cross-breeding influences at some time in the past, or less selection pressure on fiber traits. Additionally, it was suggested earlier that the absence of kemp may well result from compaction of the fleece, and with the same or similar number of follicle bundles or S/P ratios, larger animals will have less compacted follicles or less density to the fleece. When viewed across the larger goat population, including cashmere, there will be a tendency for animals producing finer fiber to show a vestigial outer coat (kemp). Thus, there may be a need for greater diligence in selection against kemp in flocks selected for fine fiber. The bottom line is that in view of the industry complaints of kemp, producers should attempt to clean up their flocks in respect to the problem. This can be done by visual evaluation, but would be enhanced by laboratory-determined values, particularly for breeding males. It may be significant that much of the buyer criticism is based on visual evaluation.

**Environmental Influences**

A number of factors such as age, feed level, year, sex, type of birth, etc. significantly affect most of the traits one would wish to measure or to emphasize in selection. This is very marked in terms of the effect of age or mohair weight and diameter. Several studies have reported estimates of environmental (age, season, sex, etc.) effects. One of the first of these was reported by Jones *et al.*

(1935) and is the source of the data in Figure 4-1 (Chapter 4). Bassett and co-workers (Bassett, 1966) reported data from five flocks collected in a period beginning in 1964 (see Table 6-4). These data show the expected age effect on body weight, fleece weight and diameter. More recently Gifford, *et al.* (1992) reported data for Angora goats in Australia. None of the above studies appear totally applicable to current U.S. populations, and probably are not useful for attempting to use these as adjustment factors. Young animals produce finer hair and often greater weight (except for kid fleece), or at least greater weight per unit of body weight. Attempting to correct for age and other environmental factors (across years or properties) is probably not realistic, or is not likely to be attempted by producers in the U.S. Instead, selections should preferably be made within age and sex groups and among animals treated alike and selections across age will be empirical. There should never be a need to select one sex against another, but if complex sire evaluations are to be attempted, there might be a need to adjust for sex differences.

Selection of breeding stock at weaning or the first shearing should be discouraged. At this early age only the obviously defective animals should be culled. Selection of breeding animals, especially breeding males, should not be made prior to the second and preferably the third shearing. Once they have been placed in use in commercial flocks, does should probably be culled primarily on soundness, their productive history (including reproduction), and the ability to hold their fleece with advancing age (taking precaution not to discriminate against does rearing kids). Once males have been placed in use, they should preferably be culled based on the performance of their offspring, although this would be possible only in the case of single-sire matings. However, it is unlikely that producers would or should fail to visually evaluate males annually with respect to both fleece and soundness. As pointed out earlier, there may be problems of soundness (especially mouths) which occur only with advancing age.

**Selection Practices**

In theory, animal improvement is best accomplished through the use of an appropriate selection index or some composite evaluation of merit. Usually these are used in combination with independent culling levels for such traits as soundness or fleece defects. The more extreme alternative to this is to practice breeding as an art as opposed to a science. Although animal breeding as an art is without merit, a closely related philosophy is to some degree applicable. Any animal breeding effort will yield response only at some future date and predicting the future is as much an art as a science. This may be doubly true of stud breeders who may be concerned not only with predicting industry trends, but predicting what producers will be looking for in the purchase of breeding stock. These are not necessarily highly correlated. Still, one should be guided by the "so called" scientific method.

The breed association has prepared a scorecard, as shown below, which may serve as a guide, particularly for judging animals in the show ring. It is unlikely that this will or should serve as an exclusive guide for selection of goats to serve commercial interests. For instance, no provision is made for use of performance data. Also, the appropriate weighing of factors should consider units of measure, amount of variability, correlation between traits, etc. in attempting to put mathematical ratings on individual characteristics. This is best done by use of selection indexes, although, it may not always be possible to convert the selection process to a purely mathematical procedure. However, the principle should serve as a base for more empirical methods of selection.

**OFFICIAL JUDGING GUIDE OF THE**
**TEXAS ANGORA GOAT RAISER'S ASSOCIATION**

**BODY 50 points**

| | |
|---|---|
| Size and weight for age | 11 points |
| Constitution and vigor | 11 points |
| Conformation | 12 points |
| Amount of bone | 8 points |
| Angora Breed type | 8 points |

**Physical disqualification**

All blue or black horn or hoof, deformed mouth, broken down pasterns, deformed feet, crooked legged (including cow hocks), divided scrotum or abnormalities of testicles, close set distorted horns, sway back.

**FLEECE 50 points**

Length of fleece must be equivalent to one inch per month or more, uniform over the body, and a high yielding fleece.

| | |
|---|---|
| Freedom of Kemp | 10 points |
| Uniformity and completeness of covering | 10 points |
| Luster of fleece | 9 points |
| Density of fleece | 8 points |
| Fineness of fleece | 9 points |
| Character of fleece | 4 points |

**Disqualifying characteristics of fleece**

Excessive Kemp, colored hair, sheepy fleece, straight beard type hair in fore-top or on back.

There are prescribed mathematical procedures to calculate selection indexes, but few attempts have been made to do this for Angora goats. An Angora goat performance test is being conducted by the Texas Agricultural Experiment Station at Sonora, Texas, U.S.A. In this work an empirically derived index has been used, as of 1990, which is as follows:

I = 4 x adjusted clean fleece weight (lbs) + 35 x average daily gain on test (lbs) + .15 x final weight (lbs) + 2 x average lock length (in) - 1.5 x fiber diameter in microns - 3 x face cover score (no credit for scores below 2)+ 1.5 x character score + 1.5 x neck cover score.

In this index, character as well as face, belly and neck cover scores were assigned on a 0-5 basis, with the higher values being more. The higher values are thus more desirable, except for face cover.

Most readers will be aware of the admonition that it is only possible to effectively select for a few traits at one time. However, in the above index face cover, neck cover and character score are all reasonably good in the population and thus, this component in the index only comes into play when there is a problem in these traits. Two components (gain and weight) emphasize body development and three emphasize mohair production (clean weight, staple length and neck cover). The only serious problem with this index is the amount of emphasis to be placed on fiber diameter. Highly variable markets, relative to the premium placed on fiber diameter, makes this a difficult decision. In addition to the index a number of independent culling levels (disqualification) are utilized in this program, but an individual producer may choose to form his own opinion relative to these disqualifications.

Turkish workers (Ariturk *et al.*, 1979) suggested the following indexes for use with Angora flocks:

$I_e$ = 0.30 body weight (kg) + 0.71 clean fleece weight (kg) + 0.16 staple length (cm.) - 0.22 fiber diameter (microns).

$I_f$ = 0.26 body weight (kg) + 0.50 grease fleece weight + 0.08 staple length.

The $I_e$ represents an experimental or elite flock on which more complete data would be available while $I_f$ represents commercial or producer flocks.

Poggenpoel and Van der Westhuysen (1980) in South Africa suggested that animals first be judged for breed character and body abnormalities, with these being used as independent culling levels followed by the use of the following index:

I = 27.6 x grease fleece weight in kg + 13.2 x spinning count + 1 x body mass in kg.

Both the Turkish and South African indexes use kilograms (kg) as a measure of weight. For those who might wish to make a conversion,

one kg = 2.2 lbs.

It will be noted that the three suggested indexes differ significantly. The magnitude of the suggested coefficients should not be compared directly as they are greatly influenced by units of measure and the amount of variation in the population. Apparently only the Turkish index is a calculated index. The others were apparently empirically derived. The U.S. and Turkish index are somewhat comparable in the relative emphasis on fleece weight and body weight whereas the R.S.A. index would be near single factor selection for fleece weight. This may be a reflection of the fact that goats are grown under better conditions in R.S.A. and that lack of size and development is less a problem.

The Turkish and R.S.A. indexes place approximately comparable emphasis on fiber diameter in relation to fleece weight, whereas, the Texas index placed less emphasis on this trait.

Face cover is included only in the Texas index. Producers in R.S.A. apparently clip fiber from around the eyes of their goats, whereas in Turkey the goats are less inclined to have covered faces and could be clipped as needed.

It should not necessarily be assumed that either of the indexes actually reflect selection practices in the respective countries. Few producers will have the data to actually compute indexes, thus, they may serve primarily as guides.

The most important factors in any selection program is to set the right goals, and to use adequate numbers. Realizing that few breeders will be able or willing to collect meaningful data on significant numbers it is the author's belief that some type of collaborative effort is strongly indicated to carry out improvement programs with a complex animal such as a range Angora goat. In a number of other countries, cooperative efforts such as nucleus flocks, group breeding schemes, etc. are being utilized, and should be considered or encouraged in this country. These types of programs are well suited for use with fiber producing animals. The performance testing program in use in Texas, is to some extent, a collaborative effort, but requires relatively little input on the part of the producer. It also does not permit selection based on female traits, and is, at present, collected under artificial (confinement) conditions.

Another form of collaborative effort which might be considered by the Angora goat industry would be an industry-wide effort such as the NSIP (National Sheep Industry Development Program) for sheep. Similar programs are underway in a number of other countries.

In addition to the above suggestions relating to choice of goals, use of records and the need for adequate numbers, the writer's primary concern relative to Angora breeding in this area is the need to develop an animal which is better suited to the environment in which they are raised. This is a problem area with goats on the range. There is a readily available mechanism to give some emphasis to this problem. Since most male kids are allowed to obtain some age or development before they are castrated a good mechanism is provided to pick at least some breeding males from animals grown under field conditions. To accomplish this, only obviously defective kids should be culled at weaning. The remaining male kids should be numbered (see Figure 6-12) and perhaps weighed at this time. At, or prior to, the second shearing they should be weighed again and visually evaluated (possible including scores). As a minimum, staple length and grease fleece weights should be collected (with more detailed values such as yield and diameter as optional) at shearing. Utilizing this information (along with a possible index) up to ⅔ of the kids can well be castrated. The remaining one-third should receive similar, and possibly more detailed study, at the third shearing. Ideally, some type of index and culling levels should be applied at this time. A simplified version of the TAES index is suggested. Up to this point, the animal should have been maintained under grazing conditions with necessary supplementation. After the final selection is made at the third shearing, the remaining animals could be castrated and the selected males placed on feed, if necessary, to get them ready for breeding. This process of sequential selection has given some of the best results the writer has observed and would, to a substantial degree, avoid the potential problems resulting from long-term selection under highly-fed conditions. This approach could be undertaken by almost any segment of the industry.

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CHAPTER 7

# DISEASE PROBLEMS OF ANGORA GOATS

In a broad interpretation the term "disease" includes anything which affects the well being of the animal., however, most people think of disease in a more restricted sense as those due to infection. The broader interpretation may include infectious and parasitic disease, as well as nutritional or metabolic disorders, toxic plants, and in the case of the Angora goat, a largely unique problem of "offshear" or freeze losses. The Angora often exhibit symptoms of "ill thrift" which is apparently predisposed by their high nutritional requirements. For this reason they may be slow to recover, even after disease or parasites are removed as a problem.

**Infectious diseases:**

The goat as a small ruminant is susceptible to the entire range of disease conditions that affect this group of animals such as anthrax, blackleg, tuberculosis, brucellosis, anaplasmosis, leptospirosis, pneumonia, mastitis, foot-rot, tetanus, etc. It would take many volumes to discuss all of these, and as a result we will attempt to deal with those which are thought to present problems to the industry, but this would not be the same for all production areas. In the primary production centers Angora goats tend to be grown under extensive conditions in arid or semi-arid regions. As a result, contagious diseases tend to be less of a problem than those of nutritional, physiologic, parasitic or toxicological origin, or less than will be the case of animals kept in more intensive settings.

Producers should familiarize themselves with health problems likely to be encountered in their area. If an individual does not have this experience or background, he should make use of educational materials or veterinary assistance, or information to be obtained from conversation with neighbors. "An ounce of prevention is worth a pound of cure" applies to the goat industry as well as other situations. Except possibly for more valuable stud animals, it is usually not economically advisable to rely on intensive treatment of individual animals, but it is important to determine the cause of losses and to prevent subsequent losses from the same or other causes. Good care, vaccination (where useful) and isolation of sick animals (in some cases) and precautions (possible quarantine) for animals being brought into the flock are important considerations.

Diseases due to microorganisms may be caused by organisms which are endemic in the environment, but are not generally regarded as contagious (enterotoxemia), while others may be transmissible, such as pinkeye or soremouth. For obvious reasons, management of diseases which fit into each of these categories would be different. A few specific diseases will be reviewed.

**Pinkeye** is a common name, at least in the U.S., for a condition which has many names in the scientific literature, such as infectious *keratoconjunctivitis* or *contagious ophthalmia*. The causative agents are thought to be *Chlamydia* or *Mycoplasma*. It may well be that more organisms are involved in the clinical expression of the disease. In outbreaks, the infection rate may be high, but the death rate is normally low. Animals seldom die from pinkeye directly, but may be lost from factors such as starvation or dehydration which is associated with the resulting blindness. Most animals go blind, at least temporarily, in the infected eye or eyes, and when both eyes are infected the result can be total blindness. Outbreaks tend to be sporadic in nature, but can be initiated or precipitated by introducing animals into the flock which may carry the disease organism. Outbreaks may be exaggerated or initiated by irritations to the eye such as hauling in the open air. This may be due to irritations of the eyes or to the stress of handling. The disease can range from mild infections to complete blindness of a temporary or (rarely) of a permanent nature. The extent of flock involvement may be greatly influenced by the amount of immunity present from past infections. Immunity is not thought to be permanent or 100 percent.

Treatment tends to be ineffectual in nature, and generally the disease is allowed to run its course. If caught in the early stages, treatment with commercial ophthalmic preparations may reduce the severity of the disease by preventing secondary infections. If only one eye is involved at a time, the animal may be little affected by the disease. If both eyes are involved at the same time and the animal is blind, the problem may seriously affect the animal. The temptation is to bring these animals to barns, but this may not be desirable. Wild, range-raised animals may suffer less if left undisturbed. This is especially true if green forage is available where the animal will not starve. If only one of a pair of animals (such as doe and kid) are affected, one may lead the other to feed or water. If only a few animals are infected it may be desirable to isolate these, but if several are involved, there would be little gain from isolation. Supportive treatment with commonly available ophthalmic preparations may be beneficial.

Caution should be exercised in using preparations which might irritate the eye. If intramuscular antibiotics are used, tetracycline or tylosin are drugs of choice. Vaccines are not yet available for this condition.

**Soremouth**. This disease may be known by a number of names such as *contagious ecthyma* or *contagious pustular dermatitis*. It is caused by a virus which is likely to be found in most goat-producing areas. Goats, along with sheep and even humans, are susceptible. The lesions, crusty scabby sores, are typically found on the mouth and lips, but may spread to other parts of the body such as eyelids, ears, teats or occasionally over the body. Lesions other than on the mouth or lips seem to be more prevalent with goats than is the case with sheep. The infectious rate may be high in a susceptible population. Death loss will likely be low, and would more likely result from starvation or other complications such as fly strike. This condition was very serious when screw worms (the larva form of *Cochliomyia hominivorax*) were a threat. Treatment is of little value except supportive treatment necessary to keep the animal alive until the disease has run its course of two or three weeks. Fortunately, vaccination is effective. Vaccination at a young age (at marking) is recommended in areas where the disease is found, but many goats are not vaccinated under range conditions. The vaccine currently used is a live virus taken from the scab of infected animals. The principle is based on the premise that the systemic effects of the disease are not great, but that the location, such as the mouth, is the primary cause of trouble. Thus, vaccination consists of applying the live virus to an abrasion or scratch in the skin at an inoffensive location such as the flank or inside the rear leg. Humans are susceptible to this condition resulting in scabs or sores and fever. Therefore producers should be cautious not to infect themselves. Since the vaccine is a live virus, its use would not be recommended in areas where the disease is not known to exist. Producers who are unable to purchase vaccine might, at times of outbreaks, be able to make their own by using the scab from active cases and mixing the ground scab with a liquid such as glycerine. The virus resists drying and thus can live for extended periods of time. Once the condition has been observed on a property, it may be expected to reoccur when susceptible animals are present.

