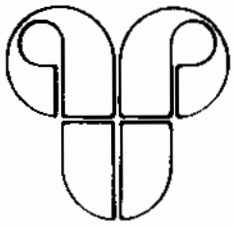
CPR 4565-4591
September 1988

RESEARCH REPORTS

Sheep and Goat, Wool and Mohair, 1988



The Texas Agricultural Experiment Station
Neville P. Clarke, Director, College Station, Texas
The Texas A&M University System

Foreword

The 1988 Sheep and Goat/Wool and Mohair Consolidated Progress Report has been prepared by Texas Agricultural Experiment Station scientists in order to communicate current research activities and results to those involved in all phases of the sheep and goat industry. Our objective is to get results to the industry as rapidly as possible.

Three different types of reports have been prepared: 1) Research Briefs, which document initial research activity, provide justification and research approach, and report only limited results; 2) Progress Reports, based on at least one completed research trial, with data reported and discussed; and 3) A few more comprehensive review-type reports, which summarize several research trials conducted to provide data on a specific topic. More detailed information on any subject matter in this report may be obtained by contacting the responsible scientist(s) directly.

Sheep and goat research in Texas is a consolidated effort involving the scientists working at College Station, San Angelo, Sonora, and other field research sites. Scientists in Texas maintain close communication with scientists in other states, including those with the USDA. Additionally, linkages are established with research organizations in other countries where sheep and goat research is being conducted. Through this network, we maintain a prompt awareness of new developments and emerging technology which may be useful in Texas. The research program maintains relationships with private organizations involved with animal health-care products; feed supplements; ration additives; growth promotants; wool, mohair, and lamb processing and marketing; and other products and concepts which may be useful in sheep and goat production.

Research is carefully targeted to address priority needs. The Texas Agricultural Experiment Station maintains a 5-year research plan in coordination with the sheep and goat industry. This research plan is reviewed annually with staff or members of the Texas Sheep and Goat Raisers Association, Mohair Council, Texas Angora Goat Raisers Association, breed associations, and others. This provides an organized approach and still allows for attention to new needs or shifts in priorities in the industry.

The current plan lists the following research needs for the industry:

1. Increase Reproductive Efficiency
2. Decrease Predation Losses
3. Reduce Impact of Toxic and Harmful Plant Problems
4. Improve Prevention and Control of Infectious Diseases
5. Increase Adaptability and Productivity Under Prevailing Conditions
6. Increase Economic Efficiency of Forage and Feed Utilization
7. Increase Fiber Production, Quality, and Value
8. Improve Consumer Acceptability of Sheep and Goat Meat
9. Improve Prevention and Control of Internal and External Parasites
10. Develop Decision Aids for Optimal Production Systems

Texas leads the nation in both sheep and goats. They play an important and unique role in obtaining maximum production and income from Central and West Texas rangelands. Therefore, most rangeland in the Edwards Plateau and some of the Trans-Pecos and southern edge of the Southern Rolling Plains regions are grazed by a mixture of cattle with sheep and/or goats. There is also considerable opportunity to expand this industry in farming areas where they can make efficient use of waste lands, glean cropland, and utilize available labor. The high production potential of both sheep and goats can be maximized under these optimum conditions.

The primary objective of the TAES research program is to provide new technology to continue to improve the productivity and profitability of this important Texas industry.

Carl Menzies, Resident Director
Texas A&M University Agricultural Research
and Extension Center at San Angelo

Sheep and Goat, Wool and Mohair, 1988

Authors

Allison, M.J., microbiologist, National Animal Disease Center, ARS, USDA, Ames, Iowa

Baldwin, B.C., Jr., research associate, Texas Agricultural Experiment Station, San Angelo

Bales, K.W., research associate, Texas Agricultural Experiment Station, San Angelo

Blakeman, N.E., research associate, Texas Agricultural Experiment Station, San Angelo

Calhoun, M.C., associate professor, Texas Agricultural Experiment Station, San Angelo

Chung, S.I., graduate student, Department of Veterinary Microbiology and Parasitology, College Station

Collisson, E.W., assistant professor, Department of Veterinary Microbiology and Parasitology, College Station

Craig, T.M., professor, Department of Veterinary Microbiology and Parasitology, College Station

Edwards, J.F., assistant professor, Department of Veterinary Pathology, College Station

Engdahl, B.S., technician, Texas Agricultural Experiment Station, San Angelo

Engdahl, G.R., associate professor, Department of Agriculture, Angelo State University, San Angelo

Fuchs, T.W., entomologist, Texas Agricultural Extension Service, San Angelo

Garza, N.E., Jr., research associate, Texas Agricultural Experiment Station, San Angelo

Herring, A.D., student worker, Texas Agricultural Experiment Station, San Angelo

Holloway, J.W., resident director of research, Texas Agricultural Experiment Station, Uvalde

Huey, R.L., graduate assistant, Department of Veterinary Microbiology and Parasitology, College Station

Hunt, L.J., technician, Texas Agricultural Experiment Station, Chillicothe-Vernon

Huston, J.E., professor, Texas Agricultural Experiment Station, San Angelo

Jenkins, R.F., graduate assistant, Texas Agricultural Experiment Station, San Angelo

Kim, H.L., assistant professor, Department of Veterinary Physiology and Pharmacology, College Station

Kuhlmann, S.W., technical assistant, Texas Agricultural Experiment Station, San Angelo

Lawford, D., director, Texas International Mohair Company, Brady

Livingston, C.W., Jr., professor, Texas Agricultural Experiment Station, San Angelo

Lupton, C.J., associate professor, Texas Agricultural Experiment Station, San Angelo

McCown, C.S., coordinator of research, MIR Center, Angelo State University, San Angelo

Miller, D.K., graduate student, Department of Veterinary Microbiology and Parasitology, College Station

Moen, R.A., technical assistant, Texas Agricultural Experiment Station, Sonora

Norman, J.L., research assistant, Department of Entomology, College Station

Olson, J.K., professor, Department of Entomology, College Station

Petersen, J.L., research associate, Texas Agricultural Experiment Station, San Angelo

Pfeiffer, F.A., research associate, Texas Agricultural Experiment Station, San Angelo

Potter, R.L., graduate research assistant, University of Georgia, Institute of Ecology, Athens, Georgia

Sappington, S.R., graduate student, Angelo State University, San Angelo

Shelton, J.M., professor, Texas Agricultural Experiment Station, San Angelo

Taylor, C.A., Jr., superintendent, Texas Agricultural Experiment Station, Sonora

Thompson, P.V., research associate, Texas Agricultural Experiment Station, San Angelo

Ueckert, D.N., professor, Texas Agricultural Experiment Station, San Angelo

Wagner, M.W., research associate, Texas Agricultural Experiment Station, San Angelo

Whipple, J.D., technician, Texas Agricultural Experiment Station, San Angelo

Willingham, T.D., technician, Texas Agricultural Experiment Station, San Angelo

Wolfrom, G.W., senior research scientist, Pittman-Moore, Inc., Terre Haute, Indiana

Table of Contents

PR-4565

Genetic Influence on Reproduction and Fleece With Booroola Merino and Other Breeds in Rambouillet Flocks

T. D. Willingham, J. M. Shelton, and C. J. Lupton

Summary

Rambouillet ewes were bred to Booroola Merino or crosses derived from Booroola, Finnish Landrace, Dorset, and Rambouillet rams to generate various genotypes for study. The use of Booroola or Finn improved ovulation rates significantly as compared to the Rambouillet, while the use of Dorset breeding caused a decline in ovulation rate. However, only one Dorset ram was used in generating experimental animals. Booroola x Rambouillet ewes, which were believed to carry a single copy of the "F" gene, had a 59% increase in ovulation rate as compared to straight Rambouillet ewes. This increase was greater than the 35.7% shown by Finn x Rambouillet animals. Ovulation rates of three or greater were frequent for all groups containing Booroola and Finn breeding. Finn x Rambouillet ewes had a higher proportion of twin ovulations and twin births, while having a lower proportion of 3's and 4's when contrasted with Booroola x Rambouillet. Lambing rates were significantly higher for those animals having Booroola (2.04) or Finn (1.91) breeding as a result of these animals having a greater percentage of triplet or larger litter sizes. Booroola-cross ewes were smaller than Rambouillet, Dorset, and Finn-crosses. Booroola-crosses tended to produce heavier, higher yielding fleeces especially as compared to Finn or Dorset-crosses. Booroola-cross fleeces tended to be slightly coarser than Rambouillet, but their fleeces still were sufficiently fine to be classified as fine wool.

Introduction

In recent years, a highly prolific strain of Merino sheep known as the Booroola has been introduced to the U.S. The reason for the Booroola's increased reproductive rate is due to a single gene (3) that is believed to suppress production of the hormone inhibin (1), allowing for increased levels of follicle stimulating hormone. The single gene of the Booroola can exist in three forms within a population of sheep (F,F) homozygous carrier, (F,-) heterozygous carrier, and (-,-) homozygous non-carrier. The effect of the "F" gene on reproduction has been suggested (2) as being additive for ovulation rate. Because the Booroola's reproductive performance is due to a single gene pair, this makes it unlike many prolific breeds such as the Finnish Landrace that are currently being used by U.S. producers. Thus, it becomes important to understand more clearly the action of this gene to effectively incorporate this genetic resource into domestic animals for efficient use of the gene.

Experimental Procedure

Beginning in the fall of 1982, grade Rambouillet ewes were bred to various sire breeds to generate genotypes as shown in Table 1. Breeding occurred at three different locations within the Edwards Plateau. Experimental animals were then moved to the Texas A&M University Agricultural Research and Extension Center in San Angelo between weaning and 16 months of age. All reproductive data were collected at San Angelo. All ewes evaluated were derived from Rambouillet ewes with one exception. The exception was the crossing of Booroola Merino rams to Booroola-cross ewes in 1984. These ewes were classified as Booroola-cross for statistical analysis since only three ewes resulted from this cross and their ovulation rates were similar to others of this type.

Two observations of ovulation rate were made on yearling ewes by the use of the laparoscopic technique (4). A single observation was made on 2-year-old ewes using the same technique. Ewes were bred for the first time at approximately 18 months of age. All ewes were pasture mated to Rambouillet and Suffolk rams with the exception of those Booroola Merino sired ewes (M) which were mated back to Booroola rams. Lamb records for each ewe were kept every year since the spring of 1983. Lamb survival and growth data are not included in the present analysis because much of the data were obtained from 2-year-old ewes lambing for the first time, and because a rather serious disease affecting lamb survival occurred in 1987.

In 1986, side samples were taken from a limited number of animals in each group and all animals in 1987 for determination of fiber diameter. Grease fleece weights were taken every year for animals evaluated. In 1987, fleeces were skirted and bagged according to genetic group. Three core samples were taken from each group and scoured for determination of yield.

Statistical analysis consisted of the least squares procedure. Age, breed, location (origin of ewe), year and appropri-

Table 1. Expected Genetic Composition, Body Weights, and Ovulation Rates by Breeding.

Breed crosses			Breeding code	Maximum expected gene frequency	Maximum expected proportion of ewes with F gene (%)	Breeding weight (lb)* Number	Breeding weight (lb)* Mean	Number of observations	LS mean ovulation rate*
Sire		*Dam*							
Booroola Merino	×	Rambouillet	M	.50	100	55	109.3[a]	77	2.45[a]
Finnish Landrace	×	Rambouillet	F	.00	0	171	124.7[b]	188	2.09[b]
Booroola Rambouillet	×	Rambouillet	P	.25	50	48	104.4[c]	96	1.86[c]
Rambouillet	×	Rambouillet	R	.00	0	154	125.1[b]	191	1.54[d]
Dorset	×	Rambouillet	D	.00	0	26	97.8[d]	82	1.36[e]

*Column means without a common superscript are significantly different (P<.05)

ate interaction were included in the model. Origin or location of the ewes was not found to have a significant effect on any of the variables evaluated. Linear Regression was used on fiber diameter and clean wool fiber present. Turkey's least significant difference test was used for multiple comparison of fiber trait means.

Results and Discussion

Breed crosses and the maximum expected proportion of ewes having the "F" gene are shown in Table 1 with the least square mean body weights and ovulation rates. For the Booroola ewes examined, the greatest expected gene frequency would be 0.5, indicating that the gene could at most exist only in the heterozygous (F,-) form.

Body weights shown in Table 1 are a result of data pooled across years and represent the weight at the beginning of breeding. Body weights indicate that the ewes having Booroola breeding were significantly lighter than the other crosses evaluated. This was also the case with the Dorset crosses but the difference was only between 6 and 7 pounds and may be more a result of the ram used than actual breed differences, as only one Dorset ram was used.

Least square mean ovulation rates in Table 1 are derived from three laparoscopic observations on each animal. Booroola-cross and Finn-cross ewes had a significant increase in ovulation rate as compared with Rambouillet with the (M) ewes showing a 59% increase over straight Rambouillets. The Finn-cross ewes were intermediate in respect to the (M) and (P) ewes, which was expected since only 50% of the (P) ewes are expected to have a single copy of the "F" gene while the other 50% are expected to be genetically similar to the Rambouillet for reproduction.

Table 2 shows the percent of ewes having various ovulation rates as determined by the number of corpora lutea observed. Each corpora lutea observed represents a single ovulation. Both the Finn and Booroola genotypes contain a number of ewes having three or more ovulations. In this comparison, the "F" gene from the Booroola appears to contribute to more ewes with three or more CL than was the case with the Finn ewes. Ewes with three or more ovulations would likely be undesirable to most producers. It should not be assumed that lambing rate will be this high because of various forms of reproductive wastage but only that the potential exists.

Ovulation rates by age are shown in Table 3. These data indicate an expected increase in ovulation rate with an increase in age for all breeds except Dorset. The lower performance by Dorset-crosses are likely a result of relatively few 2-year old ewes and the use of only a single Dorset sire in generating animals.

The number of lambs born per ewe exposed is shown in Table 4. The same trend exists in the number of lambs born as with ovulation rate, except at a reduced level. The Booroola x Rambouillet (M) and Finn-Cross (F) ewes had significantly larger litters (47% and 37% respectively) than the Rambouillet; however, these two crosses differ only slightly. One explanation for the slight difference between (M) and (F) ewes is that the Booroola x Rambouillet ewes had a higher percentage of three or more ovulations than the (F) ewes, and with each increase in ovulation rate, the probability that all ova will survive to produce a lamb decreases. The Booroola Rambouillet x Rambouillet (P) ewes failed to produce significantly more lambs per ewe exposed but when compared by number of lambs born per ewe, lambing show a 19% increase in lambs born. It should be recalled that approximately only 50% of these ewes carry a copy of the "F" gene, thus explaining the reduction in little size.

The distribution of births are shown in Table 5. Multiple births were common for both Booroola and Finn genotypes, with 47% of the ewes carrying a single copy of the "F" gene having twins, one-fourth singles, and one-fourth having three or more lambs. The tendency toward litters of three or more was not as great in the Finn-crosses with only 14.6% of the ewes falling in this category.

Fleece production and fiber characteristics are shown in Table 6. Groups which had Finn or Dorset breeding had lighter grease fleece weights with a coarser fiber. Booroola (M and P) ewes tended to shear heavier fleeces of slightly

Table 2. Ovulation Rate Distributions by Breed Group. Percent of Total Observations with Indicated Number of Corpora Lutea.