***Caseous lymphadenitis.*** Abscesses are a serious problem with goats and sheep, but less prevalent with Angoras under extensive conditions than with dairy type goats managed under intensive conditions. The apparent explanation is that the latter spend more time in or around barns and pens which can be areas of contamination. A number of organisms may cause abscesses, but in the case of sheep or goats, the problem is primarily attributable to two organisms known as *Corynebacterium pseudotuberculosis* or *C. pyogenes*. The first organism named is commonly associated with the cheesy gland disease commonly called caseous lymphadenitis. As observed, these abscesses appear in the lymph glands under the skin surface. However, internal abscesses also occur, and if it is associated with a vital organ, the animal may be seriously affected. Except when associated with vital internal organs, the disease is not acute, but presents a chronic situation which may be a source of infection to other animals in the flocks, and may result in condemnation of the animal at slaughter. The normal incidence of lesions in Angora goats under range conditions is less than 5%.

Apparently it is theoretically possible to establish and maintain flocks which are free of this condition. This is often attempted and is sometimes successful with small flocks of dairy goats. In the case of most Angora flocks this would be difficult since most producers also run sheep and cattle and attempting to maintain the high degree of isolation necessary to protect against this organism would seriously interfere with management alternatives or the introduction of desirable breeding stock. The second, and closely related organism, *Corneybacterium pyogenes* causes a very similar lesion, but may often be distinguished by location (subcutaneous) and the fact that the pus pockets are more liquid. This organism is thought to be widespread in nature, especially around barns or lots. This organism is more likely to be distributed by abrasions in the skin than is *C. pseudotuberculosis*, which tends to be confined to the lymphatic system. One precaution which should be exercised with Angora goats is to insure that the organisms are not spread with the shearing head. It is not practical to disinfect the shearing head between individual animals, but if a shearer is observed to cut into an abscess, it would be advisable to clean and disinfect the shearing head before going on to other animals.

Vaccines against *C. pseudotuberculosis* have been developed and are currently available in the U.S.. The effectiveness of these vaccines have not been tested in goats, but its use should be considered in stud flocks or flocks maintained under intense conditions. At this time, routine vaccination of commercial flocks under range conditions is probably not indicated. Therapeutic treatments such as antibiotics are not generally effective, especially after lesions are observed. External lesions may be opened and thoroughly cleaned with a good antiseptic such as an iodine solution. This would tend to reduce blemish on the animal and reduce this as a source of dissemination of the organism to other animals, as these lesions will eventually rupture, spreading the organism. Culling of affected animals should be considered.

**Enterotoxemia.** Goats are susceptible to enterotoxemia caused by *Clostridium perfringens* (Type C & D). These organisms are normally found in the alimentary tract, but develop or multiply at a rate adequate to produce disease only when the animals are fed a diet high in carbohydrates or succulent or highly digestible feed. Thus, this disease is not considered transmissible from one animal to the next, but outbreaks can occur due to predisposing factors. On the range where most Angora goats are raised, they seldom have access to overloading on grain, and thus producers do not practice widespread vaccination or other preventive measures. Most texts recommend routine vaccination, but the writer has not observed serious losses of goats attributable to enterotoxemia. However, at times of favorable prices when it is desired to maximize production through heavy feeding, vaccination may be advisable. If vaccination is practiced, it should be initiated at weaning and annually thereafter for does in late gestation. There is some concern that enterotoxemia may provide a partial explanation for heavy death losses of kids when under intensive conditions. In the cases where a complete mixed ration is being used, the addition of aureomycin and terramycin at the rate of 15 mg/lb will give some protection against this disease.

Diagnosis of enterotoxemia is difficult, and can more likely be done by conditions than by symptoms. In the case of the acute form, the animals are usually dead when observed. If the condition is observed in the very early stages, the use of massive doses of anti-toxin may effect a recovery, but this is rarely accomplished in practice.

**Other Clostridial Diseases.** There are a number of diseases which are caused by a group of organisms known as *Clostridium spp*. These include blackleg, malignant edema, tetanus, etc. Goats are susceptible to these diseases, but they are seldom a problem. Vaccines are available, but vaccination is generally practiced or recommended only on those properties where these diseases are endemic or have a history of occurrence, or where an outbreak has occurred. If these conditions are observed or suspected, a veterinarian should be consulted. The organism causing tetanus (*Clostridium tetani*) is often present around barns or pens. Vaccination (toxoid) may be advisable for animals to be castrated surgically or by rubber bands or those exposed to other types of cuts or injuries, or in flocks having a history of this condition.

**Pneumonia.** Pneumonia is seldom a primary cause of loss with Angoras grown under extensive conditions. If they are confined to overcrowded quarters with poor ventilation, pneumonia might occur. Also, pneumonia might result following exposure to wet conditions or as a secondary problem among animals ill from other causes. Treatment should consist of correcting the conditions which predisposed the animal to pneumonia. Good supportive care (fresh feed and water) along with treatment with appropriate antibiotics (penicillin, tetracycline, sulfonamide or tylosin) will often give favorable results in cases of bacterial pneumonia. Mycoplasma pneumonia is sometimes reported as a problem with goats, but it is apparently not known as a serious problem with Angora goats grown under extensive conditions. This type of pneumonia does not respond well to antibiotics (LA-200-oxytetracycline is drug of choice). The animals often show chronic lung involvement and will suffer particularly in hot weather.

**Bluetongue**. Bluetongue is found in some areas where Angoras are produced, and they are listed among the ruminants being susceptible to this disease. However, lesions or symptoms are very rare in the Angora, with the result that it does not constitute a production problem. However, it may constitute a problem in attempts to export the animals to other countries. Goats often show serological evidence of the disease, and where such tests are required in merchandizing for export, problems are frequently encountered. The disease vector is considered to be biting insects, especially the *Culicoides* gnat, which tends to be active during warm weather. Thus, producers desiring or expecting to participate in the export market should consider confining prospective export animals in screened or insect-proof quarters during warm seasons. The incidence of infection may be reduced through insect control, i.e., elimination of wet spots suitable for insect breeding or spraying the animals to reduce insect bites. Vaccines are available, but only against some of the strains which might be encountered.

**Dysentery or scours**. These terms are similar, but not exactly the same. Dysentery usually refers to bloody scours. There are three types of scours: 1.) Nutritional (succulent forage), 2.) infectious (*E. Coli* and *Salmonella*, etc.) or 3.) parasitic (coccidia). Nutritional scours is not particularly serious, and the latter will be covered at another point. For animals kidded in confinement, scours may develop as a serious problem for young kids. This is normally thought to be due to a pathological form of *Escherichia coli*, which is a normal inhabitant of soil or fecal material, but which does not normally cause trouble. Other organisms may also cause dysentery. When outbreaks occur, the best advice may be to move the flock to clean quarters and attempt to isolate active cases. Where this is not feasible, the producer would be advised to obtain veterinary assistance to identify the specific organism involved. In many cases, one of the sulfa drugs administered to the kid directly, or to and through the doe's milk, or in water, will provide some protection. Some researchers also suggest *Clostridium perfringers* (Type D, a form of enterotoxemia) can cause dysentery for the growing kid. This is not known to be a serious problem with goats on Texas ranges. This condition could theoretically be lessened by vaccination of the dam or the offspring with the appropriate vaccine (Type C and D).

**Mastitis.** Active cases of mastitis (hard, swollen, feverish udders) or damaged udders resulting from earlier cases of mastitis are a common observation in Angora goats. It most frequently is found in does which have been well fed at, or around, kidding. This may be surprising to many who consider that angora does are poor milkers. Actually, lactation is almost the only function which takes precedence over fiber production in the Angora. Perhaps the most useful suggestion is to be aware of damaged udders as a reason for culling does. Does with damaged or nonfunctional udders have been recorded as high as 15% in some flocks. Prevention should hold more interest than culling as a means of dealing with the problem. Misshapen udders in which the kid is unable to nurse are a common cause of udder problems and death loss of kids. Misshapen or damaged udders may be of genetic or nutritional origin, but perhaps the most frequent cause will be teats which are clipped at shearing. Although a high level of feeding can increase this problem, a failure to feed as a preventative for udder problems is not indicated. A number of micro-organisms can cause mastitis. These include *Streptococcus spp., Staphylococcus spp., Corneybacterium spp., Escherichia coli* or *Pasteurella hemolytica*. Sanitation (of kidding faculties) and the use of antibiotics (penicillin, ampicillin or tetracycline) used intra-muscularly may help to save the doe, but will have limited value in preserving the udder as damage to the gland will tend to be permanent. Most flocks have a significant percentage of does with damaged teats resulting from shearing. This should be minimized.

***Caprine Arthritis Encephalitis (CAE*** ) and ***Scrapie*** are two serious disease problems which are caused by slow viruses or virus-like organisms to which goats are susceptible. Scrapie apparently has not been diagnosed in Angora goats in this country except in cases where it has been intentionally inoculated in experimental animals. CAE is a serious problem which has been reported to be widespread in dairy goats in this country. This condition, or symptoms of this condition, is almost non-existent in Angora goats under range conditions. There has not been extensive testing. Since it is primarily transmitted through the milk, it will not rapidly spread to this population, but it should be remembered that it can be spread to a limited extent through contact. Care should be taken in the purchase and use of dairy-type goats as nurse mothers for Angoras. CAE should be suspected if goats develop lameness and enlarged knee joints which do not go away. Producers which have, or suspect they have, either of these conditions in their flock should seek veterinary assistance.

**Brucellosis (*Brucella melitensis)*** is due to a different organism in goats to that of sheep and cattle. It can cause abortion, but is not the normal cause of abortion in Angora goats. This disease is rarely found in goats in the U.S., but it is present in Mexico and could spread to the U.S. It is not known to have been diagnosed as a problem with Angora goats under range conditions. If it is found to be present, efforts should be directed at eliminating the problem through test and slaughter. It is a reportable disease and it can pose a danger to the human population.

**Foot rot**. Angora goats are susceptible to foot rot, but perhaps less so than sheep. Also, since goats tend to be concentrated in arid regions, they are less exposed to the problem. If the problem does exist among Angora kept under wet conditions, it must be dealt with by use of a combination of foot trimming, foot baths (Zinc Sulfate or Formalin), and isolation of infected animals; vaccination may also offer potential. A single management tool is seldom effective in controlling infectious foot rot. Lame goats, particularly under moist conditions on the range, may result from a number of conditions other than foot rot.

**Other Infectious Diseases**

A number of other infectious diseases such as **Johne's disease, listeriosis, salmonellosis, leptospirosis, rabies, Chlamydia abortion, toxoplasmosis**, etc. can occur with Angora goats. The writer has not observed or known these to be a problem with Angoras under Texas range conditions. There is limited evidence that Johne's disease is found in more than one species of domestic livestock in range areas and could present problems. At present there is little that can be done about this condition.

**Internal and External Parasites**

Both internal and external parasites constitute problems which must be dealt with in producing Angora goats. Their high level of fiber production tends to place them in nutritional stress for much of the time, which accentuates the debilitating effects of parasitism. Since many Angoras are run in arid regions and because of their browsing behavior, they may have some protection against internal parasites. At the same time, their lack of exposure may make them more susceptible (due to a lack of resistance) on those occasions in which they do become infected.

**Internal parasites.** The primary parasite problems are the gastrointestinal nematodes (roundworms) and coccidia, but lungworms, tapeworms, liver flukes and nose bots may also occur.

**Roundworms.** Essentially the same roundworms affect Angoras as other domestic ruminants. These include the *Haemonchus contortus, Ostertagia* (more than one species), *Trichostrongylus* (more than one species) *Cooperia sp*. and *Nematodirus sp*. Others of less importance are *Oesophagostomum* (nodular worm), *Trichuris* (whipworm), *Bunostomum sp*. (hookworm) and *Dictyocaulus filaria* (lungworm).

A detailed discussion of each of these groups or species would require a great amount of space and time. There is a great deal of similarity in life cycle, symptoms of infection and methods of treatment for the more important species. Perhaps the most important internal parasite is the *H. contortus*, which is sometimes called the large roundworm or barber pole worm. This parasite can be easily visualized in the fourth stomach or abomasum at autopsy. Other types of roundworms are more difficult to see without magnification. The first symptom of parasite infection is one of reduced growth or performance, but this may not always be evident over a short period of time. The most obvious clinical symptom is anemia as indicated by pale membranes of the eyes or similar tissue or edema (accumulation of fluid) along the underline. There is an often held belief that roundworms cause scouring, but this is rarely the case, especially with *H. contortus*. The more typical parasites, such as *H. contortus*, will actually cause anemia and hypoproteinemia resulting in fluid retention. It can be safely assumed that essentially all goats harbor stomach worms, but the challenge to the producer is to appraise the severity of the problem and to devise an appropriate management or treatment schedule.

The life cycles of the major roundworm species tend to be very similar and will be reviewed here only in general terms. The adult worms produce a large number of eggs (*H. contortus* are thought to produce up to 10,000 eggs per day) which are passed out with the feces. These hatch or develop into infective (third stage) larvae. These crawl onto grass or forage and are, in turn, consumed by goats and again develop into adult intestinal parasites in the abomasum or intestines. This process is hastened or enhanced by warm, moist conditions. Cold or dry conditions retard the development of internal parasites, but neither is adequate to insure against a problem. The entire process requires approximately three weeks under warm conditions, but will be longer in cold environments. A minimum of approximately five days is required from the time eggs are released in the droppings until the larvae become infective.

Clinical parasitism is more likely to be observed under nutritional or other types of stress (young or growing kids or lactating does) or when goats are forced to exist on low protein, prostrate growing forages (curly mesquite or bermuda grass) which are particularly condusive to parasitism in goats. Clinical parasitism is more likely to occur in the summer time, but producers should be aware of the problem or possibility of overwintering of parasites in the G.I. tract. This can result in an exploding population in the spring (spring rise or post-parturient rise phenomenon). Hopefully, producers should attempt to go into the spring with clean (de-wormed) animals and clean pastures. With at least one parasite (*Trichostrongylus columbiformu*), the larvae may overwinter in an immature state which is more difficult to remove with anthelmintics and can be a cause of serious problems with Angoras.

Management of internal parasitism should consist of: 1.) maintaining a good level of nutrition, 2.) do not practice overstocking, 3.) use some type of rotation, 4.) allow the animals to browse as much as possible 5.) use mixed species grazing and 6.) the use of therapeutic treatments (de-worming) as necessary to prevent mortality or economic loss.

Each of these will be discussed briefly. For animals on a high plane of nutrition, internal parasites (excluding coccidiosis) may not show clinical symptoms or even evidence of economic loss. Unfortunately, natural pasture conditions are not always adequate to maintain the animal on a high level of nutrition. Concentrate or supplemental feeding is seldom justified, in economic terms, merely to provide resistance to parasitism as therapeutic drenching is less expensive. However, this may be an additional benefit from overcoming nutritional deficiencies. A high stocking rate will contribute to internal parasite load through increasing the level of contamination and reducing the level of nutrition. It should be obvious that a totally browsing animal is unlikely to become infected with internal parasites as the larvae will not be able to negotiate this high from ground level. This is seldom the case as some ground feeding will occur under most situations. It appears that over the long term Angora goats will primarily be found where browse is available, but in times of favorable prices they can be produced successfully on grass alone. Angora goats do well and are well adapted to utilization of the winter grazing from small grains (wheat, oats, etc.), but it is only in times of favorable prices for mohair that they can compete with cattle or sheep as income producers from this type of forage. Even in the absence of browse, goats prefer to graze above ground level, which provides significant protection from internal parasitism. They will often be observed to be feeding on seed heads of plants well above the level of which parasite larvae are present.

The concept of pasture rotation along with strategic drenching are important concepts which should be exploited or considered. Rotations have often been oversold as a means of internal parasite control. Two important concepts should be kept in mind in considering rotation in respect to parasite control; the minimal time required for parasite larvae to reach the infective stage after the eggs are deposited in the pasture; and the maximum survival time of eggs or larvae on pasture. Unfortunately, neither of these can be stated exactly, since they are highly dependent upon environmental conditions. In general, parasite larvae can reach the infective stage in as little as five days, when temperature and humidity are optimal. Thus, if relatively clean animals are put into a "short duration" grazing system where they remain in the same pasture less than one week, they should be able to go for extended periods of time without developing a parasite load. This has been successfully demonstrated with sheep, but the writer is unaware of similar data with goats. However, there appears to be no reason why the same principal should not apply to goats as well. An equally important concept is how long the animals must remain out of the pasture to insure that the larvae are no longer infective. There have been instances in which rotation actually intensified parasitic problems when animals were rotated back into a pasture at a time when large numbers of infective larvae were present. Under arid conditions, where the larvae are exposed to sunlight and low humidity (little ground cover or short grass) survival times may be short with most gone within 30 days. Alternatively, where good ground cover exists and humidity is relatively high, larvae may survive 90 days or more. Thus, in an idealized intense rotation scheme the animals would stay in a pasture for less than one week and would not return in less than 90 days. This would require at least 12 pastures. Few goat producers are involved in such intense schemes at the present, and this grazing system cannot be justified for parasite control alone. No doubt other less intense schemes, such as four pasture rotation systems will be beneficial in reducing the parasite load and can be utilized along with monitoring the animals for parasite build up by the use of fecal egg counts or measures of anemia. Most rotations are better than none at all, but for flocks (especially muttons) run under extensive arid and browsing conditions, rotations should not be considered as a necessity in respect to parasite control. In less intense rotation systems such as the two, three and four pasture systems where animals are moved from one to four times per year, consideration should be given to the use of strategic drenching just before the animals are turned to a clean pasture. It should be remembered that a drug which is 100% effective in removing the parasitic stages will usually not destroy the eggs in the lower part of the gastro-intestinal tract. Thus, if animals could be held off clean pastures for 1 to 3 days following drenching, there should be some reduction in the transfer of parasites to the clean pasture.

It should be remembered that some of the same species of intestinal roundworms infect cattle, sheep, goats and wild ruminants, and this is particularly true of sheep and goats. The amount of cross infection between these species is not clear, but most parasitologists consider parasites to be host species specific and thus that cross infection should be limited. The writer does not feel comfortable with stating categorically that cross infection does not occur between sheep and goats, but the likelihood of cross infection between more distantly related species such as cattle or game animals appears minimal. If it is accepted that there is no cross species transmission between cattle and goats then mixed (or rotated) species grazing will reduce the parasite load to both species. This has important implications where the animals are primarily grazing as contrasted to browsing.

Another use of strategic drenching would be to treat the animals in the fall to reduce worm burden going into winter, or to treat in the spring prior to kidding or the time the kids start to graze to remove overwintering parasites and minimize the dam contribution as a source of parasite infection to the kid. Optimally, drug use should be minimized except on an as-needed basis, dependent upon diagnosed parasite loads. Treatment may vary from none under extensive grazing and arid conditions, to as many as monthly drenchings where goats are concentrated on warm season forages, such as bermuda grass, under humid conditions. It is the writer's belief that many producers practice excessive use of drugs, which is expensive, and also contributes to the development of parasite resistance to available drugs. No more than two treatments per year should be the goal, but regardless of the goal, they should be treated when the need is evident.

**Anthelmintics**.

Treatment regimes should follow closely the label instructions on the anthelmintics chosen.

Unfortunately, in the U.S. many useful drugs are not labeled and approved for goats. Treatment regimes (dosage, etc.) are often based on producer experience or extrapolated from recommendations for sheep. Since the Angora goat is primarily a fiber producer, there is less cause for concern about tissue residues in meat since most are not used for meat except for those that are culled at advanced ages. However, it is prudent to advise that only approved drugs be used or that treatment be under the direction of a veterinarian to protect against unsafe, unwise or illegal use of drugs.

The drugs (anthelmintics) available or of choice will vary with time and locality involved. At present there are three anthelmentics or groups of anthelmentics . The two most recent of these are Ivermectin (Ivermec) and Levamisole (or Tramisol). Ivermec may well be the most effective for most producers, but it may be advisable to use it sparingly. The third represents a group of drenches sometimes called the white drenches; thiabendazole (TBZ), albendazole, fenbendazole (Panicur or Safeguard) or oxfendazole. **All** of these are or were reasonably effective against roundworms, and in some cases tapeworms (Albendazole), except as parasite resistance has developed from repeated use. It has now been demonstrated that resistance exists to all these drenches, but this is not the case on every property. All of the so-called white drenches are chemically similar and one would expect parasites which become resistant to one will likely show some cross resistance to the others in this group. Only Thiabendazole has been used extensively in the country in the past. There is some concern about an adverse effect of Albendazole when used shortly after mating. It would be preferable that does not be drenched with any anthelmintic shortly after mating. Phenothiazine was extensively used in the past, and should be considered again if other or newer drugs become ineffective. Many other compounds are effective as anthelmintics, but most have narrow safety margins. Some of these are available on the market for other uses, but they cannot be generally recommended or sold for use as anthelmintics. No anthelmintic is ideal in terms of cost and effectiveness, and resistance has developed to most over long-term use. Unless or until new drugs become available, it is important that producers attempt to safeguard the usefulness of those available by using them in rotation. It is not clear to the writer what is the best rotation. The options are: rotate with each use, rotate annually or use one drug until it is no longer effective. Some professional parasitologists recommend the latter.

**Coccidiosis**. Coccidiosis is a protozoal parasite which is a serious problem with goats in general, especially Angora kids. This is known to be a problem with Angora goats in most countries where they are produced. In the absence of preventive measures or effective treatment, losses as great as 25% of weaning age kids have been reported to the writer. All goats harbor coccidia, but at a low level which may contribute to the development of host resistance and not cause disease. Some form of stress often triggers the diseased condition. The primary problem occurs when young or weaned kids, are accumulated or allowed to accumulate in concentrated areas where contamination and infection builds up. Rapid infection with high numbers of cysts occur through contamination of feed or water sources, or ground feeding. The symptoms are weight loss, debilitation and scouring. Death will result in a significant percentage of the cases unless treatment is instituted early. The disease causes scar tissue on the intestines with the result that some may survive, but perform poorly thereafter due to limited absorption tissue. Adult animals normally develop clinical coccidiosis only after some type of stress such as malnutrition.

The life cycle of this parasite is complicated, having both sexual and asexual forms. Eggs, known as oocysts, are passed in the feces, which, upon ingestion by a susceptible animal, the numbers replicate or multiply rapidly inside the intestines resulting in an acute phase of the disease. This usually occurs within three weeks. The animal either dies or recovers in which case the animal tends to develop an immunity to that particular coccidia species. Unfortunately, there are many species of coccidia, but it is not known how many of these affect the goat. *Eimeria arloingi* is usually the most important, but many others such as *E. ahsata, E. parva*, etc., are present at times. It is considered that there is some cross infection between sheep and goats in respect to coccidia, but not with most other livestock species or birds.

A number of highly effective preventive or treatment regimes are available but may not always be easily implemented in practice. The first of these is to avoid those situations in which susceptible animals are allowed to heavily contaminate areas. Under pasture conditions susceptible animals should be prevented from spending a large amount of time around feed and water sources which are areas favorable for coccidia. In lots or corrals infection may be prevented by cleaning the feed or water sources frequently. The problem with this is that few people are willing or able to serve as a chambermaid to a goat. Where the animals are fed under controlled conditions, a number of good coccidiostats are known which may be added to the ration. Included in this list are: monesin (Rumensin), amprolium (Corid), sulfamethiazine (and other sulfa drugs), lasalocid (Bovatec), decoquinate (Deccox) and to some extent elemental sulfur. Unfortunately, some of these may not be approved or available to the individual producer in a form in which he can use them. When they are used, they should be used in accordance with labels. Of those listed, monesin is one of the more effective and it has other desirable effects, such as improved efficiency of feed use or protein sparing effects. It may be used at the rate of 5 to 15 grams of active ingredient per ton of feed. The lower range is somewhat effective as a coccidia preventive, but for treatment or maximum nutritional advantage the higher rate should be used. The above suggested levels are for use in a complete ration, and should be adjusted upwards when it is to be utilized in supplements. For therapeutic treatment of clinical cases, most producers rely on oral treatments with one of the sulfa drugs. These treatments are administered for three or more consecutive days by drench or through the drinking water. It is possible to manage this problem to the extent that no losses occur, but it may require close observation and attention to detail. Tannic acid and those browse plants containing tannin are thought to have some benefits in reducing coccidiosis. Thus, the browsing animal may be less susceptible to coccidiosis.

**Liver flukes**. Goats are susceptible to liver flukes, which can cause severe problems, including death. However, the liver flukes require standing water as an aquatic snail is necessary to complete their life cycle. Thus, it is difficult to visualize this as a problem with range goats. For the producer, diagnosis may be difficult, but once diagnosis can be made, treatment is possible. Of those available in the U.S., Albendazole is the drug of choice.

**Tapeworms**. Tapeworms are long white flat worms, some of which may reach from one to several feet long. Infestations can often be determined by visualizing segments (like rice grains) in the droppings. Their life cycle is similar to roundworms, except that they require a free living grass mite to complete their life cycle. Tapeworms are not considered to be particularly harmful except for heavy infestations in young animals, where they may cause blockage of the intestines. They are removed by albendazole, oxfendazole, and fenbendazole, but not by levamisole, ivermectin or phenothiazine.

**Others**. Goats are susceptible to a number of parasitic diseases, but which are normally of minor importance in the U.S. Among these are Anaplasmosis, Babesiosis and Parelaphostrongylus tenuis (the menengial worm) in the U.S and others such as heartwater and trypanosomiasis in Africa. Of those occurring in the U.S., only Anaplasmosis can be treated by use of tetracycline. The menengial worm (Scarfe, 1990) results in posterior paralysis in goats and can be a potential threat to goat production in the wetter regions of the Southeastern U.S.

**External parasites.**

Angora goats are subject to much of the same external parasite problems as other livestock such as ticks, lice, scabies (mites), flies, grubs, etc. and dealing with these is much the same as with other types of livestock. Lice are much more prevalent on Angora goats than with most other types of livestock, and thus they deserve special treatment. In the U.S., Angoras can have biting and/or blood-sucking lice. These are considered to be of two genera and more than one species. These are Linognathus stenoosis and L. africanus (blood sucking) and Bovicola crossipes, B. limbata and B. caprae (biting lice). The blood sucking type cause a more serious problem. In one study the species found on Texas Angora goats were all of the Bovicola type (biting lice). Most lice tend to die or leave the animal following shearing, but this is never complete, and unless checked, the population may build up to large numbers between shearings. The actual production loss from lice infestation is apparently small, as several research studies have not shown an advantage from control efforts, but they are more likely to have a negative than a positive influence on production. It may well be that research studies have not been conducted in the most heavily infected flocks or that such studies have involved only the biting as contrasted to the blood-sucking species. Many producers appear to be overly concerned about lice on goats. Some flocks are never treated and appear to suffer little loss in production. Goats which spend their time in open areas (no shade or no barns) appear to have a lower infestation. Genetics (hair cover and amount of oil) may also have an effect. Apparently the most serious effect of lice infestation results from irritation or itching sensation causing the goat to scratch or rub. This can cause partial shedding and entangled or matted fleece, and possible loss of luster which may adversely affect market price of the mohair. A heavy infestation of the blood sucking species would be more serious and could cause anemia, especially in kids.

Most producers spray for lice and ticks out of the shearing pen, but this is largely a matter of convenience because the animals are already in pens or corrals. Most hand-held sprays do not kill all the lice and they rapidly repopulate. As previously stated, most lice leave the animals anyway following shearing. Spraying with hand-held spray guns is a useful practice, but if a producer plans to make a serious attempt to eliminate or to control lice, dipping provides a more satisfactory result. A shower type of treatment (See Figure 7-2) in which the animals are wet from both bottom and top appears to almost equal that of a plunge dip and will conserve spray material. Equipment of this type is not generally available for sale in the U.S., but can be fabricated or imported. Each of the above treatments may be made more effective by allowing the animals to grow a short fleece (two to eight weeks) before treating, in order to have a more lasting effect. Two treatments at approximately two-week intervals will give much better control as some lice will survive in the form of nits (eggs). However, once the animals get more than two months growth of mohair, treatment by sprays or dips becomes more difficult. In this case, "pour on" or "spot on" type of treatment may be effective (Fenthion, Neguvon or Ectrin) until the lice develop a resistance to these insecticides.

When used in a spray or dip, any of a wide range of insecticides will kill lice and ticks on goats. These include toxaphene, malathion, diazinon, lindane, etc. These should be used according to instructions. Although some sprays may be more effective than others, and lice have developed some degree of resistance to some of the drugs, essentially all will appear effective initially; but none will keep the lice off until the next shearing. Since lice can be easily seen on the animal, the producer can estimate the degree of infestation, the success of treatment and thus resistance to the drug being used.. If lice are viewed as a serious problem, the use of delayed and/or repeat spraying

(2 sprays at 2-week intervals) should be considered or dipping might be substituted for sprays. Finally, the use of topical applications to the skin should be considered if the infestation is heavy and shearing is not immediate. Treatment for lice will usually also remove ticks, but it may occasionally be desirable to treat for ticks at alternate times. The use of Ivomec for internal parasites should assist in the removal of blood sucking lice and ticks.

Goats are also susceptible to **headgrubs or nose bots** (larval form of *Oestrus ovis*), but apparently are more resistant than sheep. These grubs are difficult to remove. They can be successfully treated during a certain critical stage of larval development. The use of Ivomec for removal of intestinal round worms should be beneficial in removal of nose bots as well.

**Mange, Scabies or Scab**. Mange or scab, if present, is more serious than lice on goats. Mange is caused by mites which burrow into the skin or skin follicles causing serious irritation. There is more than one type of mange mite and most animal species (including humans) are susceptible to scab. The mange mite on various livestock species is largely indistinguishable, but the mites tend to be species specific and are not normally thought to move from one species to the next. Mange or scabies in sheep is a reportable disease, but this apparently does not apply to goats. There are at least three types of parasitic mites. These are Psoroptes, Sarcoptes and Chorioptes. A fourth type, Demodex caprae, is sometimes found in goats. Diagnosis of the mange mite is made from locating the mite in scrapings of the skin. However, location and identification of the mites is difficult and may require professional assistance.

In goats the mites may be found in the ear, especially of non-Angoras. Observed cases in Angoras have been on the scrotum and adjacent regions, especially the lower legs. Scab is rarely found on the body, but might spread to these areas if left untreated.

Scab in the Angora goat, although infrequently observed, is a serious problem and should not be tolerated. The first line of defense is to prevent introducing this problem into the flock, but once it is present it must be dealt with. It is passed from one animal to the next, but fortunately it is slow to spread through the flock. If only one, or a very few animals are affected, it may be advisable to sacrifice these. Treatment is difficult. A number of insecticides will kill the mite, but since it burrows into the skin, not all of the mites come in contact with insecticides and are removed by treatment. Ivermectin used as an injection or as a topical application has been reported to be effective against scab, but the writer's experience is that this material has limited value for control of scab. Control will usually require repeated treatments with insecticides, preferably used as a dip. Lindane appears to be one of the most effective insecticides available in this country for control of scab. Animals treated with Lindane require a 30 day time lapse prior to slaughter. Others which have been used include ectrin and diazinon. Regardless of the insecticide used, treatment must be repeated periodically (such as every two weeks) until the problem is cleared up.

## METABOLIC DISEASES

A metabolic disease technically refers to altered metabolism, but as used in this context refers to conditions which have their origin in nutrition or management as contrasted to infection. There are a number of such conditions which can occur with sheep and goats, but seldom represent a major constraint under commercial conditions. Included in these are acidosis, bloat, grass tetany, milk fever, posthitis, swelling disease (edema), urinary calculi, white muscle disease, etc,. Few of these actually cause serious troubles with goats under grazing conditions. **Acidosis** refers to overloading on grain in an animal which is not adapted to this type of feed. The result is a high acidity of the digestive system which can kill the animal, but more frequently cause the animal to go off feed for a variable period of time. There is little reason or logic to free choice feeding of goats on high grain rations, and thus little reason to incur this problem except for the case of accidental access to feed. **Bloat** is an extended rumen filled with gas which can result in death. It usually results from consuming fresh legume forage which also rarely occurs with the Angora under range conditions. Goats are less subject to bloat than some other species such as cattle, and they do not have a high dietary preference for or access to legumes such as alfalfas or clovers. There are two types of bloat which may have different origins. These are free gas bloat or frothy bloat. If observed early enough, some types of bloat can be treated by passing a stomach tube to release the gas. Prevention is more important and consists of altering the type of feed and/or by the use of anti-bloat agents in the feed. Rumensin which is often used with goats as a coccidiostat tends to reduce bloat. Other compounds in this group probably have similar properties. Poloxalene is a commonly used bloat retardant or can be used for treatment. It should be effective if taken regularly (daily), but the method of administration (i.e., in feed or salt) can present problems. It can be used to treat frothy bloat when given as a drench or directly into the rumen as an injection or by stomach tube.