Breed group	No. of observations	Number of corpora lutea observed				
		1	2	3	4	5
M	77	7.8	46.7	37.7	6.5	1.3
F	188	16.5	65.9	15.9	1.6	.0
P	96	25.0	57.3	13.5	3.1	1.1
R	191	52.4	45.5	2.1	.0	.0
D	82	67.1	29.3	1.2	2.4	.0

Table 3. Least Square Means for Ovulation Rate by Age.

Breed group	No. of obs.	Yearling ovulation rate*†	No. of obs	2-year-old ovulation rate*
M	66	2.44^{a}	11	2.64^{ab}
F	127	1.98^{b}	61	2.11^{c}
P	96	1.98^{b}	—	—
R	132	1.44^{c}	59	1.63^{d}
D	58	1.45^{c}	24	1.25^{e}

* Column means without a common superscript are significantly different (P<.05)

† Yearling ovulation rate is the mean of two consecutive measurements.

Table 4. Least Square Means of Lambs Born Per Ewe Exposed by Breed.

Breed	No. Ewes exposed	Lambs born per ewe exposed*	Lambs born per ewe lambing*
M	55	1.93^{a}	2.04^{a}
F	171	1.77^{a}	1.91^{a}
P	48	1.52^{bc}	1.66^{b}
R	153	1.31^{bc}	1.39^{c}
D	60	1.25^{c}	1.34^{c}

* Column means without a common superscript are significantly different (P<.05)

Table 5. Distribution (Percent) of Ewes Having Various Number of Lambs by Breed.

Breed	Open	Single	Twin	Triplet	Quadruplet
M	5.5	23.6	47.3	20.0	3.6
F	7.0	25.7	52.6	12.3	2.3
P	8.3	41.7	39.6	10.4	.0
R	5.9	58.8	34.0	1.3	.0
D	6.7	65.0	25.0	3.3	.0

Table 6. Fleece Production and Fiber Characteristics of Various Breed Crosses.

Breed	Breeding code	No. animals	Fleece weight (lb)*†	Fiber diameter (μm)*†	Spinning count	Yield (%)
Booroola Merino × Rambouillet	M	81	10.41[a]	21.87[b]	64's	59.7[b]
Finn × Rambouillet	F	223	7.39[d]	22.12[bc]	62's	54.6[de]
¼ Booroola Merino–¾ Rambouillet	P	92	9.49[bc]	22.98[cd]	62's	61.1[a]
Rambouillet × Rambouillet	R	205	9.99[ab]	20.90	64's	50.0[f]
Dorset × Rambouillet	D	83	7.49[d]	27.65[e]	56's	53.4[e]

*Values for fleece weight and fiber diamater are least square means. Yields are actual means of core samples from skirted fleeces for the 1987 shearing season.

†Column means without common superscripts are significantly different (P<.05)

coarser and higher yielding wool than the straight Rambouillet. The end result should be a higher clean fleece weight.

The overriding conclusion concerning these data is that the Booroola genotype is markedly smaller than the Rambouillet and may have an objectionable body conformation. Thus the immediate effect of using Booroola rams to generate (F_1) ewes is the loss of sale weight in the male offspring even though they are out of Rambouillet dams. Backcrossing to the Booroola (F_1 ewes x Booroola sires) would be expected to result in still further reduction in weights. Thus, pure Booroola genotypes would likely be unacceptable to the U.S. sheep industry. The F_1 females resulting from crossing Booroola or percentage Booroola rams on other breeds will certainly be smaller than the Rambouillet, but this may not prove to be a big disadvantage. The market lamb resulting from a cross of this F_1 ewe to a third breed or sire breed would carry no more than ¼ Booroola genes and would likely be indistinguishable at slaughter. These data suggest that crossing Booroola to Rambouillet will not improve wool quality (fineness), but may result in some increase in clean fleece weights. This conclusion is even more significant when wool production is expressed as a function of body size or feed intake.

Literature Cited

1. Bindon, B.M. 1984. Reproductive biology of the Booroola Merino sheep. Aust. J. Biol. Sci. 37:163.
2. Davis, G.H., G.W. Montgomery, A.J. Allison and P.W. Kelley. 1982. A test of the hypothesis that progeny of Booroola sheep segregate in the ratio expected from a single gene controlling fecundity. N.Z. J. Agri. Res. 25:
3. Piper, L.R., and B.M. Bindon. 1982. Genetic segregation for fecundity in Booroola Merino sheep. Proc. World Cong. Sheep and Beef Cattle Breeding. 1:395.
4. Seeger, K.H., and P.R. Klatt. 1980. Laparoscopy in the Sheep and Goat. In. Animal Laparoscopy. pp. 107-120. Williams and Wilkins, M.D.

PR-4566

Pre-Breeding Nutrition Effects on Ovulation Rate in Angora Nannies

C. A. Taylor, Jr., N. E. Garza, Jr., J. E. Huston, R. A. Moen, and T. D. Willingham

Summary

A study was conducted to determine the effects of prebreeding nutrition and fasting on blood glucose levels, ovulation, and kidding rates in adult Angora nannies. The results indicate that fasting followed by heavy feeding results in elevated blood glucose in Angora nannies. Responses in ovulation and kidding rates are less conclusive. These data will be further evaluated and considered along with other data not included in this report.

Introduction

The potential for an Angora nanny to produce multiple offspring is determined by the ovulation rate. Although this is strongly influenced by the genetic make-up of the nanny, it can also be affected by changes in the goat's body chemistry. It has been suggested that ovulation rate can be stimulated by changes in the blood glucose level. By subjecting goats to short-term nutritional stress, and then putting them on a high level of feed, blood glucose level was stimulated to increase ovulation rate.

Experimental Procedure

One hundred thirty-one adult Angora nannies were divided randomly into a free choice feed group (High) and a limited feed group (Low; 1.5% body weight) 5 weeks prior to breeding. Five days prior to breeding (designated as day zero) the High and Low groups were further divided randomly into three subgroups designated as Control, 1-day fast, and 3- day fast. Feed was withheld between days 0 and 3 for the 3-day fast, High and Low groups, and between days 2 and 3 for the 1-day fast, High and Low groups. The Control High and Low groups were fed as usual. At the end of day 3, all groups (Control High and Low, 1-day High and Low, and 3-day High and Low) were given feed free choice. Free choice feeding continued through breeding and gestation.

Blood samples were taken from all nannies on day 0, from the 1-day and 3-day fast groups on day 3 prior to feeding,

from all groups at approximately 6 hours after resumption of feeding on day 3, and from all groups on day 5 (48 hours after resumed feeding). Analyses for glucose levels of the whole blood were completed within 2 hours of sampling.

Billies, fitted with marking harnesses, were turned in with the nannies, and breeding marks were recorded. The nannies were checked for ovulation rates by determining formation of corpora lutea by use of a laparoscope. The nannies were held in confinement during kidding season and birth data were collected at parturition.

Results and Discussion

Initial glucose levels were higher in the High group (Table 1). Fasting for either 1 or 3 days lowered glucose level in the High group, but only the 3-day fast lowered glucose in the Low group. At 6 hours post-fast, glucose levels in the fasted groups appeared to be rising but had not reached Control levels. By 48 hours post-fast, glucose levels in the fasted groups had risen above the Control groups. Although the 3-day fast Low group was not significantly higher than the Control Low group on day 5, it was substantially higher than on day 0. Overall indications are that fasting followed by heavy feeding results in elevated blood glucose in Angora nannies.

Ovulation and kidding data are less conclusive than the glucose data (Table 2). Whereas there was a small indication that fasting for 1 day improved both ovulation and kidding rates (not significant), fasting for 3 days did not. These data will be further evaluated and considered along with other data not included in this report.

Table 1. Effects of prebreeding level of nutrition followed by fasting and refeeding on blood glucose levels in Angora nannies.

	Prebreeding feed level					
	High			Low		
Item	Control	1-day fast	3-day fast	Control	1-day fast	3-day fast
Number of nannies	19	22	25	22	18	25
Blood glucose, (mg/100ml)						
Initial	52[a]	49[a]	51[a]	41[b]	42[b]	42[b]
Fasted		38[b]	39[a,b]		43[a]	33[c]
6-hrs post fast	50[a]	44[b]	46[b]	50[a]	43[b]	44[b]
48-hrs post fast	54[c]	59[a,b]	59[a,b]	53[c]	61[a]	55[b,c]

[a,b,c] Values in the same row not sharing a common superscript letter differ ($P<.05$).

Table 2. Effects of prebreeding level of nutrition followed by fasting and refeeding on ovulation and birth rates in Angora nannies.

	Prebreeding feed level					
	High			Low		
Item	Control	1-day fast	3-day fast	Control	1-day fast	3-day fast
Number of nannies	19	22	25	23	17	25
Ovulation rate, number/nanny	1.26[a,b]	1.36[a]	1.20[a,b]	1.04[b]	1.24[a,b]	1.12[a,b]
Kidding rate, number/nanny	1.10[a]	1.18[a]	.92[a]	.91[a]	1.06[a]	.84[a]

[a,b] Values in the same row not sharing a common superscript letter differ ($P<.05$).

PR-4567

Reproductive Response of Angora Nannies in Confinement to Changes in Diet Quantity

C. A. Taylor, Jr., N. E. Garza, Jr., J. E. Huston, and R. A. Moen

Summary

The results of a study conducted during the breeding season of 1986-87 on Angora nannies suggest that flushing (feeding at a high plane of nutrition) prior to exposure to fertile billies can improve conception rate. Differences (statistically nonsignificant) occurred in number of kids born to flushed and non-flushed nannies. Data also suggest that feed level during breeding and gestation can influence reproductive success. However, it appears that bred Angora nannies are capable of performing well, physiologically and reproductively, on reduced levels of feed, provided feed is supplied consistently.

Introduction

Because of an emphasis on mohair quality, breeding programs on Angora goats have sometimes neglected reproductive efficiency. And although the Angora goat is a resourceful animal, it often does not produce a very high percentage of offspring. Flushing, or feeding a high quality feed prior to breeding, has resulted in variable results when used on Angora nannies to increase reproductive rate. A study was conducted during the 1986-87 breeding season to determine if flushing prior to breeding improved conception rates in Angora nannies. Researchers also wanted to see what effect different levels of feed during gestation had on reproductive rate.

Experimental Procedure

Beginning in September 1986, 100 Angora nannies were kept in confinement for approximately 180 days. Nannies were sorted by age into adults (>2 yr) and yearlings (<2 yr), and then assigned randomly to pens in groups of five. There were 40 adult goats (8 pens) and 60 yearling goats (12 pens). Pens provided protection from precipitation and north wind but not from changes in temperature.

During the flushing period, 5 weeks prior to breeding, half of the nannies (four and six pens of adult and yearling nannies, respectively) were fed a complete pelleted ration free choice. The other half were fed the same feed at approximately maintenance level, or 1.5% of their body weight. Since the goats were kept in groups of five, the feed level was calculated using an average pen weight taken at the beginning of the study. Nannies were fed daily.

Feed rations were changed after 5 weeks, at the start of the breeding season. Adult nannies were placed into one of four categories and fed this amount of feed until they kidded (Table 1). Yearling nannies were divided into three categories. In each category the feed amount was divided by trimester of gestation. Feed amount for yearlings was given as indicated until the nannies kidded (Table 2). Each group of yearling nannies received the same total amount of feed for the total gestation period (60+60+60 = 40+70+70 = 40+60+80).

Results and Discussion

The results of this study suggest that flushing was beneficial for improving conception rates in both adult and yearling Angora nannies, even though differences were not statistically significant. In the adults, flushed nannies had a fairly high conception rate regardless of the subsequent feed level (Table 3). Nannies that were not flushed had a greater variation in conception rates between feed levels. This suggests that nannies brought up to a suitable body condition before breeding, then dropped to a lower level of feed during gestation, were able to maintain an adequate body condition at least long enough to be bred. Nannies that were not flushed, then put on a higher level of feed, appeared to be able to improve their body condition enough during the 5-week breeding season to conceive. Flushed yearling nannies had a fairly uniform conception rate across all feed levels (Table 4). Those nannies not flushed conceived at an adequate rate only when put onto a sufficiently high feed level (60-60-60) during the breeding season. Those goats not flushed and put onto a lower feed level (40-70-70; 40- 60-80) had lower conception rates even though subsequent feeding rates were higher.

Table 1. Feeding levels for adult Angora nannies during the gestation period.

Treatment group	Feeding levels during gestation	
	Flushed	Non-flushed
	g/kg MBWa	
High	90	90
Mod. High	70	70
Moderate	60	60
Low	45	45

[a]Metabolic body weight.

Table 2. Feeding levels for yearling Angora nannies during the trimesters of gestation.

Group no.	Prebreeding treatment	Feed level during trimester of gestation		
		1	2	3
		g/kg MBW[a]		
1	Flushed	60	60	60
2		40	70	70
3		40	60	80
4	Non-flushed	60	60	60
5		40	70	70
6		40	60	80

[a]Metabolic body weight.

Table 3. Numbers of kids born to adult Angora nannies either flushed or not flushed prebreeding and fed at different levels during gestation.

Treatment group	Avg. no. kids
Flushed prebreeding	
High	1.2[a]
Mod. high	1.2[a]
Moderate	1.2[a]
Low	1.0[ab]
Not flushed prebreeding	
High	1.0[ab]
Mod. high	1.0[ab]
Moderate	.8[ab]
Low	.4[b]

[a,b]Means with the same letter do not differ (P<.05).

Table 4. Number of kids born to yearling Angora nannies either flushed or not flushed prebreeding and fed differently during the trimesters of gestation.

Treatment group	Avg. no. kids[a]
Flushed prebreeding	
60-60-60	1.0
40-70-70	1.1
40-60-80	1.2
Not flushed prebreeding	
60-60-60	1.0
40-70-70	.8
40-60-80	.8

[a]Values do not differ (P<.05).

In confinement, the Angora nannies did well on 60 g/kg MBW. For an 80 lb doe, this would amount to about 2 lb of dry matter intake of a good quality forage per day, or 2.4% of her body weight. Goats fed at lower levels had lower conception rates. On pasture or in a rangeland situation, it would be necessary to monitor forage quality and quantity to determine if a feed supplement was necessary. It should also be noted that our goats were kept in confinement. The nutritional needs of free ranging goats could be somewhat different.

In conclusion, flushing Angora nannies appeared to improve conception rates. However, if forage conditions are good, flushing prior to breeding would not increase conception because the nannies already would be in good body condition (1). Also, different amounts of feed during gestation seemed to increase reproductive success if nannies were underfed prior to the breeding season. The results suggest that nannies which conceive can sustain their needs on good to marginal levels of feed, as long as the feed amount or availability is consistent.

Literature Cited

1. Hunt, L. J., N. E. Garza, Jr., C. A. Taylor, Jr., T. D. Brooks, and J. E. Huston. 1987. Influence of supplemental feeding on voluntary forage intake and on reproductive efficiency in Angora does. SID Research Digest. Summer 1987. pp. 18-20.

PR-4568

Effects of Flushing Ewes in Three Different Body Conditions on Ovulation and Lambing Rates

L. J. Hunt, J. E. Huston, B. S. Engdahl, and K. W. Bales

Summary

This study used 130 mature Rambouillet ewes in three different body conditions (fat, medium, and thin) to determine the effects of flushing (high level feeding at breeding) on ovulation and lambing rates. Flushing had no significant effect (P>.10) on ovulation or lambing rates as a whole. However, non-significant trends observed showed that ovulation increased as body conditions increased and flushing did increase ovulations within groups. Increased body condition resulted in higher ovulation rates in both control and flushed groups, but appeared to decrease lambing rate in flushed groups. Ewes with poor body condition had higher lambing rates when flushed.