**Grass tetany** results from an electrolyte imbalance as a result of consuming fast growing highly succulent forage. The condition is rarely observed in Angora. An affected animal will die unless they are treated, but most can be saved by providing electrolytes in the form of glucose solutions (containing magnesium) in the vein. **Milk fever** is a similar condition with the lactating animal which is producing a large volume of milk. Thus this problem appears to be rare in the Angora. It is caused by a rapid lowering of blood calcium as calcium is deposited in the udder following parturition. It can be treated by the use of electrolytes such as calcium gluconate in the vein or possibly under the skin or in the peritoneum. The author has not observed **white muscle disease** in the Angora, but it may well occur in areas which have low selenium levels in the soil. It is due to a deficiency of vitamin E or selenium or a combination of these. It can be treated or prevented by providing these as supplements in the feed, or injection. Selenium should only be used as directed, as it can be toxic. **Posthitis** (inflammation of the prepuce) is a condition which will frequently be observed in goats. It is restricted to the male as it represents a scabby ulceration over the sheath or prepuce. It may result in an inability of the animal to extend the penis or urinate. The condition tends to result from one or more of three situations. One of these is a high protein feedstuff in which the excess nitrogen is excreted in the urine as urea which changes the pH of the urine causing irritation of the tissue of the prepuce or sheath. A second condition is that the animal spends a lot of time around barns or contaminated bed grounds resulting in unsanitary conditions which may predispose infection of this area. The third condition is the presence of a specific organism belonging to the *Corneybacterium* (*C. renale)* group which is often found in the urine or under unsanitary conditions. This condition may be found in either intact males or in wethers and can at times represent a high infection rate. Testosterone implants have been used in some countries to combat the problem as it causes the wethers to extend their penis and reduce the irritation from the urine or the threat of blockage. This material is not available to livestock producers in the United States. Another preventative is not to overload the animal on protein. However, under some grazing conditions a high protein intake can occur from natural vegetation. Antibiotics in the feed, such as terramyacin or aureomycin as used in feedlot rations, will tend to reduce the likelihood of infection and to reduce the problem. This solution is somewhat impractical for the grazing animal. Treatment is possible, but is time consuming and may be slow to yield results. It consists of cleaning the infected area and removing the scab if the animal is unable to urinate. A good antiseptic solution, such as iodine scrub or hydrogen peroxide or a mild chlorine solution can be used. The use of a medicated antibiotic ointment applied to the area and in some cases an injection of an antibiotic is sometimes advisable.

**Urinary calculi** (waterbelly or urolithiasis) can also be a problem of Angora males. It can occur on the range, but under production conditions it tends to be restricted to potential breeding males which are receiving a high level feeding of formulated rations. It is also often seen in wether goats kept around the barns or in pens as lead animals. It is caused by formation of stones or calculus which block the urinary tract preventing urination and can cause rupture of the bladder. It can largely be prevented, but treatment has limited value. For young males to be fed in confinement, special rations should be formulated. The problem often results from animals being fed high phosphorus feeds such as rations containing grains (sorghum) and oil meals (cottonseed meal) and alfalfa. This problem can largely be prevented by insuring that the calcium to phosphorus ratio is 2 to 2.5 :1. This may require the addition of calcium supplements such as Calcium Carbonate to the ration. With valuable males it may also be advisable to include in the ration 0.5% ammonium chloride or 0.6% ammonium sulfate to acidify the urine. Potassium chloride may also have a similar effect, but would be preferable only if the ration tended to be low in potassium. Also salt (sodium chloride) should be included in the ration to insure that the animals drink plenty of water. The latter practice reduces the concentrations of chemicals in the urine and the tendency for calculus formation. It is important to insure that the animals have access to water (not frozen) on a continuous basis as calculi cases often show up during or after a period of water deprivation. The condition may be treated by surgical intervention, but this course of action has little value for goats since the cost would exceed the value of the animal. In some cases the initial blockage occurs in the urethral process (the small filiform appendage at the end of the penis). If this is the case it is possible to extend the penis and clip this off with no adverse effect to the animal. Any more drastic surgery would require veterinary assistance and likely leave the animal useless for breeding purposes. If detected in the very early stages some cases may be reversed by administration of urine acidifying agents. One of these is methionine hydrochloride, administered orally as a paste, or a solution of ammonium chloride used as a drench. The latter material could potentially be toxic or caustic and should be used with care. Relaxing drugs (such as Atropine) may be used to assist in passing stones. If treatment is to be effective, an early diagnosis must be made. The symptoms include dribbling of urine, sand or crystals around sheath, obvious signs of discomfort including biting or kicking at the sheath or belly.

**Swelling disease** (waterbelly or ventral edema) may sometimes be confused with urinary calculi, but it has totally different physiological explanation. It is largely due to anemia or fluid loss in the tissue with the excess fluid accumulating along the underline or in the legs (the lower part of the body). Affected animals do not normally appear sick, but the condition is usually evident to the observer. It is rarely fatal, but is certainly an indication that all is not well with the animal (See Figure 7-3). This condition is almost totally restricted to reasonably high producing Angora goats indicating that it is nutritional or physiologic in origin, and is associated with the high level of mohair production. It appears often to be increased or predisposed by parasitism, low protein intake or some type of stress such as shearing. Prevention should call for insuring that the animals are not suffering from a high level of parasitism and that they are receiving an adequate level of protein and to minimize stress. Hypoproteinemia may not necessarily result only from a low protein content in the ration, but also from a high protein (or a specific amino acid) requirement of the animal as a result of a high level of fiber production. An iron deficiency is sometimes considered to be a predisposing factor. The condition is often seen in young males being developed for breeding purposes, but since this condition is a strong clue that the animal may be "over bred or otherwise unsuited" for their environment, it may not be desirable to use this type of animal for breeding purposes at least as a stud animal, even if they recover. Treatment consists of removing the above mentioned predisposing conditions and in extreme cases treatment with a diuretic (such as lasix) to encourage the animal to pass the excess fluid accumulation. A complete or total explanation for this condition is not available at present.

**Pregnancy toxemia** (ketosis, twin lamb or kid disease or pregnancy disease) is often listed as a metabolic disease. It is due to incomplete breakdown of fat among pregnant animals requiring a great amount of energy (glucose) during late gestation. The writer has not observed this as a problem with Angoras but it presumably can occur. The small amount of fat on Angoras and their tendency to abort partially protect them from pregnancy toxemia. Prevention would consist of providing adequate energy during late pregnancy. Treatment might consist of oral administration of molasses or propylene glycol.

**Abortion** occurs more frequently in Angora than other types of farm or ranch livestock. Goats in general, and the Angora in particular, are highly predisposed to this problem. It is generally realized that this condition is related to nutrition, primarily a deficiency of size or energy or to stress which disrupts normal feeding. This problem was discussed more thoroughly in the chapter on reproduction.

**Toxic Plants**

Due to the nature of their grazing habits and conditions under which they are raised, toxic plants are one of the major problem areas for Angora goat producers. Discussing this problem is made more difficult by the realization that toxicity is a relative term in that most feedstuffs or forages can have adverse effects at some time or some place or in some amounts. For instance, some favorite feedstuffs can cause trouble. Alfalfa may cause bloat and a condition known as "red gut," and in some cases a high estrogen content interferes with reproduction. Small grain forages carry a threat of producing "swellhead" or photosensitization. Sorghum forages carry a threat of prussic acid poisoning. Overfeeding on grain carries the threat of acidosis or enterotoxemia. Cottonseed or cottonseed products have the potential, under some condition, of causing gossypol toxicity. Toxic plants are present on almost all rangelands, and the ability to use these lands is based on the premise that animals will not eat these plants or will not eat them in sufficient amounts to cause trouble. Many toxic plant problems result from overstocking (sometimes intentionally for control of noxious plants), forcing the animals to utilize plants which they might otherwise ignore. Additionally, goats may be included in grazing programs in the belief that they are less likely to graze toxic plants or are more resistant to them or that goats may be used in some causes to remove plants (leafy spurge) which constitute a problem with other livestock species. It is important for individual producers to know the potentially troublesome plants in their area, the likelihood of their causing problems and the symptoms they produce. There are a number of reviews of toxic plants (see James, *et al*., 1980, Sperry, Dollahite, Hoffman and Camp, 1977 and Rowell, undated) which collectively list approximately 100 plants which have the potential of causing problems, and still do not list some of those which can be a threat to goats. Many of the more common plants found on rangelands are listed as a threat under some conditions. These include most types of oaks, mesquite, white brush, black brush, a variety of milk weeds, and number of plants in the nightshade or Solanum group, etc. Fortunately the writer has had little experience with many of these potential problems. In many cases a good source of information may be obtained from producers who have had long experience running goats in a given area. A number of plants with the potential to cause trouble (taken largely from the above mentioned sources) are listed in outline form in Table 7-1. Some of these plants have not been reported to cause trouble with goats, but they are listed in the belief that this may reflect the fact that goats are not routinely produced in areas where these plants are present. The current tendency for goats to move into new areas may result in losses in the future. Admittedly, this list does not contain all potentially toxic plants and tends to emphasize the plants found on the range lands of the Southwest. In addition to this listing, a few individual plants or conditions or groups of plants will be discussed in more detail. Losses due to toxic plants are more likely to be observed on overstocked ranges, or when hungry animals are turned to pastures where toxic plants are a threat.

A number of poisonous plants cause **photosensitization or "swellhead"** (sensitivity to light). These conditions (See Figure 7-4) are usually due to liver damage, but some plants result in this condition without evidence of liver damage. If caught in the early stages and removed to shady or protected areas some of the affected animals will recover, depending on the amount of liver damage. More importantly, if producers become proficient in identifying the early symptoms they may be able to take protective action (ie. move to pens or to new pastures) before heavy losses occur.

A number of plants are **nitrate accumulators** (pigweed, carelessweed, kochia, etc.) and thus can be toxic. These tend to be those found around barns or pens where the soils have a high level of fertility, but the problem can also be encountered under field conditions. Care should be exercised in allowing hungry animals access to the areas or type of plants mentioned. Nitrates or their by-products bind with hemoglobin in the blood to reduce the oxygen carrying capacity. There is little warning of toxicity and death may be the first evidence, but occasionally labored breathing, particularly after being stressed may be seen.

Some plants are also **selenium accumulators**, but these are not common in areas where Angoras are normally produced.

**Oak** poisoning is rare in goats as many Texas ranges have some type of oak as an important forage for goats, and goats may be included in the range management program to control or utilize oaks. Problems are rare, but heavy losses are known to have occurred in cases where goats are forced to live almost exclusively on oak forage. Since most parts of the oak plant are low in feed value, losses may have been due to a combination of starvation and poisoning. Observed losses have been mostly with broadleaf type of oak such as scrub oak or blackjack oak. Early growth or buds of shin oak are known to be dangerous to cattle, and potentially goats as well. The problem with oak is tannins or tannic acid, and the feeding of an anti-acid such as calcium oxide (slaked lime) has been shown to be beneficial in preventing losses in cattle. It is usually administered in a salt or mineral mixture at 8 to 10%. In theory, animals such as the goat which rely heavily on the oak as a feed source might benefit from routine administration of calcium oxide. The writer has made repeated attempts to demonstrate such a benefit without success, but in those cases no death losses were encountered even in the control groups. However, since the tannin in these plants interferes with protein digestion (and perhaps energy sources as well) a good response can usually be obtained by providing protein and energy to animals utilizing the oak plant extensively.

**Hydrocyanic** or **prussic acid** poisoning represents a threat with certain groups of plants. The plants most commonly put into this category are the various forms of sorghum. However, other plant including chokecherry, plum, flax, mountain mahogany, and elder also fit into this category. These plants represent major threats after they are wilted or damaged by drought or freezing, and should not be used under these conditions without testing. Sodium thiosulfate or methylene blue are specific antidotes for hydrocyanic acid poisoning, but have little value because the time available for administration is short.

Some specific plants with which producers in Texas should be familiar with before exposing goats to them are Guajillo, Coyotillo and Sacahuista. **Guajillo** is an important leguminous forage plant for goats, but animals existing almost exclusively on this plant develop "limberleg" or "wobbles" of the rear legs. Fortunately the condition is slow to develop and heavy losses can be prevented by close observation and removal to other areas or management system as soon as symptoms appear. **Coyotillo** also produces a condition sometimes called "limberleg", but the problem is much more acute than with Guajillo. Producers are able to use rangelands where this plant is present by developing a population of animals which either do not eat the plant or which have developed a tolerance for the plant, and exercising caution in introducing new or naive animals to these areas. The entire **Sacahuista** plant is toxic, but problems primarily occur when sheep or goats consume the blooms or seed heads. These plant parts are highly toxic, but are not a threat except at certain seasons of the year (summer or fall). This plant causes photosensitization or swellhead and animals exposed to the plant should be observed carefully at critical times in order that appropriate action can be taken. It is possible to run goats on pastures where Sacahuista is present depending on the stocking rate, amount of Sacahuista present, the amount and quality of alternate forage available and with careful management at critical times.

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# CHAPTER 8

## THE PROBLEM OF COLD STRESS OR "OFF SHEAR" LOSSES

One of the major problems facing the Angora goat and Mohair Industry is that of death losses following shearing. The term "off shear", originally coined in Australia and referring to sheep, seems an apt term to apply to this problem. Most species of domestic livestock and even some wild species are sometimes lost as a direct or indirect result of cold weather. This problem is most severe with Angora (or Cashmere) goats, although on a world wide basis the total losses with wooled sheep are, no doubt, many multiples of that of goats (Glass and Jacob, 1992). This is due in a large measure to their presence in greater numbers. One survey (Hutchinson, 1968) indicated an annual loss of 0.7% of the sheep in Australia to cold stress following shearing. This percentage applied to the number of sheep in Australia represents approximately the total number of Angoras in the U.S. at present. Over the period of history of the goat industry in Texas there are numerous hearsay stories of severe losses either in total numbers or as a function of herd size. In a recent survey of Angora owners in Texas (Shelton and Terrill, 1989) 72.6% of 702 producers responding to the survey indicated that in their lifetime they had suffered losses to cold stress. Almost certainly the problem impacts 100% of producers through losses or labor, feed and facilities costs associated with protecting freshly shorn animals. Goat owners have both a moral responsibility and an economic incentive to deal with this problem effectively. The survey referred to earlier, indicated that 95% of the animals were provided with some type of protection. In this same survey producers were asked to rank problems they experienced in the Angora Goat or Mohair business. Two problem areas consistently ranked higher than "off shear" losses. These two problem areas were predation and erratic mohair prices. It should be pointed out that this survey was conducted at a time when mohair prices were low. These two factors are, to a significant degree, outside the individual producers contro1, whereas, the individual producer can do something about losses from cold stress. In analyses of the questionnaire the data were also tabulated for the Eastern and Western part of the state, based on a line running north and south through essentially the center of the Edwards Plateau. In general the producers in the eastern part of the state rated "offshear" losses below prices, predation, parasitism and feed costs as problems to be dealt with. Producers in the western part of the state tended to rank freeze losses as third, below price and predation. Generally producers in the eastern part had smaller herds, run at heavier stocking rates, which were more intensively managed, and thus they were "for the most part" able to provide protection. The more intense management would result in more problems with parasitism and require increased use of feed. The producers in the western part of the state would tend to be the opposite in respect to most of these points.

The problem of cold stress appears to be more serious with Angora goats than with other livestock species, and is more severe in Texas than in other areas where they are produced. It may be of interest to speculate why this is the case as a guide to some approaches to dealing with the problem. A major factor with the goat is their small body mass which gives them a low reserve of body heat or low body heat stores relative to the surface area exposed. In addition they seldom have any significant amount of subcutaneous fat cover which would increase body mass and provide some degree of insulation for vital organs. Also their rapid rate of fiber growth likely impacts the problem of cold stress in two ways. One of these is that they have adequate fleece cover throughout most of the year with the result that they are not challenged or prepared to respond to cold stress, and second their pathways of nutrient utilization are directed to meeting other needs, such as fiber production, and not maximizing body heat production. It has been shown that the Angora has a reduced ability to synthesize glucose (Cronje, 1992). This problem (freeze losses) appears to be particularly important in Texas, because this is where most of the goats are located, and they are raised in larger herd sizes and under more extensive conditions thus making it more difficult to insure protection. Also the area is subject to extremes in climate and weather changes may be rapid and unpredictable (at least to the goat). The nutritional conditions under which commercial herds are raised are less than optimum resulting in animals which are more susceptible to cold stress. This is largely a condition of their use under range conditions, and does not necessarily represent negligence on the part of the producer.