Introduction

The ultimate goal in any business is to maximize net returns. In the sheep industry, improved net returns can be achieved by increasing lamb production (5). Many methods are slow or may have detrimental effects on the production of marketable lambs (4). Since ovulation rates establish the upper limits of fertility (1), the effect of nutrition on this aspect of reproduction is an important consideration. This experiment was designed to determine the effects of body condition, flushing, and the interaction of the two on ovulation and lambing rates.

Experimental Procedure

This study, involving 130 mature Rambouillet ewes, was conducted at the Texas A&M Research and Extension Center at San Angelo, Texas. These ewes were divided by visual and manual evaluation in late June into three body condition groups of fat, medium, and thin. Live weights were recorded on all ewes.

Group 1 (fat) was turned out on improved pasture with access *ad libitum* to a 12% crude protein (CP)/high energy supplement (Table 1). Group 2 (medium) was allowed to graze on improved pasture with no supplementation. Group 3 (thin) was kept in drylot and fed a low quality 10% CP ration (Table 1) *ad libitum*. Each group was weighed weekly to monitor body conditions and weights. Body condition was controlled by pasture rotation or limitation of feed.

In mid-August, each group was separated randomly into two equal sub-groups. One group served as a control group and the other as a treatment group receiving supplementation for flushing. At this time, all ewes were flocked together. Flushing consisted of a high protein/high energy non-pelleted feed (Table 1) fed at 681 g/hd three times per week to the ewes individually. Flushing continued for 6 weeks.

Three weeks after flushing began, three Rambouillet rams, fitted with marking harnesses, were turned in with the ewes. Once a ewe was identified by a mark as being bred, she was removed from the original flock and retained in a separate pasture. In approximately 1 week, she was checked for ovulation rate via laparoscopy. After the laparoscopy, the ewe was either returned to the treatment group, if the 6 weeks flushing period was not over, or put in improved pasture where she would be exposed to a Suffolk ram for cleanup.

Near the end of gestation, ewes were placed in drylot so that dam and lamb could be paired and lambing data could be recorded. Data were analyzed by using ANOVA (6) procedure of the SAS statistical program.

Table 1. Ration formulas used in flushing study in finewool sheep.

Ingredients[a]	Ration 1[b]	Ration 2[c]	Ration 3[d]	Ration 4[e]
			%	
Milo	87.0	28.0	60.0	53.5
Cottonseed meal	8.0	7.0	35.0	10.0
Cottonseed hulls				33.5
Peanut hulls		60.0		
Molasses	3.0	4.0	5.0	3.0
Salt (NaCl)	2.0	1.0		
Total	100.0	100.0	100.0	100.0
Crude protein	12.0	10.0	20.5	10.8
TDN	75.0	44.6	72.8	64.9

[a] Ingredients expressed as a percentage of ration (as fed basis).
[b] Supplement for ewes in fat body condition when grazing on improved pasture.
[c] Peanut hull maintenance ration for thin ewes in Group 3.
[d] Ration used for flushing.
[e] Maintenance ration for pregnant ewes approaching parturition.

Results and Discussion

The results of this experiment were confounded somewhat by several unexpected problems encountered through the experiment. Above average rainfall in August and September resulted in high quality forage available before and during the flushing period. Also at lambing, a syndrome known as arthrogryposis — hydranencephaly became evident. This epidemic, characterized by stillbirths, premature births and skeletal malformations made it difficult to record accurate lambing data.

Ovulation rates were not significantly affected by group, treatment or the combination of the two as a whole (P>.10) (Table 2). Even though these findings were consistent with other studies (2,8), non-significant trends toward increased ovulation rates in the flushed ewes in each body condition were observed when compared to the control ewes. Non-significant increases in ovulation rates were also noticed as body condition increased in both the flushed and control ewes.

Table 2. Mean ovulation rates by subgroup.

	Treatment			
	Control		Flushed	
Group	Number	Ovulations	Number	Ovulations
1	19	1.84[ab]	22	1.95[b]
2	20	1.80[ab]	21	1.81[ab]
3	22	1.64[a]	22	1.77[ab]

[a,b] Means not sharing a common superscript are significantly different (P<.10).

Table 3. Ewe Weights (lb) at the Beginning (SFW) and End (EFW) of Flushing and Weight Change (WC).

	Initial condition					
	Fat		Intermediate		Thin	
	Control	Flushed	Control	Flushed	Control	Flushed
n	16	12	16	16	13	13
SFW	126[a]	124[a]	122[a]	117[b]	93[c]	97[c]
EFW	133[a]	133[a]	128[ab]	125[b]	109[c]	114[c]
WC	7.3[b]	8.4[b]	6.2[b]	7.9[b]	15.9[a]	16.8[a]

[a,b,c]Means on the same row not sharing a common superscript are significantly different (P<.10).

Table 4. Mean lambing rates by subgroup.

	Treatment			
	Control		Flushed	
Group	Number	Lambs born	Number	Lambs born
1	16	1.88[a]	12	1.58[ab]
2	16	1.56[b]	16	1.56[b]
3	13	1.38[b]	13	1.62[ab]

[a,b]Means not sharing a common superscript are significantly different (P<.10).

Ewes in Group 1 were heavier at the start (SFW) and end (EFW) of flushing (Table 3). Ovulation rates in Group 2 showed no significant relationship to weight. These findings are contrary to Torell, et al. (7) but support the results of Hill, et al. (3) which show over-nutrition in heavy ewes can result in lower ovulation rates.

Lambing rates were not significantly influenced by group, treatment, or the combination of the two (P>.10). Mean lambing rates presented in Table 4 show that Group 1A had significantly more lambs than Groups 2A, 2B, and 3A. This would suggest that heavier ewes have higher implantation rates. However, flushing in Group 1 resulted in lower lambing rates (NS).

Birth weights were not statistically analyzed due to the uncertainty of the effects of the disease on the growing fetus. However, the incidence of twinning was high in all groups. Group 1A produced 13 sets of twins and 1 single. Single lambs exhibited higher birth weight averages than lambs born as twins.

Collectively, these results show that flushing probably is not a rewarding practice under good range conditions. It appears that whenever possible, ewes should be provided a plane of nutrition that will maintain a good body condition. Trends observed in this study tend to show that maintaining a high body condition in the ewe is perhaps better for ensuring high productivity than flushing ewes in lower body condition. However, flushing ewes could be practical in circumstances when conditions are not suitable to maintain better body conditions.

Literature Cited

1. Allison, A. J. 1975. Effect of nutritionally induced live weight differences on the ovarian response and fertility in ewes treated with pregnant mare's serum gonadotropin. New Zealand J. Agric. Res. 18:101.
2. Cuming, I. A.. 1977. Relationships in the sheep of ovulation rate with live weight, breed, season and plane of nutrition. Aust. J. Exp. Agric. Anim. Husb. 17:243.
3. Hill, J. R., Jr., W. C. Godley, and D. R. Lamond. 1969. Nutritional effects on fertilization of the ewe. J. Anim. Sci. 28:148.
4. Huston, J. E. 1983. Production of fine-wool ewes on year long rangeland in West Texas. II. Effects of supplemental feed and breeding frequency on reproductive rate. J. Anim. Sci. 56:1277.
5. Robinson, J. J. 1973. Some aspects of ewe nutrition. Vet. Rec. 92:602.
6. SAS Institute Inc. 1985b. SAS User's Guide: Statistics. Version 5 Ed. SAS Institute Inc., Cary, N.C.
7. Torell, D. T., I. D. Hume, and W. C. Weir. 1972. Flushing of range ewes by supplementation, drylot feeding, or grazing of improved pasture. J. Range Manage. 25:357.
8. Willingham, T., and M. Shelton. 1986. The effect of feeding on ovulation rate at three different breeding seasons. Texas Agric. Exp. Stat. Prog. Rpt. 4376.

PR-4569

Association Between the Hymenoxon Content of Bitterweed Determined by Gas Chromatography and Its Toxicity to Sheep

M.C. Calhoun, B.C. Baldwin, Jr., S.W. Kuhlmann, and H.L. Kim

Summary

The major toxic constituent in bitterweed is an unsaturated sesquiterpene lactone called hymenoxon. When sheep were fed an equivalent amount of hymenoxon from five bitterweed collections varying in hymenoxon content from 1.15% to 2.27% (air dry basis), with minor exceptions, the degree of poisoning as measured by reductions in voluntary feed intake and increases in a number of blood constituents were similar. These results indicate a close relationship between the hymenoxon content of bitterweed, as determined by gas chromatography and the degree of poisoning in sheep.

Introduction

The toxic constituent of bitterweed *(Hymenoxys odorata)* is an unsaturated sesquiterpene lactone called hymenoxon by Kim, et al. (6) and hymenovin by Ivie, et al. (5). A gas chromatographic procedure developed by Hill, et al. (4) has been routinely used to measure the hymenoxon content of bitterweed plants, but no attempt has been made to examine animal response in relation to hymenoxon content. At least in one instance, there was not good agreement between hymenoxon content as determined by gas chromatography and animal toxicity (1). In this case, a collection of bitterweed plants harvested in April of 1982 which contained 2% hymenoxon were found to be relatively nontoxic when force-fed to sheep.

The purpose of this research was to examine the relationship between the hymenoxon content of bitterweed, as determined by gas chromatography, and the degree of poisoning when this bitterweed was force-fed to sheep.

Experimental Procedure

Five collections of bitterweed plants varying in hymenoxon content from 1.15% to 2.27% were used in this study. The ranch locations where the bitterweed was collected, sampling dates, and hymenoxon contents are given in Table 1. These collections were air-dried in the shade and/or dried at 75 degrees C in a forced-draft oven. Subsequently, they were ground through a hammermill with a ¼-inch screen and stored dry in a tight container at ambient temperature. Prior to being used in this study the bitterweed was reground through a Wiley Mill (2 mm screen).

Nineteen Rambouillet sheep (115.6 ± 1.8 lb), approximately 1 year old, were placed into individual pens with raised, expanded metal floors and given a 20-day preliminary period to adapt to the new facilities. The diet shown in Table 2 was fed to all sheep at a rate of 2.2 lb/day until 6 days prior to bitterweed dosing. Then they were offered all they would eat for the remainder of the study.

Table 1. Collection Dates, Ranch Locations Where Plants Were Collected, and Hymenoxon Content (Air-Dry Basis) of Bitterweed Used in This Study.

Collection no.	Date collected	Ranch location[a]	Hymenoxon %
1	4-27-82	Bill Pfluger Ranch	1.15
2	5-18-82	Lee Pfluger Ranch	1.52
3	Spring 1984	Hill Ranch	1.55
4	6-3-86	Bill Pfluger Ranch	1.92
5	4-4-86	Hill Ranch	2.27

[a]Ranch locations were 35 km southwest of San Angelo, Texas, in southeastern Tom Green County for the Bill and Lee Pfluger Ranches and 45 km south-southeast of Sonora, Texas, in northwestern Edwards County for the Hill Ranch.

Table 2. Percentage Ingredient Composition and Calculated Nutrient Content of the Experimental Diet.

Ingredient	%[a]
Sorghum grain, milo (dry rolled)	54.7
Cottonseed hulls	29.9
Cottonseed meal (41% crude protein)	7.9
Molasses, sugar cane	4.0
Salt, plain mixing	.5
Calcium carbonate	1.5
Ammonium chloride	.5
Vitamin-mineral premix[b]	1.0
Nutrient values[c]	
Total digestible nutrients, %	68.8
Digestible energy Mcal/lb	1.36
Crude protein, %	11.5
Calcium, %	.68
Phosphorus, %	.31

[a]As fed basis.
[b]The composition of the vitamin-mineral premix was: sodium chloride, 64.7%; potassium chloride, 19.0%; sulfur, 10.0%; molasses, 1.5%; zinc oxide, .274%; vitamin A palmitate (13,607,700 IU/lb), .730%; vitamin D (13,607,700 IU/lb), .093%; d,l-α-tocopheryl acetate (125,304 IU vitamin E/lb), .720% and chlortetracycline (50 g/lb), 3.0%.
[c]Dry matter basis.

Reground bitterweed was mixed with 1.5 quarts of warm tap water and administered via stomach tube to all sheep at a level to provide 17 mg hymenoxon per lb live weight per day for 4 consecutive days. Three sheep received collection No. 1 (Bill Pfluger Ranch, 4-27-82) and four sheep were given each of the remaining collections. Bitterweed dosing was done at 9:00 a.m. each day.

Blood samples were collected from the jugular vein into vacutainer tubes just prior to the first bitterweed dose and again 24 hours after the last dose. Changes in voluntary feed intake, hematocrit, and serum concentrations of urea nitrogen, creatinine, aspartate aminotransferase, and gamma glutamyltransferase were the criteria used to assess the degree of bitterweed poisoning.

Statistical procedures as outlined by Steele and Torrie (7) for the analysis of variance of a completely random design were used in the statistical analysis of the data. Duncan's New Multiple Range Test was used to test for differences between treatment means.

Results and Discussion

Actual bitterweed dose varied from .37 lb/d (.33% of live wt) for the sheep given collection one containing 1.15% hymenoxon to .19 lb/d (.16% of live wt) for the sheep given collection five containing 2.27% hymenoxon (Table 3). Total hymenoxon dose received by all lambs over the 4-day period was 68 mg/lb live wt. This compares with a reported acute oral LD fifty in sheep of 34 mg hymenoxon per lb live wt (8). Although Terry, et al. (8) found that the clinical signs and pathologic lesions were qualitatively identical for sheep fed whole bitterweed and hymenoxon, they also reported whole bitterweed produced lower percentages of mortality than hymenoxon at dosage levels of 34 and 45 mg hymenoxon/lb live wt. Furthermore, as demonstrated by Dollahite, et al. (3), spreading the dose out over a period of days, as was done in this study, increases the amount of bitterweed required to produce signs of poisoning. Because of this, although the sheep became sick in this study, none died from bitterweed poisoning.

Feed intake during the last four days of the preliminary period averaged 3.7 lb/d and was not different for sheep assigned to the different bitterweed collections. Administration of bitterweed resulted in a decrease in feed intake the first day and, with the exception of sheep fed bitterweed collection five, all sheep essentially had stopped eating by the third day. On the second and third days, sheep fed collection five consumed more feed than sheep fed the other collections ($P<.05$) (Table 3).

Reduction in feed intake has been shown to be a sensitive indicator of bitterweed/hymenoxon intake. In a previous study, 92% of the variation in feed intake was associated with hymenoxon intake (2) and voluntary feed consumption ceased at a daily hymenoxon intake of 17.6 mg/lb live weight. Similarly, sheep fed four of the five bitterweed collections in this study were completely off feed by the third day. Since all sheep received an equivalent hymenoxon dose (17 mg per lb/live wt per day), it is possible that factors other than hymenoxon may be involved in the reduction in feed intake.

Bitterweed treated sheep developed increased hematocrits (% packed red blood cell volume) and serum levels of urea

Table 3. Live Weight, Bitterweed Dose, and Voluntary Feed Intake of Sheep Given an Equivalent Amount of Hymenoxon from Five Bitterweed Collections Varying in Hymenoxon Content.