The three climatic elements contributing to death losses are rain, wind and low temperatures. Of these, rain appears to be the most important. Generally at least two of these elements are required for losses to occur, but this is not universally true as losses sometimes occur from low temperatures alone. Usually losses from temperature alone are restricted to small animals such as kids or emaciated goats or from trampling or "piling on" among goats seeking protection from cold. In the survey discussed earlier over 5% losses were reported among kid goats even though they were generally provided with shelter. Losses were only approximately one-half as high with adult goats. Serious losses sometimes occur following shearing in August when the animals were exposed to wind and rain even though environmental temperatures do not drop below 60 degrees Fahrenheit. Wind alone is not known to cause loss. Ideally producers should have access to information to predict cold stress based on the three elements. This type of information is apparently not available in easily interpretable form. Two way charts based on temperature and wind are available (see Table 8-1). These were developed for application with humans which are normally able to protect themselves from the third element (rain), and thus only limited inferences should be drawn from this information as applied to the problem with goats.

Death losses from cold stress may occur in several ways. The most serious of these is an acute form in which heat is removed from the body at a faster rate than it can be generated. This can occur or can be set in motion in less than one hour in the case of a freshly shorn goat exposed to cold, wind and rain. The goat may not actually die for several hours, but once the body temperature starts to drop the animal stops moving or searching for shelter and humps up and starts shivering. This animal will, in essentially all cases, be lost unless man intervenes. These animals are relatively easily revived, but this seldom happens in practice. In order to revive the animals they must be removed from this environment (hauled or carried) and placed in a warm room for as much as 24 hours or more. The writer has often revived animals of this type, but few ranchers are in a position to do this.

A less acute form of cold stress occurs when the animal is initially able to maintain their temperature balance for an extended period of time (hours or days) but eventually loose this capacity due to depleted reserves of readily available energy or to fatigue resulting from efforts (shivering) to elevate heat production. If the animals can be fed during this time their chances of survival are greatly improved. This situation is often encountered when the animals have some cover (were shorn days or weeks earlier) or where initial conditions are less extreme but persist, and often become worse, over an extended period. Animals in near full fleece have been lost under these conditions when rain persists for days along with low temperatures. Producers often have time to intervene under these conditions, but once the animal's body temperature drops substantially this animal is difficult to revive. The distinction between these two situations are not always clear as they may both exist with different animals in the herd. Attempts to revive these would consist of providing heat and energy. Since the animals cannot eat, any energy given must be in the form of intravenous or intraperitoneal injections. The writer has had very little success in reviving animals which have been chilled for several hours or days.

A third form of loss may occur following several days of cold stress in which the animal's system loses the ability to deal with stress due to adrenal fatigue. This is extensively covered in the literature dealing with "off shear" losses of sheep in Australia (Panaretto and Ferguson, 1969). This has not been specifically identified with goats in this country, but does no doubt at times occur. This may be a factor in the second form of loss mentioned above. It may be less of a problem with goats in Texas because cold stress conditions are often of short duration. If this is identified as a significant type of loss it is theoretically possible to intervene with hormone injections of adrenal corticosteroid (Panaretto and Ferguson, 1969).

A fourth type of loss which is sometimes mentioned is due to infections, such as pneumonia, which might follow a period of cold stress. The writer has not observed this problem. Cold weather does not directly lead to infections, but associated conditions such as confinement in enclosed barns and interrupted feeding could well contribute to disease problems. If these are identified they can often be dealt with through the use of antibiotics. Other associated forms of loss include trampling or smothering in sheds. Instances have been reported of animals being lost from barn fires as a result of attempting to heat barns or from ammonia toxicity due to too many animals being too tightly enclosed in the barn.

An additional cost to the producer. which results from cold stress is that of increased feed requirements or reduced performance in cold weather. This could be substantial for long continual cold, but is apparently a relatively minor factor in Texas because cold weather is generally of short duration. Even though it may be minor, providing protection should reduce feed requirements or improve performance.

**Choice of Shearing Date**

One of the obvious questions which should be addressed is the choice of shearing date, but this decision will often involve factors other than cold stress. Over the larger area some goats will be shorn in every month of the year in Texas, and losses can occur in every month of the year. However, the most typical times for shearing are February and August. Since they are shorn twice per year, at approximately six month intervals, the choice of one date tends to fix the other. It is not imperative that they be shorn exactly six month intervals, but deviation very much from this will create problems with mohair length for one or both clips. As expected, spring shearing represents a greater hazard, but heavy losses can occur following an August or September shearing since few producers make an attempt to provide protection at this time. The popularity of the August - February shearing suggest that this timing has merit. Period of year averages for monthly temperature, wind speed and rainfall at Waco in central Texas is shown in Figure 8-1 and Table 8-2. As expected, these data show January as the coldest month with April or May as months most likely to be subjected to wind and rain. These data tend to support August - February or March as preferable shearing dates, but the choice of these dates do not provide assurance that cold stress will not be a problem and that protection will not be needed. If shearing is delayed to April, there will generally be conflicts with kidding, and some loss of fleece through shedding may occur and still the producer cannot be assured that losses will not occur unless protection is provided. Early March and late August might be suggested as shearing dates which would approach two six month shearing intervals. Kidding dates may have some impact on shearing dates or vise versa. It may be desirable to shear two or more weeks prior to kidding in order for the doe to grow some cover. Mohair growth is very slow in lactating does.

**Methods of Providing Protection**

It was stated earlier that lack of body mass (body condition or fleshing) is one of the predisposing conditions, and thus improvement in this respect is important. Data presented in Figure 8-2 shows the influence of body weight on "offshear" losses. These data were collected following shearing in late August, and clearly showed that heavier animals are much more resistant to losses.

Another important concept is to have the animals full of feed when exposed to cold stress. This comes into play at shearing time by insuring that the animals are not starved in the process of shearing and/or have time to feed before there is a risk of being chilled. An example of the importance of this factor is shown in Figure 8-3. This factor comes into play when they are exposed to cold stress over an extended period of time. Their normal feeding habits will be disrupted or prevented when subjected to serious cold stress. Thus, it is important to keep them as well fed as possible, and this can go a long way to preventing losses under some conditions. This is often difficult because it may not be possible to get to the animals or to manage or move them. The type of feed itself can be of some importance. Feed provides heat energy through two pathways. One of these is that readily digestible feedstuffs provide immediate energy for generation of heat. This can sometimes be provided in the form of corn or range cubes during stressing conditions. The more important pathway is that heat is generated as a natural process of microbial digestion and metabolism. This is a major source of heat to a ruminant animal. Thus a complete ration offering both roughage and readily available energy will be more beneficial to the animal under most conditions, but it is important to remember that heat produced as a byproduct of roughage digestion will not be immediate. A period of a few hours is required for this to occur (see Figure 8-3). They need not be provided a complete ration if they are able to graze roughage from the range and have access to protein-energy supplements.

The above stated factors can provide complete protection from losses in some marginal conditions, but will not provide complete protection under more extreme conditions. Also, if the animals are to be fed heavily to reduce risks from cold stress it may as well be done in a protected environment which would eliminate the threat of loss. Therefore, producers may as well make plans for protection. This can be done by alleviating one or more of the elements of rain, wind or low temperatures. Although some producers do at times provide heated barns, it will be assumed for this discussion that this is not reasonable (or justifiable) under commercial conditions. In addition, open flames in barns can be a serious hazard. Heat in barns may be justified for intense kidding systems (registered flocks) especially when shearing and- kidding are scheduled for January or early February. Another case in which it may be beneficial is for small kids or weak animals exposed to extreme cold as a result of shearing in January or early February. The writer's approach is to delay these practices, at least for young or thin animals, to at least mid-February to reduce the risk of exposure to extreme low temperatures.

This leaves the provision of protection from wind or rain as a reasonable alternative. The alternatives in this respect include:

1. Use of natural protection such as hills, trees, caves, ravines, etc.
2. Provision of artificial wind breaks.
3. Provision of barns or sheds.
4. Leaving natural capes of mohair (cape shearing).
5. The use of artificial capes.

One of the more obvious is to place goats following shearing in areas having natural protection. This might include hills, rocks, caves or vegetative cover such as timber or browse (especially plants such as cedars or liveoak). In addition to or instead of natural windbreaks it may be possible to build artificial windbreaks out of wood, stone, hay or straw or plastic (see Figure 8-4). Plastic is an economical material from which to build temporary shelters or windbreaks. This has not been used to the extent that it should by the industry. It is desirable that animals be familiar with the areas in which they are to be kept following shearing in order that they will knowingly seek protection in times of stress. This will more likely be successful if these structures are in smaller pastures or traps in which the animals cannot stray for long distance. Even this approach will not always provide 100% protection and should be used with other practices or with the potential for the producer to intervene in threatening or extreme cases.

The provision of barns or sheds (goat sheds) along with care to insure that the animals are in the structures will provide essentially complete protection (Figure 8-5). The only case in which this is not true is for small animals which may be trampled or which die due to extreme cold. Construction costs can be made low enough that most producers can afford sheds, but insuring that the animals use the sheds may present difficulty. Feeding near the sheds or placing them at strategic locations increase the likelihood that goats will use them.

The most widely used practice of all is leaving a natural cape of mohair (cape shearing). Ideally this will consist of a 4 to 5 inch strip left unshorn down the back (see Figure 8-6). When this is combined with an overhang of approximately 4 inches fiber length on each side a total cape of up to 10-12 inches will be provided. It is difficult to insure that this is done properly as the shearers will often chop the fibers. With dense or matted fleeces, there may be no alternative. This type of shearing will provide near total protection except for small weak animals or for extreme conditions. In the survey mentioned earlier, which involved a very severe year, death losses of cape shorn animals were approximately 112 that of slick shorn animals (Figure 8-7). In milder seasons the "off shear" loss of cape shorn adult animals should approach zero. The disadvantage of cape shearing is that approximately 314 pound of mohair is left on the animal. Much of this is lost through shedding, and if this is not the case it will be present in the fleece and will contribute to irregular length at the following shearing. It is preferable that this be removed approximately 30-40 days later using shearing equipment which will leave a small amount of stubble. Few producers go to the trouble of gathering all their animals and hiring a custom shearing crew, with the result that the cape is often left on the animal until the next shearing. However, removing the capes requires very little effort or skill and the writer recommends consideration be given to removing this by using ranch labor. This can often be combined with other practices such as marking the kid crop while working one pasture per day.

The last option mentioned was the use of artificial capes which would cut down on death losses and some feed costs by keeping the animals warmer. Artificial capes or coats made of canvas ducking were on the market in the past and can be purchased today, but in sizes meant for sheep. This practice was never widely or consistently used. This was apparently due to materials and labor costs. However, at the present, materials (plastic) are available from which low cost coats can be made (Panaretto, Hutchinson and Bennett, 1968). These are not on the market at the present time but could easily be produced if there was an indication of demand (see Figure 8-8). Another practice which has been suggested is to walk or ride a horse through pastures when goats are being chilled and place garbage bags or canvas bags over animals which have recently chilled. They will either break out or can be turned loose if, or after they revive. Although it cannot be guaranteed that this will work it represents a low cost if it is successful in saving only a few goats. The writer has not attempted to use this in practice. It has been reported to work with sheep.

In summary, the threat to shorn Angora goats is very real and producers must take seriously the charge to provide some type of protection. In the survey mentioned earlier, 95% of the producers indicated that they did make some effort to provide protection.

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## CHAPTER 9

## THE PROBLEM OF DEFECT IN MOHAIR

Technically, defect would imply any condition that lowers the value or utility of a product such as mohair. In a broad sense this could represent genetic defects, contamination or shearing or packaging methods. However, as applied to mohair, the term is used primarily to indicate vegetable matter contamination. This normally represents plant seed or plant parts which are picked up on the range or pasture. Thus, it must be obvious that the degree of defect is highly variable between seasons, areas, or type of forage being utilized. For instance, goats being run under farm conditions and grazing a mono-culture crop such as alfalfa should show little problem of defect. On the other hand, animals on the same property which are run in weedy fields or pastures may have a high level of defect. Under range conditions there is less problem of defect in dry areas or dry years when plant (weed) growth is less evident. Thus, each geographic area will differ both in the degree of defect and the source of defect. Some types of plant defect are more serious than others because they are much more difficult to remove from the fleece.

It is not realistic to attempt to discuss plant species which present problems in mohair on a worldwide basis . However, it is not difficult to visualize plants which may cause trouble, or if this is not done, it will become obvious shortly after stocking a property with Angoras. In this discussion, we will concern ourselves primarily with a partial list of those plants which may cause trouble on Texas ranges. Some of this information was originally compiled by Jenkins (1987) and Landers (1991).

**Plants causing trouble**

**Grassbur or sandbur** (*Cenchrus spp., longispinus, echinatus and incertus*). This is an annual grass which produces a small bur which is very difficult to remove from wool or mohair. The seeds mature in summer, but may be picked up by the animal throughout the year. This grass is palatable during the growing phase, and thus it is not very prevalent in range settings. It is primarily a problem on or near old fields, ditch banks or road banks. Angora goats simply should not be put in areas heavily infested with grassburs. Seed production within the year may perhaps be destroyed by fire. Grazing may, over time, remove enough plants that the area can be used by sheep or goats. Mechanical disturbances, such as plowing, of areas subject to grassbur should be avoided, as this may only spread the plants. Herbicides such as "Roundup" may be used for spot treatment of small areas to prevent spreading.

**Beggars lice** (*Daucus pusillus*). This is a broadleaf weed which might be found throughout much of the U.S. It is more of a problem in fall-shorn mohair, and is more likely to be a problem following a wet winter or spring. It is difficult to justify control efforts for this plant, but fortunately, it is not a major problem for most producers. Prescribed burning in late winter or the use of herbicides such as "2, 4-D" or "Picloram" is effective, but broadcast spraying of entire pastures is seldom justified.

**Horehound** (*Marrubium vulgare*) This plant is a short-lived perennial which might be found throughout much of the U.S. It produces a seed which is readily picked up in mohair. It may well be the most troublesome plant for Texas Angora goat producers. It is most prevalent following a period of wet years and is more prevalent around pens, bedgrounds or heavily grazed areas. It grows in winter and spring. Sheep and goat producers should attempt to control this plant through the application of herbicides during early spring. It is difficult to control at any time and especially following seeding in late spring and late fall when it is growing. The plant occurs in dense clusters and thus control efforts may be selectively applied by ground application. It is used by livestock to a limited extent (low palatability) and will be utilized by animals (especially cattle) in some winters.

**Burclover** *(Medicago minima* or *polymorpha*). Burclover is an annual plant that may be found throughout much of the U.S. It is commonly found in the eastern half of the Edwards Plateau following a wet fall and winter. It produces a seed which can persist in the soil for years. The seed capsule becomes attached to the fleece. However, it is an excellent feed during late winter and spring, and most sheep and goat producers will actually look with favor on this plant. Heavy grazing will markedly reduce seed production. Once it is present in the fleece, it does not rot out and will be there at the next shearing. It is not generally practical to try to control this plant.

**Devil's claw** *(Proboscidea louisianica*). This plant is concentrated largely in Oklahoma, Texas and New Mexico. The term, "devil's claw" is distinctive of the seedhead which may be 4-6" long and has horns or hooks which are readily picked up by the fleece. It competes poorly with established grasses and tends to occur only as scattered plants. It can be controlled by grubbing or with herbicides (Grazon P+D). However, the most practical way to deal with this problem may be to remove the seed heads at shearing and burn them. The latter is important as the seed pod is slow to rot and will be picked up again unless it is burned.