Item	Bitterweed collection 1	2	3	4	5	SEM[c]
Sheep, no	3	4	4	4	4	
Initial live wt, lb	112	116	117	118	114	
Bitterweed dose, lb/day	.366	.286	.283	.230	.188	
Hymenoxon dose, mg/lb live wt[d]	17	17	17	17	17	
Feed intake, lb/day						
Pre-bitterweed, 4 day avg	3.58	3.85	3.72	3.71	3.69	.28
Post-bitterweed						
Day 1	2.38[ab]	2.29[ab]	1.68[b]	1.01[b]	3.33[a]	.48
Day 2	.44[b]	.35[b]	.11[b]	.15[b]	1.90[a]	.18
Day 3	0[b]	.07[b]	0[b]	.02[b]	.35[a]	.07
Day 4	0	.02	0	0	.46	.18
Day 5	1.34[a]	.42[ab]	.15[b]	.22[b]	.79[ab]	.29

[a,b]Means on the same row without a common superscript are significantly different (P<.05).
[c]Standard error of the mean.
[d]This amount was given daily for 4 consecutive days.

Table 4. Percentage Hematocrit and Concentrations of Several Serum Constituents of Sheep Administered an Equivalent Amount of Hymenoxon from Five Bitterweed Collections Varying in Hymenoxon Content.

Item	Exp. day	Bitterweed collection 1	2	3	4	5	SEM[c]
Hematocrit, %	1	41.0	44.1	41.4	43.2	41.6	1.5
	5	46.2	50.2	51.2	49.6	47.5	2.1
Serum urea nitrogen, mg/dl	1	8.0	6.4	7.9	6.9	6.5	1.1
	5	33.4	25.5	35.7	22.4	28.6	4.7
Serum creatinine, mg/dl	1	1.07	1.04	1.04	1.06	1.05	.07
	5	2.55[a,b]	2.38[a,b]	3.13[a]	1.80[b]	1.90[b]	.32
Serum aspartate aminotransferase, SFU/ml[d]	1	56.7	56.9	56.4	61.5	61.2	3.5
	5	340.9	333.8	388.2	276.0	361.1	71.4
Serum gamma glutamyltransferase, U/ml	1	62.2	58.6	57.5	62.7	68.0	3.9
	5	234.4	254.1	300.8	281.4	317.9	58.8

[a,b]Means on the same row without a common superscript are significantly different (P<.05).
[c]Standard error of the mean.
[d]Aspartate aminotransferase (Sigma-Frankel units/ml of serum).

nitrogen, creatinine, aspartate aminotransferase, and gamma glutamyltransferase. Increases in these blood constituents are indicative of the degree of bitterweed poisoning (1,2). Bitterweed source was without effect on hematocrit, urea nitrogen, aspartate amino transferase, or gamma glutamyl transferase responses; however, there were significant differences among bitterweed collections for creatinine. Final values for creatinine were lower for collections four and five compared with collection three (P<.05) (Table 4).

The research of Terry, et al. (8) in which similar responses were observed when sheep were orally administered pure hymenoxon or an equivalent amount of hymenoxon in bitterweed, as well as the similarity of responses observed in this study when sheep were administered an equivalent amount of hymenoxon from five bitterweed collections varying in hymenoxon content, tends to validate the gas chromatographic procedure used to measure hymenoxon content of bitterweed. However, one instance (1) in which there was poor agreement between hymenoxon content and animal response remains to be explained.

Literature Cited

1. Calhoun, M.C., H.L. Kim, F.A. Pfeiffer, and B.C. Baldwin, Jr. 1983. Association between hymenoxon content of bitterweed *(Hymenoxys odorata)*, as measured by gas chromatography, and its toxicity to sheep. Tex. Agr. Exp. Sta. Prog. Rpt. 4171.
2. Calhoun, M.C., D.N. Ueckert, C.W. Livingston, Jr., and B.C. Baldwin, Jr. 1981. Effects of bitterweed *(Hymenoxys odorata)* on voluntary feed intake and serum constituents of sheep. Amer. J. Vet. Res. 42:1713.
3. Dollahite, J.W., L.D. Rowe, H.L. Kim, and B.J. Camp. 1973. Control of bitterweed *(Hymenoxys odorata)* poisoning in sheep. Tex. Agr. Exp. Sta. Prog. Rpt. 3149.
4. Hill, D.W., H.L. Kim, and B.J. Camp. 1979. Quantitative analysis of hymenoxon in plant tissue. J. Agr. Food Chem. 27:885.

5. Ivie, G.W., D.A. Witzel, W. Herz, R. Kannan, J.O. Norman, D.D. Rushing, J.H. Johnson, L.D. Rowe, and J.A. Veech. 1975. Hymenovin. Major toxic constituent of western bitterweed *(Hymenoxys odorata* DC.). J. Agr. Food Chem. 23:841.
6. Kim, H.L., L.D. Rowe, and B.J. Camp. 1975. Hymenoxon, a poisonous sesquiterpene lactone from *Hymenoxys odorata* DC. (Bitterweed). Res. Commun. Chem. Pathol. Pharmacol. 11:647.
7. Steel, R.G.D., and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill, New York.
8. Terry, M.K., H.L. Kim, D.E. Corrier, and E.M. Bailey, Jr. 1981. The acute oral toxicity of hymenoxon in sheep. Res. Commun. Chem. Pathol. Pharmacol. 31:181.

PR-4570

Managing Pricklypear with Herbicides and Fire

D.N. Ueckert, J.L. Petersen, R.L. Potter, J.D. Whipple, and M.W. Wagner

Summary

Pricklypear causes serious economic loss to sheep and goat producers. Research was initiated in 1977 to develop more effective and less expensive pricklypear control practices. Our results suggested that herbicidal control, as a single-treatment approach, can be achieved most effectively with aerial sprays of picloram at .5 lb/acre applied during late August through October when photosynthates are being replenished in pricklypear crowns and sub-terminal pads. Prescribed fires in heavy fine fuels such as tobosagrass reduced pricklypear cover by 80% to 90% and provided effective control for about 10 years. However, control following fires in lighter fine fuel types, such as sideoats grama and buffalograss, was often not adequate to satisfy the management objectives of sheep and goat ranchers. The sequential application of fire and aerial sprays of picloram at .13 lb/acre reduced pricklypear by an average of 98% in 10 experiments. Herbicide costs are reduced about $9/acre when the low rate is used after controlled burning or wildfires, compared to the high rate necessary for acceptable control on unburned rangeland.

Introduction

Pricklypear (*Opuntia* spp.) occurs on about 28% (25.5 million acres) of the rangeland in Texas, and more than 40% of it occurs in the Edwards Plateau where most of the state's sheep and goats are produced (9). Pricklypear causes severe economic losses to sheep and goat producers. Sheep and goats readily eat the fruits and pads of pricklypear, especially when quality of desirable forages is low. The small spines (glochids) of pricklypear cause bacterial infection in the mouths and gastrointestinal tracts and the hard seeds cause rumen impaction (10,11), resulting in death losses, orphaned kids and lambs, decreased fiber production in affected animals, and the culling of many ewes and nannies that would otherwise remain productive for many years. Dense stands of pricklypear also interfere with the handling and movement of livestock (5), and the utilization of forages by livestock (1,14), and compete with desirable forage plants. Pricklypear is recognized as an emergency livestock feed during drought (17) and as food and cover for several species of wildlife.