**Cocklebur** (*Xanthium strumarium* or *spinosum*). Cocklebur is a warm season annual weed that tends to be found in draws, roadsides, old fields and especially in overflow or wet areas. It is not a major problem in upland range areas. It has very low palatability to animals and can actually be toxic. Animal losses have been observed after spraying which either increases toxicity or palatability. The plant produces numerous seedpods. The seed head is 1 to 2 cm long and oval in appearance, which is coated with hooked spines which readily attach to the fleece. The seedhead is very durable and will remain a threat to the animal throughout the year. It is very difficult to remove from the fleece and thus wool or mohair which is heavily contaminated with cockleburs has low value. Producers with small lots of mohair which are lightly contaminated with cockleburs often attempt to remove it by hand. It is the writers recommendation that producers either get rid of the cockleburs or get rid of the goats. Fortunately, this plant can be controlled by pulling or spraying with any 2-4-D type preparation. Since the plants are often concentrated in limited spots (at least in range areas) control is usually feasible. However, control practices may need to be repeated for several years before the problem disappears.

**Needlegrass** (*Aristida spp.*). There are several species of *Aristida* which are commonly called needle grass or threeawn. They are found on poor or arid range sites throughout much of the western states. In the Edwards Plateau and West Texas, this group of plants is found on most ranges, but are more likely to be concentrated on overgrazed ranges as the plant is low in palatability, being used only in the early growth stage. The seeds, complete with three awns each, shed readily when mature and are easily transferred to the fleeces of animals. The seed are sharp at the base and will penetrate the fleece and even the skin of the animal. The plants tend to be low growing, and the goat is more likely to pick them up on the face or legs as they feed through the grass. In some cases, the fleece can become badly contaminated with balls or clumps of needle grass on the face or legs, which should preferably be removed by hand at shearing. Goats make little use of needle grass and thus should not be present on these ranges unless other plants such as good browse plants are also present to be utilized by goats. Control is not practical except through good range management which encourages improved range condition. Needle grass is more likely a problem at fall shearing. A low level of contamination in the fleece is more easily removed in processing than some other types of defect, but that which remains in the fleece is especially troublesome to the processor since it is in the form of a fiber and is **not** readily removed in combing.

**Burrograss** (*Scleropogon brevibolius*). Most of the comments relating to needlegrass also apply to burrograss.

**Speargrass or Texas Wintergrass** (*Stipa leucotricha*). Texas wintergrass is a cool season perennial and during the cool season of the year can represent a valuable forage resource. This, or related species, are found widespread throughout the world. At maturity the plant has a seedhead which truly acts like a spear in penetrating the fleece of sheep, and, to a lesser extent, goats. Goats may be successfully produced in areas with extensive cover of speargrass. Angora goats are normally shorn in the spring before the seedheads are mature, and seeds may often be rotted out or lost by the time of the fall shearing. Still, if possible, it may be desirable to move the goats to field grazing or seeded pastures during the time the seedheads are shedding. Speargrass constitutes less of a problem with goats than sheep and thus, they may replace sheep on some properties for this reason. Heavy late winter grazing, especially by cattle, may reduce the problem by reducing seedhead production.

**Stickleaf** (*Mentzelia oligosperma*) can be common on rangeland in summer following a wet spring. Leaves and seeds have "velcro-like" hooks which will become attached to the surface of the fleece. It is seldom sufficiently abundant to warrant control, but it is susceptible to "2-4-D" type herbicides. Since the plant attaches to the surface of the fleece it will tend to dry and be rubbed off or lost from the fleece in a few days. Thus, precautions should be taken in driving through water lots or weed fields immediately before shearing.

**Buffalobur** *(Solanum rostratum)* can be a problem with mohair. Both the seedhead (bur) and the plant stems contain spines or stickers which may stick to mohair. The plant heads-out in summer and fall, and care should be taken to keep goats away from this plant immediately before shearing. Fresh-shorn animals will not pick up this defect to a great extent or much of it will be lost before the next shearing season.

**Others**

Many other plants may cause trouble at some time or place. These tend to be the seed head of weeds which are shed and picked up by the fleece, but also certain types of cactus (joints or pods) may be picked up in the fleece. Other problem weeds may include sticky foxtail or stickweeds. Other plants such as briars *(Smilax spp.)*, catclaw *(Acacia spp. and Mimosa spp.)* and blackberry *(Rubus spp.)* may not only serve as a contaminant in the fleece, but can entrap and endanger the animal as well.

**Approaches to dealing with defect**

The first line of defense should be avoidance. It has been suggested earlier that mohair production is simply not consistent with a significant presence of some plants (grassburs or cocklebурs). If the land owner wishes to raise Angora goats, he should attempt to remove or minimize plants and the approaches for doing this are different for each plant species. Attempts should be made to remove or minimize horehound, but limited amounts of this species are found on many goat ranges. Other plants such as Burclover or Texas Wintergrass may actually be viewed as a positive even though they do present problems with the fleece. Other contaminants such as Devil's claw and some of the problems with needle grass may be removed at shearing.

Another approach is to maintain cultivated fields with annual or perennial forages in which the animals may be placed at critical times while the seed heads of problem plants are being shed. This will often work for Texas wintergrass and in some cases, for other species as well. Another approach is to spray one or more pastures in which the animals may be concentrated at critical times. This will often work for broadleaf weeds, but not for the grasses. Few people will spray for this purpose alone, but they may have sprayed for mesquite or prickly pear control which often, concurrently, reduces the weed problem.

Age and genetics of the animal will also impact the defect problem. Kid goats often pick up defect to a greater degree than older animals. This is because they are smaller and their entire body or fleece is more likely to be exposed to the seed head of problem plants. Also, the kid fleece is usually light and fluffy and higher yielding and picks up defect more readily. Realizing that they also produce the most valuable mohair, there will be occasions in which producers should consider putting the kids in pens on feed or in restricted acreage for a short period of time to avoid defect. The fall shearing normally coincides closely with weaning which is a critical period for the kid goat. Many producers place the kids on feed at this time. Thus, a period of confinement feeding can often be justified to accomplish the multiple objectives of reducing defect, shearing, reducing weaning stress and protection from rain after shearing. As inferred above, the fluffy or high-yielding fleece picks up defect much more readily than fleeces with a slightly higher oil content and a distinct and well defined lock. Thus, those producers who anticipate specific defect problems may wish to breed goats with a well defined lock and a moderate amount of oil. This should not be used as an excuse to breed heavy oil goats, as this appears to be undesirable. It is the writers belief that producers should look with favor on goats with well-defined lock formation and a mohair hair yield of 85-88%.

Another approach which is often used to avoid or reduce defect is in the choice of shearing date. Most types of defect are picked up over a short period of time, usually associated with maturity and shedding of seed. This may differ for each plant species. If the goat can be shorn or removed immediately before this happens, the particular clip involved will be free of this defect. The following clip may also be free of this defect because the fresh shorn animals will not pick up defect (at least not to the same degree). Also, some types of defect, particularly the grass seed defect, will decay or fall out before the next shearing. Some other types of defect such as burclover or cocklebur will not be lost from the fleece regardless of the time lapse since contamination.

Finally, some of the defect may be removed by hand at shearing or sorting the clip. It was pointed out earlier that, at least with certain types of defect and certain age groups, much of the defect is on the head, legs or along the underline. This is especially true with needle grass defect. This often occurs as little balls on the affected part of the fleece. This material is often totally without value, and the clip can be improved by removing at shearing or at sorting. Devil's claw can often be removed by hand.

Even considering the above information, problems with defect will still occur. Some producers make use of a practice of spraying with oil two weeks to one month prior to shearing in the belief that this reduces the problem of defect. The material most commonly used is "red oil" (oleic acid). Other materials sometimes used are mineral oil, vegetable oil or corvus oil (a light-colored paraffinic oil). The general belief is that the presence of the oil lubricates the fiber and the plant material with the result that over time some of the defect is lost from the fleece. Several research studies have been conducted to evaluate the benefit from spraying with oil or other preparations (see Bassett and Engdahl, 1971; Bassett, Engdahl and Shelton, 1970; Jenkins, 1987 and Pfeiffer, Lupton, Blakeman and Jenkins, 1990). Generally the results of these studies do not verify a significant reduction in vegetable matter defect from this treatment. It is generally recognized that spraying with oil will improve the handle or feel of mohair, and in some cases may increase fleece weight. If the latter is true, it will be through the medium of reduced yield. There are many options in treatment, such as dates or times of application, amount of oil applied, types of oil and types of defect. It seems likely that all of the various options have not been tested. It seems obvious to the writer than some types of defect such as grassburs or cockleburs will not be benefitted by spraying. Others such as needle or spear grass seem much more likely to be affected since some of these are lost over time anyway. Some producers spray before the defect is picked up, some after, or some at both times. Also, some spray first with oil and later with a detergent spray to attempt to loosen and later to wash the material out. In one study (Pfeiffer et al., 1988) spraying with oleic acid before the defect was picked up appeared to provide a benefit at one location but not at two others (see Table 9-1). It has been previously stated that oil in the fleece will reduce the extent to which goats pick up defect. The end result is that so long as buyers do not object and that if producers believe they have benefitted from the practice, they may wish to continue with the practice in the absence of research confirmation of a benefit. There will be some cost in carrying out the practice for materials and labor. This cost may be partially justified by spraying for insect (lice) control at the same time since these practices can be combined.

In treating with oil it is important to realize that oil does not mix with water, and thus an emulsifying agent must be used. The mixture used by Jenkins (1987) was:

Oil - 2%, Insecticide - 1%, Nonionic detergent - 2%,
water - 95%.

**Merchandising mohair containing defect**

Almost all mohair will have some vegetable matter present if it is nothing more than feed residue or fecal matter. Usually, this will be on the order of less than 1% of the fleece by weight. In commercial warehouses the mohair clip is classified as normal (or free), light defect, medium defect or heavy defect. This may be done by the warehouse operator, a commercial mohair classer and eventually the buyer must concur. The price is then discounted according to the classification. These discounts may be variable, but typically are 10, 20 or 30% for the respective levels of defect. Bassett and Engdahl (1971) conducted a study evaluating the accuracy of these classifications and the impact this level of defect has on the clip (Table 9-2). This study confirms that there is a relationship between defect classification and the amount of defect present and the value of the clip. This represents only one study and due to normal variation incurred in sampling the exact same results would not be expected from other samples, but the overall conclusions are thought to be valid. The first loss to the buyer is that the greater the amount of vegetable matter present, the less mohair is present per unit of weight. Some of the defect is lost during scouring, carding and combing. Some loss even occurs during the initial opening or dusting before the fibers enter the scouring bowls. Excessive amounts of vegetable matter in mohair can result in fiber breakage during mechanical processing. This was confirmed by the reduced yield of top and the average length of fiber in the top as shown in Table 9-2. If a sufficient amount of the defect is not removed in scouring, carding and combing, the mohair may require carbonization. The need to carbonize may be dependent on the amount of defect or the type of defect which can only be removed by carbonization (i.e., cocklebur). In carbonization, the vegetable matter present is destroyed (burned up) by the use of sulfuric acid and removed from the fiber in the form of carbon. This represents an additional cost, and it may also cause some damage to the fiber. In the study shown in Table 9-2, the heavy defect lot was carbonized. Please note that the yield of top as a function of grease weight was only 43.8% as compared to 70.2% for the normal lot. The average fiber length in the top was significantly shorter as well (2.77 for the carbonized lot versus 4.50 for the clean lot). The end result was that the value per grease pound was less than one-half that of the other lots. In addition, mohair is valued for its affinity for dyes and its suitability to be dyed to brilliant colors. Carbonization is often blamed for damaging this property of mohair. Thus, the need for carbonization should be avoided if at all possible.

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CHAPTER 10

# CONTROL OF PREDATION

As stated earlier (Chapter 8), predation is one of producers' major concerns and certainly represents a threat or constraint to the sheep and goat industries. The Angora goat, especially the young kid, may be the most susceptible to predation of any species of range livestock. Predators causing trouble with goats include coyote, domestic dog, fox, bobcat, mountain lion, wild or feral hogs, golden eagles, etc., and in the case of the kid, many other small mammals and birds. It has been estimated that as much as 80% of predator losses to the sheep and goat industries on a nationwide basis (Shelton and Wade, 1979) is caused by coyotes. However, at any given time or location, any one of the others listed may constitute a serious problem to an individual producer. The financial value of direct losses to predation is substantially greater for cattle than sheep and goats (Gee, 1979; Shelton and Wade, 1979). This is largely explained by their greater numbers, greater value and wider distribution. However, predation losses to the sheep and goat industries are many multiples of that of cattle when losses are expressed as a function of the size or value of the industry (Figure 10-1). It is difficult to demonstrate that predation is having a direct impact on trends of the cattle industry, but this can be shown to be the case with sheep and goats (Shelton and Klindt, 1974). The financial value of animals actually killed by predators is a small part of the total cost of predation. Other costs represent the expense of attempts to control or evade predation, the disruption of management options, and the inability to produce goats in large areas because of the threat or certainty of losses from predation. Predation has been shown to have a major impact on certain wildlife or game species. Large numbers of fawns of both antelope (Arrington and Edwards, 1951) and white tailed deer are taken by coyotes and mountain lions. In a south Texas study, 60% of the fawns were lost to predation and 75 to 85% of the coyote diet was comprised of fawns during fawning season. This may be construed as a loss only in those cases where hunter pressure would otherwise be adequate to keep numbers in check. However, it is evident that both cattle and game interests benefit from the effort of the sheep and goat industries to keep numbers of large predators in check.

There are numerous approaches to prevent or evade losses to predation, but the persistent nature and seriousness of the problem may be taken as an indication that none of these are totally satisfactory. Certainly the writer has no simple or complete solution to the problem, but some resolution appears to be necessary for the long term survival of a range goat industry. There is currently relatively little research underway relating to predation, and little reason to expect breakthroughs which will completely resolve the problem.

Perhaps the initial concern of the producer is to be aware of those instances in which predation is occurring and to determine the species of predator involved. Heavy losses of the young (kids and lambs) can he sustained before the producer becomes aware that losses are occurring. The carcass of the young may be completely consumed, taken away to dens, hidden or buried, or producers may not be spending adequate time in the pastures to observe losses. The observation of carcasses may be a clue, but others would be a number of ewes or does with large udders, but no offspring. It is a good practice to periodically count the ratio of does and kids. If this is decreasing, this is a strong clue that predation is taking place Losses of older animals can usually be ascertained by viewing the carcasses. This is made easier by observing the activities of vultures or other carrion-eating birds. Once it is determined that predation is occurring, the next question is to determine what species of predator is involved. This can usually be done with a fair degree of accuracy, but may require more experience or initiative than an individual producer can bring to bear. There is an excellent guide to characterization of losses by different species of predators (Wade and Bowns, undated). Copies of this can be purchased through the Extension Service. The first requirement is to attempt to distinguish predation from carrion feeding on animals which died from other or natural causes. The writer has not found this to be easy. A careful observation of the conditions may provide some clues. The presence of bright red blood on or near the carcass is a strong indication that the animal was killed. In the case of larger and fresh carcasses, the presence of punctures of the skin is also a strong clue the animal was killed. It is not possible to always be sure or certain as to the guilty predator species. Individual animals within a species may vary with respect to method of attack and feeding behavior, however, there are strong clues which can be used. **Domestic dogs** (commonly more than one) typically attack the animal in an indiscriminate manner, often leaving multiple injuries on a number of animals. Thus, the flock is badly scattered. A high percentage of the animals are only injured, but will almost invariably die later. Dogs may actually feed on the animal while it is still alive. They may attack many animals, but may do very little actual feeding on the carcass. With experience some dogs become more proficient killers. Dog attacks should be suspected on properties adjacent to population centers. Dog attacks are less likely in more remote areas. Dogs are more commonly removed by shooting, but they can often be removed by any of the techniques used to control coyotes. With careful observation, dogs can often be caught in the pasture, and occasionally in the act of killing. The early morning hours may provide the best opportunity to observe them. Dogs should not be allowed to serve as an excuse for terminating goat production, but the sociological consequences of their control may be as serious as the losses themselves.

The **Coyote** is the most serious, most common and most widespread predator of livestock. This species is a growing threat to the very existence of the goat industry throughout most of the country. It is usually possible to identify coyote kills. They typically attack larger sheep and goats by biting the throat behind the jaw and below the ear. Tooth punctures on each side of the throat are usually evident. There may be repeated bites - rarely do they puncture the jugular views and bleeding may be minimal or secondary. Death is more likely through suffocation or shock. This kill pattern, along with widely spaced punctures by the canine teeth are largely unique to the coyote. However, not all coyotes kill by this procedure. Young coyotes (especially a litter learning to kill) may appear more like dog kills, but they will usually quickly revert to catching at the throat. Some other individual coyotes may attack at the flank or the nose of the animal. Coyotes may kill younger animals by biting over the back or head. Coyotes frequently feed from the flank. They will usually feed on their kills, but once they are experienced, they tend to kill fresh animals each time they are in the pasture. They will readily visit old carcasses and may feed on these, especially if the rest of the flock have been removed. Thus, trapping of previous kills may be useful, but other carrion feeding animals may foul the traps. In exploited coyote populations (those where control is attempted) they often travel as a single or as breeding pairs and cover Large areas (except during whelping season). In flocks of mature animals, they normally kill only one or two animals, but will do this repeatedly (every 1 to 3 days) until losses become intolerable. The number of kills of lambs or kids will be greater. Coyotes more readily attack freshly shorn goats. They often drag the carcasses in the process of feeding, which tends to distinguish them from smaller predators. The presence of tracks or droppings (scats) in the pasture or near the carcass also provides strong clues. Control of coyotes will be discussed under the heading of "Control Methods."

**Foxes** (both red and grey) may prey on livestock, more commonly young lambs or kids. The red fox is considered as a more likely predator, but both may be present in a given area. In an earlier period, the fox population was usually kept in check by fur trappers, but with the current low prices for furs, these species are likely to constitute a more serious problem than in the past. Foxes may attack young animals by the throat or back or head. Multiple bites are usually evident. They frequently feed on the viscera by entry back of the ribs. However, fox kills may be rarely observed as the young carcasses may be removed to dens or isolated locations. A typical suggestion of fox predation is missing lambs or kids. Control of foxes may be much the same as coyotes, but perhaps more of them are removed by calling and/or shooting or trapping.

**Bobcats**, like foxes, are likely to be increasingly more serious with a reduction in the pelt trade. They tend to prey on smaller animals such as lambs, kids or fawns, but they can kill mature animals of these species. With smaller animals, they tend to bite over the skull or neck. They have relatively small teeth and do not show the large widely-spaced punctures as do the canine teeth of coyotes. They often drag their kills to secluded areas and may attempt to cover the carcass after feeding. As with foxes, unexplained disappearances of small kids or lambs should be cause to suspect bobcats. Steel traps are allegedly one of the most effective means of removing bobcats, but the writer cannot confirm this from personal experience.

**Mountain lions or panthers** are considered to be the same species. This species is apparently increasing. They are thought to frequently originate in or near the Big Bend area of west Texas, but during their lifetime may spread over much of the state, and may be breeding in other parts of the state as well. They frequently kill by biting the neck or head. Claw marks may also be evident. One of the more distinctive features of mountain lion behavior is multiple kills. The writer has observed as many as 40 kills in a very restricted area (in a ravine near cover). Obviously, few of these are fed on. They do not readily feed on carrion if fresh animals are available. For obvious reasons, cougars cannot be tolerated in pastures where livestock are located, but it is likely that they pass through many properties without creating problems or making their presence known. Trail hounds, shooting or traps are the more common methods of dealing with cougars. Traps used to remove smaller predators will not hold mountain lions.

**Wild (feral) hogs** are an increasing problem in much of Texas. Mendoza and Turman (1989) discussed their distribution and some control methods. They will often consume most of the carcass of kids or lambs, thus missing kids and dams with full udders may be the most frequent observation resulting from predation by hogs. The term feral refers to domestic hogs which have reverted to the wild state, but not necessarily in the current generation. The term wild hogs may also represent true European or Russian wild boars which have never been domesticated. These have been brought to this country and released for hunting. Most wild hogs on ranges are a mixture of the two as they are fully interfertile. In only a few generations, feral domestic hogs revert to the appearance similar to wild types. Wild hogs may damage several types of livestock, crops or game species. They may kill mature animals caught in the process of giving birth. The existence of hogs on the property can usually be ascertained from their habit of rooting the soil or vegetation in search of food. Ideally, these should not be tolerated in pastures where goats are found, and especially doe flocks which are to be kidded. They are most frequently removed by live trapping or shooting. They are often viewed as a game animal and have at times been introduced for this purpose. Thus, hunting should be an important mechanism for their removal. Few older fences will turn hogs and thus they often spread from one ranch or pasture to another and thus, over time, may constitute a threat over much of the state. They are now thought to be in 190 Texas counties.

**Eagles** and other scavenging birds (**vultures**, **ravens**, and **magpies**) may take kid goats. Golden (and Bald) eagles appear to be the most serious threat, but the others may kill or damage kid goats which are unable to escape. Golden (and Bald) Eagles are protected species, and ranchers are advised not to kill these species. Attempting to scare them away, at least if caught in the act of predation, might be considered, but where this has been tried on an area basis it has not been very successful, as they promptly return. Some properties are consistently bothered by eagles, whereas, others are not.

They are apparently more frequently found in timbered areas or areas of rough terrain where cover exists. Fortunately, Golden Eagles migrate north during the spring (usually March to April) at the time vultures return from their winter migration to the south. Therefore, producers who expect eagle predation on kid goats should consider delaying kidding until the eagles are expected to be gone. Deep talon punctures three or more inches apart are characteristic eagle wounds. In feeding, eagles tend to skin out the carcass, leaving much of the skeleton stripped with the legs and skull attached. In the case of young kids, they may break off the ribs near the backbone. The rumen is not normally consumed.

**Control of Predation**

The discussion of control techniques will be largely directed at the coyote due to the fact that this is the most serious predator, but some of the methods used against the coyote will have some value against others such as dogs, foxes, etc. There are many potential techniques to prevent or reduce predation (Rollins, 1990), and some of these are shown in outline form below:

- Coyote removal:
    - Leghold traps
    - Snares
    - M-44 devices
    - Livestock Protection Collars
    - Denning
    - Shooting; aerial or calling

- Management Practices:
    - Confinement
    - Fencing
    - Use of repellents, lights or noise

- Guarding Animals:
    - Dogs
    - Donkeys
    - Other

Books could be, and have been, written about any or all of these techniques and still the problem will not likely disappear. In this discussion, we will be concerned primarily with evaluating the potential of many of these techniques. Selected references which provide more detail on how these practices may be conducted will be listed at the end of this chapter and may be obtained from Extension or Animal Damage Control personnel or from the author.

**Trapping** is one of the oldest techniques used for removing predators (Pederson, undated). It is also one of the more difficult and expensive techniques, but in the case of some animals, may be the only or last method for removing the problem animals. It might be used for many of the predators listed, but the methods or procedures will differ somewhat depending on the target species. Dorsett (undated) described methods of trapping coyotes. Individual producers may not wish to attempt to trap coyotes unless they have the skill or intend to develop the skill to use this procedure. Amateur attempts to use leghold traps may only make the animal wary of traps, and make it more difficult for others to use this approach. Allegedly, dogs, foxes, bobcats and smaller species may be more easily removed by traps than are coyotes. The use of traps is an unacceptably expensive procedure to remove large numbers of coyotes, but may be the only way of dealing with an individual or small number which are actually preying on livestock or individual animals which cannot be removed by other methods.

**Snares** may well be one of the simplest tools and one that most producers can and should utilize, but as with traps there is the potential to make animals wary. This method may be used with many types of predators, but is widely used against coyotes. Although coyotes can jump or climb most older ranch fences, these are learned techniques and many will choose to go under or through fences. If this is done with any degree of frequency, they tend to leave a very tell-tale sign (see Figure 10-2). If predation is occurring, or there is a threat of predation, producers should spend some time checking the fences for slides or passages. Snares are more likely to be useful where a reasonably good fence exists, thus forcing the animal to use specific travel routes. Methods for use of snares are described in a report by Sims (1988).

**M-44 Devices** represent one of two legal options for the use of toxins in predator control. Its use was discussed in a report by Shult, Ramsey and Klussmann (Undated). The M-44 is a patented spring-operated device which ejects a capsule containing sodium cyanide into the mouth of any animals which pulls on the capsule. A fetid or "rotten" bait is applied to the capsule holder to attract the target animal. The animal dies quickly, and thus it is a relatively humane approach to coyote removal which poses little hazard to humans or livestock. It can be made somewhat selective for larger carnivores by the size and placement of the device and by the nature of the attractant. Small mammals may be somewhat less threatened by the device in that they may approach the device from the side as contrasted to placing their mouth over the device. The bait used should be decayed meat, eggs or blood type preparations, and not urine type attractants often used with traps. Methods of use of the M-44 and especially the preparation of baits are discussed in a report by Polsen (undated). This represents a type of control method which producers should be able to use safely and with a great deal of success. It is normally directed at coyotes, but foxes and dogs may also be removed. For this reason, it must be used carefully where working, hunting or guard dogs or even family pets are likely to be present. Producers planning to purchase and use the M-44 must attend a training course conducted by the Texas Department of Agriculture (TDA) to be certified in its use. They would also be encouraged to obtain the above mentioned reference, or others, as they provide recommendations for use of this device.

**Livestock Protection Collars** (LPC) are an alternative use of toxicants in predator control. The collar consists of a rubber container holding a liquid toxicant which is attached with straps around the neck of sheep or goats. Collars currently in use by the industry contain Compound 1080 (sodium monofluoroacetate), but the potential perhaps exists to use other toxicants in a similar manner. Compound 1080 is somewhat selective for canines, and based on this manner of use is selective for animals which are actively killing by attacking the throat. The disadvantages of the collar are that they are expensive, and because of the use of a toxicant may be controversial. It may be desirable to remove a portion of the flock from the pasture to increase the probability that coyotes will attack the collared animal. Some counties maintain collar pools, which permits putting collars on more animals. Livestock Protection Collars tend to be used when other methods of coyote removal have been unsuccessful. A training course (conducted by TDA) is required before an individual producer is authorized to purchase and use LPC. Methods of use of LPC as well as other useful information relating to predation can be found in a publication authored by Wade (1985).

**Denning** implies the removal of the adults and/or young from dens or in the vicinity of dens (denning) to reduce predation and limit the size or growth of coyote populations. Coyotes use dens only for about two months during the spring and early summer during whelping and while the pups are small. Dens are more likely to be in use from April through June. It should be the goal of every producer to insure that no coyotes are successfully reared on their property. If this is applied across a number of properties in a given area, predation in the future will be limited to those coyotes which move in from other areas. This reduces the number of predators and facilitates removal of encroaching animals. The methods of denning are covered in a report by Crosby and Wade (1978). Denning can often be used to remove both the young and old, as their activities are concentrated in a given area. Location of dens may be difficult, especially on large properties. Concentrated and frequent predation in a given area or pasture during the whelping season is a strong clue that a den is close by. A concentration of coyote signs and trails in a given area is a useful clue. In relatively open country, large areas may be searched for dens by air. Trail hounds or even ranch dogs may be useful in locating dens. Pups may be dug out or gassed once the dens are located. Adults may be removed by trapping or shooting. Calling is often more effective around den sites, and the coyotes may also chase dogs, which will facilitate their removal. As the young are being weaned and/or taught to kill, predation may be heavy in a given area with more of the animals being mangled instead of a clean throat kill.

**Hunting or shooting**

Hunting or shooting is one means of removing predators, but except for aerial hunting, can seldom be relied on as a means of preventing predation. Shooting may be opportunistic, as a result of calling, by deer hunters shooting from stands or by aerial hunting. Most ranchers carry a gun for predator control, and should not neglect an opportunity to remove predators by this method. Calling for the purpose of shooting predators is frequently employed both as a sport and as a control measure. In unexploited (non-controlled) populations, calling may be an effective method of removing a number of foxes or coyotes. However, it is rarely effective in removing individual preying coyotes. Coyotes within sheep and goat producing areas are generally wary of man and may have been subject to calling on a number of occasions. When it is realized that coyotes may cover a distance or areas as much as 15 miles square and that they more frequently hunt at night, the difficulty of removing them by shooting is apparent. However, during deer hunting season, hunters may be present on a number of properties where the coyote may be active. Hunters should be enlisted in the cause of predator removal (encouragement or reward) as it may be to their advantage as that of the rancher. Finally, removing predators through shooting from the air is an important means of control, but there are a number of limitations. First there are often regulations which must be dealt with. Coyotes, dogs, bobcats, foxes and feral hogs may be removed by aerial hunting with proper permits. Aerial hunting does not work well in areas with extensive ground cover (liveoak, cedar or mesquite in season). It is usually a very expensive method to try to remove individual offending coyotes in controlled areas, but may still be justified or necessary. Aerial hunting may be a reasonable economical method for removing a number of coyotes in areas where control has not previously been practiced. The helicopter is a more effective tool than fixed-wing aircraft, but it is also more expensive. Aerial hunting is an important tool, but the use of this technique will likely require or benefit from a joint effort between a number of property owners and Animal Damage Control personnel.

## Animal Management

### Confinement

As a final resort, animal management can be used to some extent to evade predator losses. It must be obvious that livestock can be confined to prevent predation. It must also be equally obvious that a goat industry, in which browse control or removal is one of the objectives, cannot be conducted in confinement. Also, economics will not generally permit raising goats in confinement. Night confinement offers some possibilities, but is of limited value to traditional ranchers. Night confinement can be largely effective in preventing predation. It might be employed temporarily until offending predators can be removed or it may be used in isolated locations with small flocks where stocking rates are high. Sanitation, especially in wet areas, is a problem when animals are confined nightly over long periods of time. Coyotes are reluctant to go into confined locations. The writer has successfully confined sheep or goats in modest type structures out in pasture areas without loss. However, a number of producers can confirm that this is not universally true. Confinement, except in very elaborate structures, may only make it easier for domestic dogs to kill or mangle a large number of animals.

Predation tends to be higher on young animals. Losses to smaller predators such as foxes and other small mammals or birds may be limited to the young. A very old practice of kidding on the stake (see Figure 10-3) was one method of protecting the very young from predation as well as other types of losses. Coyotes often initially start to kill the young animal, but will readily graduate to mature animals. A frequent observation is that they will shift to mature animals after they have been shorn. Early weaning of lambs can sometimes be practiced to protect these younger and more valuable animals from predation. This practice is not as useful with Angora goats.

**Fencing**

In order to be a threat, coyotes, and to some extent other predators, must either be produced on or in a given pasture, property or area or they must invade from adjacent regions. It was suggested earlier (denning) that producers should ensure that no large predators are reared on their property. If this is successfully accomplished, the next task is to prevent their entry to the property. Fencing, along with the use of snares, is the primary means of doing this. Many of the fences throughout range areas no longer constitute a significant impediment to coyote passage, although they served a useful role in removing predators when range areas were initially stocked. Replacing these older fences would be expensive. Consideration should be given to replacing peripheral fences, especially along roadways. If all new fences along new road construction had been designed to prevent coyote passage, the predation problem would be markedly reduced and perhaps even manageable. There are numerous reports concerning fencing against coyotes (Shelton and Gates, 1987; Shelton, 1984; Gates, 1978) covering the use of new fencing, adaptations to existing fencing and electric fencing. There are serious problems in utilizing fencing as a means of coyote control. The major one of these is cost, and the cost per head of livestock protected varies inversely with stocking rates and size of the area fenced (see Table 10-1). It can be seen from this that cost will be a major problem, and new fencing for this purpose may well be limited to peripheral or drift areas. A second problem is that no fence can provide 100% assurance against coyote passage, as they must only dig deeper or jump or climb higher. Third, the type of net wire generally available or commonly used in the area does not provide complete protection from passage. Any coyote, and certain smaller predators, can readily pass through fencing consisting of 6" horizontal and 12" vertical spacings. The alternative of 6" vertical spacings will provide resistance to passage to adult coyotes, but it is known some will pass through this fence given sufficient time and motivation. Actually, most coyotes will search for a slide in preference to working their way through a 6" x 6" opening. Thus, this type of fence will deter passage somewhat but will not insure against passage. It is preferable, at least for the lower part of the fence, that spacings be less than 6" x 6". It may be desirable, and should be possible, to purchase different types of wire or even have it manufactured to facilitate predator control.

A coyote's response to fencing is likely influenced by factors such as previous experience with fences, motivation for passing through fences, coyote density, and the amount of time spent in the area of the fence. A coyote which has not previously encountered fences, particularly net fences, may be deterred by most fences in reasonably good repair. The ways a coyote passes through fences largely result from learning, and the speed with which this is done is likely influenced by a variety of factors including the amount of time spent in the area of the fence.

If a coyote encounters fencing in reasonably good condition, the most likely method of passage is through holes or under the wire at washes. They may also dig under or jump or climb over. These are learned behaviors. The readiness with which coyotes dig under fencing is greatly influenced by type of soil. It is nearly impossible to use fence, against coyotes in sandy soils, as digging is easy. Methods to deter digging are placing barbed wire at or under ground level or use of a buried wire apron. If a barbed wire is used at ground level, it should be tied to the net between posts. In early times some ranchers placed rocks along fence lines. The use of a buried apron is most satisfactory but is expensive.

If coyotes are not able to go through or dig under a fence, the next option is to jump over. Up to 5 feet (and preferably 5 1/2) of fence height is required to give reasonable insurance against jumping. Fortunately, climbing can be largely prevented, often at modest cost, through use of an electrified wire near the top or by providing an overhang on the outside of the fence. Since coyotes are rarely observed when they cross fences, it is not always possible to distinguish jumping from climbing or some combination of these, so the need for electrified top wires is not always clear.

Where new fencing is required, a less expensive fence design is desirable. Electric fencing provides an alternative. Simple types of conventional electric fencing were tried unsuccessfully. More recent developments, including fence energizers with an increased output, greater resistance to grounding, and reduced fire hazard, suggested a need to re-evaluate electric fencing. Initially, the improved fence chargers were produced in New Zealand, but similar types are now available in the United States. An additional factor was the development of solar-powered battery chargers that permitted use of electric fences at remote locations. The use of alternate charged and grounded wires eliminated the problem of animals not receiving a charge under very dry conditions. Another correlated development was the availability in the country of smooth wire with high tensile strength, which permitted better construction.

Gates (1978) first reported an effective new electric fence that prevented coyote passage. It consisted of 13 wires, including a trip wire outside the main fence. Less expensive options might include less elaborate styles of new-construction electric fencing or electric modification to existing, but often poor quality net fences.

Surveys in Oregon (De Calesta, 1983) found that ranchers using 4- to 9- wire fences had success similar to that with 12-wire fences (see also Linhart, et aL, 1982). Shelton (1984) reported that a 9- or 10-wire electric fence was generally effective in deterring predation except when the fence charger was inoperable. The fence used in the later studies consisted of a 9 smooth wire alternately charged and grounded with the 10th being a barbed wire at the ground level. Maintenance of the fences was a significant problem. Failure of the fence resulted from vegetative grounding; damage to the fence due to weather, livestock, farm equipment, or road traffic; and interrupted electrical supply. Observations suggest that animals, particularly coyotes, learn when the fence is not charged and may go through the fence on these occasions.

In the same study, a similar design consisting of 7 alternately charged and grounded wires was tested in south Texas where density of coyotes was relatively high (Shelton, 1984). The spacings between the lower wires were 6" - 7" with 40 feet spacing between posts. This fence did not exclude coyotes but tended to concentrate them and other wildlife inside the pasture. Apparently, the coyotes were passing through the fence, receiving a charge, and becoming trapped inside (see Figure 10-4). This experiment indicated that under these conditions, a physical as well as psychological barrier was required. A trip wire and a barbed wire were added at ground level (thus making a 9-wire fence) making the fence more successful, but some coyotes still passed through. The use of a guard dog inside the fence further reduced losses to predators.

Dorrance and Bourne (1980) reported success with a 7-wire fence, but they also mentioned the problem of coyotes becoming trapped inside. This would constitute less of a problem in open country where coyotes could be seen and removed. However, in the south Texas study they could remain trapped inside without being observed.

Knipe (1985) reported complete success with an 8-wire fence in Arizona. The fence consisted of "eight alternating grounded and charged wires with a bottom grounded wire at or very near the soil surface." He made a point of using 4" spacing at the lower level and stated that 5" or wider spacings were less successful. He also emphasized the need for good construction with high tension on the wires. However, it should be pointed out that he was working with Angora wether goats which are less susceptible to predation than some other livestock. The type of fencing he described would not prevent digging under.

Most sheep and goat producers use net fencing. However, many of these fences are not in good condition, and the prospect of refencing extensive areas with the types of new construction previously discussed is not practical. If existing net wire fences are in reasonably good condition, electric modifications to discourage digging under, climbing, or jumping can sometimes be done at modest cost (Linhart, el al., 1982).

Since a high percentage of coyotes pass through fences by going under them, a charged trip wire placed outside the fence will deter many animals from using slides under the fence or making new ones. The optimum spacing on these wires is not known, but generally suggested at 8-10" outside the fence and a 6 to 8" above ground level. The placement of a trip wire is likely the single best investment that can be made to reduce coyote passage. This can occasionally be done simply and economically. However, the suggested placement outside the fence may require that it be placed on roadways or property owned by others. In response to these difficulties, some people have placed a trip wire inside the fence. No experimental data have been reported testing this approach, but it is likely less satisfactory than placement outside the fence. A significant deterrent to the use of a trip wire with old fences is that fence rows often contain trees or other vegetation that may interfere with the placement of the wire. Removing the vegetation must often be by hand since mechanical methods cannot usually be used close to an existing fence without damage to the fence. This difficulty may prevent some producers from using a trip wire. In addition, maintaining trip wires may require considerable time and effort.

Climbing and jumping can be reduced by placing a charged wire 4-5" above or outside an existing net wire fence. A single wire thus placed will deter climbing or jumping. If more height is desired, additional wires can be added by alternating charged and grounded wires above the existing net. This type of construction is usually relatively simple and economical. The major problem is damage to the fence by wildlife, especially deer. By jumping the fence, they may damage or twist the charged wires with the existing net, thus grounding out the fence. Although this type of fence is not usually harmful to deer, it may be more useful where the deer population is limited.

In summary, electric modification of existing fences may be an economical means of reducing predation. However, producers should be aware of some of the difficulties and should also realize that this approach, like many others, is not likely to be 100% effective.

**Repellents (taste or smell), noise** or **light** have been extensively tested as a means of controlling predation. Generally the results have not been encouraging. As of this writing, an ear tag is being marketed as a repellent to predation. Limited research has not confirmed claims of effectiveness. The USDA-APHIS (ADC) is marketing "The Electronic Guard" which makes use of sight and sound to repel predators (Pocatello Supply Depot, 238 East Dillon, Pocatello, ID 83210). Allegedly, these devices have been shown to reduce, but not totally prevent predation. In general, the above approaches (taste, smell, light or sound) can be shown to have limited and temporary value in restricted situations, but to be of limited long-term value. This is especially true under extensive conditions.

**Guard Animals**

One of the more recent developments in respect to reducing predation is that of guard animals. However, it should be pointed out that this is only new in a restricted sense as it applies to the typical sheep and goat producer in this country. On a world scene, guard dogs have been used for thousands of years, and the American Indians in the Southwest as well as some pioneer producers have used them for much of this century. In addition to guard dogs, other animals which have been considered for this purpose are donkeys, horses, cattle, llamas, ostrich, etc.

Clearly the **guard dog** has met with the greatest success as a guard animal in many areas in Texas. This animal has made a great contribution to Angora goat production. There are now numerous research reports (see Green and Woodruff, 1990) and considerable producer experience verifying their value. Although the American Indians in the Southwest used a variety of available dogs which were reared with or by sheep and goats, the major success from the use of guard dogs followed the introduction of Old World guarding dogs. Some of those which have been introduced into the country are shown in Figure 10-5, taken from Green and Woodruff (1990). Producers which do not have experience with guard dogs and are planning to use them are encouraged to obtain a copy of this report as it contains a relatively thorough discussion of the use of guard dogs. Basically, the dogs are obtained as working age dogs or as weaning age puppies. The latter are confined with a small group of goats (or sheep) such as doggies (bottle-raised kids or lambs). As the dog matures, they are moved to larger areas with a larger group of animals. Most dogs will be working by the time they are one year of age. The guarding instinct tends to be natural with them. The only training the dog may require or need is that required in order that they can be controlled by the owners. The writer regards the guard dog as being almost a necessity for goat producers in peripheral areas where total removal or exclusion of the coyote is not feasible. Guard dogs work well in combination with fencing as a defense measure, as a good fence serves a dual role in keeping the dog in and the coyotes out. Guard dogs work better where the area (property or pasture), the animals and man tend to be constants. They often present problems when a lot of movement is necessary.

In the writer's experience, when coyote pressure or density is modest and a good guard dog is present with the animals, protection is almost 100%. However, not all guard dogs work out satisfactorily, with success rates in the range of 50 to 80% as applied to individual dogs, but this does not prevent guard dogs from being a good investment. There are many reasons for failure. These include a failure to work or stay with the goats, that they kill goats themselves, they stray from pastures, or they die or are lost for a variety of reasons.

It seems less fitting to attempt to use guard dogs in areas of concentrated sheep and goat production and where essentially all pastures and properties are stocked with these species. This would require a large number of dogs and the probability of keeping these working harmoniously in separate pastures is not good. Also, guard dogs rarely kill coyotes, but merely force them into other areas. For a variety of reasons, this does not work well in areas where all pastures contain sheep or goats. It seems preferable in these areas that coyote removal should be the goal.

Another guard animal which has been extensively promoted and used to a significant extent is the **donkey** (see Figure 10-7). The use of donkeys is considerably simpler and more economical to use than dogs, but they are not as effective. The number of producers who promote and use donkeys suggest that they do at times serve a useful role. The writer has on several occasions attempted to demonstrate this on an experimental basis, without success. However, all these studies were conducted in peripheral areas where coyote density was great. In no case was the donkey successful in preventing predation, and in many cases, appeared to feel threatened themselves. The writer is also aware of producers who have had failures in attempting to use the donkey for protection against coyote predation. This apparent inconsistency may possibly be explained by differences between individual donkeys or the conditions under which they are being used. Walton and Field (1989) with the Texas Department of Agriculture (TDA) conducted a survey of producers who have used donkeys (see Table 10-2) with less encouraging results than with guard dogs. Donkeys appear to be more likely to work in areas where coyote control is attempted, resulting in reduced coyote density. In this case the mere presence of a large animal with the goats (especially one which adopts a protective stance) will likely cause the predator to avoid this pasture in favor of an adjacent one in which no guard animal is found. The presence of donkeys in the pasture does not create problems with other methods of coyote control. On the other hand, a high coyote density makes it more difficult for the donkey to be successful in that a number of coyotes are less likely to be intimidated, and the adjacent range may represent the home range of a different group of coyotes.

The author has known of instances in which an individual **horse** or **mule** served a protective role. However, such instances are no doubt isolated, but might be increased through some effort at bonding.

Research work (Hulet, et al., 1992) has shown that it is possible to bond sheep and goats to **cattle** to the extent that they remain in the proximity of cattle and that predation is markedly reduced. In addition, the author has known of instances in which an individual cow (or cow with young calf) has been successfully used to keep predators (usually dogs) out of sheep or goat pasture. This would work only for a small acreage situation. The mere presence of cattle in a pasture (or even equines) is not likely to significantly deter predation. First of all, most pastures in Texas already have cattle present and they apparently do not prevent predation. In addition, cattle themselves are often subject to predation. The necessity to bond (by confining them together for a period of time) cattle and goats would present serious problems in respect to management options and movement and management and replacement of livestock.

Other proposed guard animals (**llamas, ostrich**) seem to fit into a similar situation in that they do not appear to offer much potential at present. Availability would be one limitation. The writer is also aware of one instance where guard dogs were used to protect llamas and alpacas from molestation by coyotes.

## Philosophy of Predator Control

Predation is as old as the sheep and goat industries themselves, yet it has only become a direct threat to the continued existence of these industries in the U.S. in recent decades. This suggests that conditions or the approach to dealing with the problem has changed, and the resolution of this problem, if one is to be found, may require new approaches. Predators (coyotes and wolves) were present when sheep and goats were initially brought into the west. The chronology of events relating to Texas was reviewed by Nunley (1985). Initially, sheep and goats in western range areas were managed under herd, with predation control as an essential part of the herder's assignment. At that time, the large predators present consisted of the coyote, the Texas red wolf and the "lobo" or timber wolf. Due to the fencing of much of the range area with new net wire (predator) fencing, the establishment of a Predatory Animal Control Service (1914), and the diligence of the early pioneering ranchers, these large predators were largely removed from within and east of the Edwards Plateau by 1931. The pure Texas red wolf is now thought to be extinct in the wild as a result of genetic erosion due to crossing with the coyote. The resulting animal, sometimes referred to as the "hybrid swarm," and generally regarded today as a coyote, started to reinvade the sheep and goat producing areas following the break of the severe drought of the 1950's. This is sometimes referred to as the "coyote irruption" and resulted in the reestablishment of coyotes throughout the state in the period from the late 50's through 1985. Potential explanations for this reinvasion should hold some interest in respect to dealing with the current problem. To begin with, the present day coyote is viewed as a more difficult adversary than the wolves or even earlier coyotes which populated the area. Additionally, most of the predator fences which were erected in the early part of this century are no longer effective in deterring coyote passage. Also, there may well be fewer people living in range areas or at least fewer who are involved in predator control, and almost certainly, they are less diligent, less determined and less skilled than were their ancestors. Also, some tools, such as the use of trail hounds, are not being utilized today. Finally, more restrictions or controls have been placed on control methods. Beginning in 1972, the use of all toxicants were banned for use in predator control. This has been relaxed to a limited extent, but the most effective tools are still banned. This is due in a large measure to public resistance on the part of the uninformed, but with 250 million people in this country, as compared to a few thousand sheep and goat producers, it is unlikely the larger population can be educated or converted. Therefore, producers should endeavor to protect their interests on political and legal fronts and otherwise go about the tasks of removing coyotes.

What lessons are to be learned from the extirpation and reestablishment of the coyote in Texas range areas? The coyote is not likely to change his spots, and will likely become more difficult to deal with. Improvement of fencing and greater diligence on the part of producers is certainly indicated. Refencing of the extensive range areas as a means of predator control is not likely to happen. Hopefully, improved fencing can he utilized in peripheral or drift areas, or where new construction is to be undertaken for other reasons (roadways).

It appears to the writer that the industry is still losing ground in the battle with the coyote, or at least it is not overly clear that the reverse is true. This suggests that some new approach is indicate, On the other hand, there are a number of areas in the state or county in which predation would be expected to be a serious problem, but where losses are minimal or non-existent. What characterizes these areas as different is that, in some cases, groups of producers have banded together, mostly informally, with the determination that they were not going to be defeated in this battle. Generally, an attack on any one producer is regarded as an attack or a threat to all and whatever measures are required are brought to bear to solve the problem. This approach needs to be replicated many times within the industry. It may or may not be desirable to involve governmental agencies in these efforts because of regulations and limitations under which they must operate.

At present the industry relies heavily on the efforts of the Animal Damage Control Service currently administered through the USDA-APHIS and which in Texas is affiliated with the Texas Agricultural Extension Service. This is an important program, and at present, the goat industry simply would not exist without their efforts. However, this service presently exists in the form of 0, 1 or occasionally 2 or 3 trappers per county. Participation at the county level is optional and dependent on the request for their services and availability of funding. However, some of the counties encompass more than one million acres, and there is no way one or a few trappers can effectively control predators over these large areas. Thus, to have any chance of success, .this effort must be amplified manyfold. In fact, the predator control force within the county should consist of every livestock producer in the county plus the available number of ADC people. There are a number of ways this could be accomplished. One of these is that ADC personnel should work with the producer in order that both parties are involved in resolving the problem. Also, control should be an ongoing process with the prevention of losses as a major goal. The necessity to wait until losses are sustained and discovered before control measures are attempted should be unacceptable. Individual producers, their organization, ADC personnel and/or Extension personnel should serve an organizational and training role to insure that an effective program is in place. Such efforts might consist of daily or frequent reports of where coyotes are active and what is being done to contain them. Joint action in many cases may be required. Halfway efforts have not been successful in the past and are not likely to be in the future.

Cattle producers and game interests should be strongly encouraged to get involved in control efforts as they are currently benefitting from these programs. Local governments should be encouraged to play a part as the sheep and goat industries make important contributions to local economics. In some countries there are legal statutes requiring property owners to control noxious species which may endanger the public good. Although this is not likely to be the case in the U.S., this possibility or concept may be utilized to encourage broader participation in control efforts.

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