The abundance of pricklypear on a given range site or region and the periodic fluctuations in its abundance are a function of weather, soils, grazing, insects, fire, and interactions among these factors (1,2,7,8,18). Pricklypear has been recognized as the major undesirable plant problem on many ranches in central and western Texas during the last decade and there is evidence (12) and general concern that its abundance is increasing. Pricklypear infestations were controlled for many decades by hand grubbing and stacking and later by aerially applied sprays of a 1:1 mixture of 2,4,5-T and picloram during spring or early summer. The increasing costs of ranch labor and new federal labor laws have essentially eliminated hand grubbing and stacking as a viable pricklypear management practice. Aerial sprays of 2,4,5-T + picloram did not consistently control pricklypear. Furthermore, the cost of aerial spraying increased to the extent that the practice was not considered cost-effective by many ranch firms, and in 1982, the registration of 2,4,5-T was cancelled. We initiated research in 1977 at the Texas A&M University Agricultural Research and Extension Center at San Angelo to develop more effective and less expensive technology for controlling pricklypear. The objective of this report is to summarize our findings.

Herbicidal Control

Aerial Spraying. The standard recommendation for herbicidal control of pricklypear in the Edwards Plateau and Rolling Plains for many years was aerial spraying with a 1:1 mixture of 2,4,5-T and picloram at .5 lb/acre during late spring or early summer (6). A higher rate (1.0 lb/acre) was recommended for the South Texas Plains area. These recommendations were developed from observations made in numerous experiments and demonstration plots in which honey mesquite was the primary target plant.

Broadcast applications of 2,4,5-T + picloram at .5 lb/acre during late spring through early summer did not consistently control pricklypear (Table 1). We hypothesized that the inconsistency of pricklypear control might be due to inadequate translocation of herbicide to the older pads and crowns of pricklypear. Translocation of photosynthetic products is an important consideration when timing herbicide applications to pricklypear because picloram, the herbicide that is most effective on pricklypear, moves within the apoplast and symplast of plants, and, thus, its efficacy may be affected by photosynthate translocation. We initiated a study in 1982 to determine the seasonal trends in total nonstructural carbohydrates (photosynthates) in the various structures of Lindheimer pricklypear and to establish carbohydrate source-sink relationships during the different growth stages as an aid in determining proper timing of herbicide applications.

We found that photosynthates in the roots, crowns, and mature pads of Lindheimer pricklypear were rapidly depleted during spring through midsummer as they were translocated upward into new pads and fruits (Figure 1) (13). This depletion period coincides with the period when control had traditionally been attempted with aerial sprays of 2,4,5-T + picloram. Replenishment of total nonstructural carbohydrates in

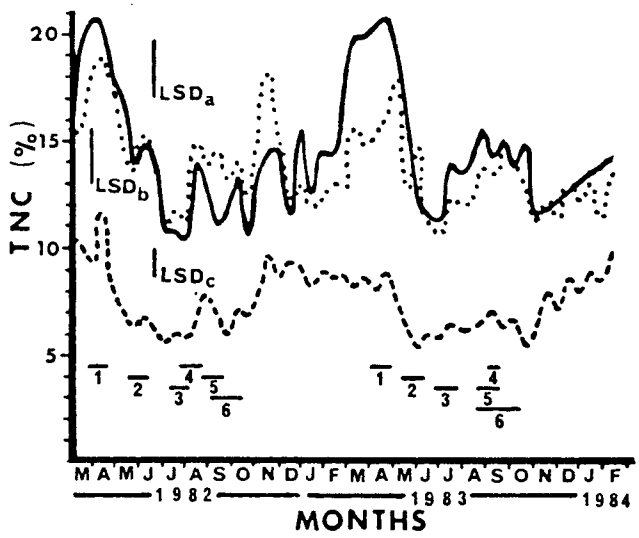


Figure 1. Percent total nonstructural carbohydrates (TNC) in pads (solid line), basal crowns (dotted line), and roots (dashed line) of Lindheimer pricklypear determined at 2-week intervals from March 2, 1982, to February 10, 1984, near San Angelo, TX. LSD_a, LSD_b, and LSD_c apply to pads, crowns, and roots, respectively ($\alpha = 0.05$). Points are averages from five plants sampled on each date. Horizontal lines on the lower portion of the figure represent selected phenological stages (1 = bud break, 2 = flowering, 3 = fruit full size (green), 4 = new pads full size, 5 = fruit drop and 6 = pads flaccid).

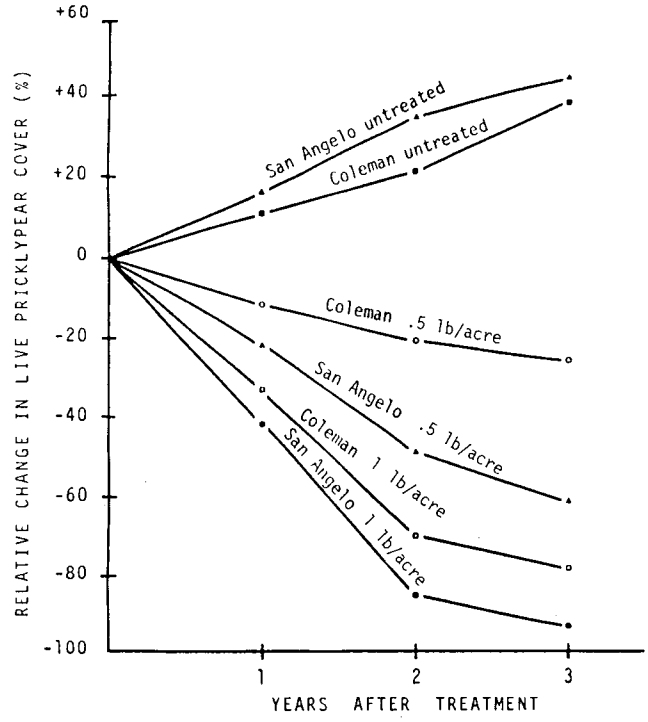


Figure 2. Relative changes (%) in live pricklypear cover for 3 years following broadcast applications of a 1:1 mixture of 2,4,5-T and picloram at .5 and 1.0 lb/acre and on untreated rangeland at study sites near San Angelo and Coleman, Texas. Data were averaged over daytime and nighttime treatments in December 1981, June 1982, August 1982, and October 1982.

old pads and basal crowns occurred during August through March and those in the roots were replenished from early autumn through mid-winter. These results suggested that herbicide applications during late summer, autumn, or winter (when total nonstructural carbohydrates are being replenished in the basal crowns, older pads, and roots) might be more effective if the herbicide is translocated with photosynthates (12,13).

In 1981, we initiated a study to determine the relative susceptibility of pricklypear to the 2,4,5-T + picloram mixture in various seasons of the year and to determine if efficacy of the treatment could be improved by increasing the rate from .5 lb/acre to 1.0 lb/acre or by applying the sprays at night. The herbicide mixture was applied as broadcast sprays at day and at night at the two rates in December, June, August, and October to research plots at two locations (12).

Phytotoxicity of the herbicide mixture was not fully manifested until 3 years after treatment (Figure 2), apparently because of limited absorption of herbicide into pricklypear pads and roots and subsequent slow and limited translocation (3,4, H.S. Mayeux, Jr., unpublished data). Live pricklypear cover on untreated plots increased 38% at the Coleman County site and by 47% at the San Angelo site during this 3-year period (12), confirming that the pricklypear problem was increasing. The 1.0 lb/acre rate of 2,4,5-T + picloram killed more Lindheimer and Edwards pricklypear growing on clay loam soils near San Angelo compared to the .5 lb/acre rate during most seasons (Figure 3, Table 1). The high rate did not increase control of hybrid pricklypear growing on clay soils near Coleman sufficiently to justify the added treatment cost or to satisfy the management objectives of most ranchers (Figure 3).

Night applications of the 2,4,5-T + picloram mixture killed significantly more pricklypear than daytime treatments only during June (Figure 4). Schuster (15) found that wetting sprays of 2,4,5-T and silvex applied at night during June and July killed more plains pricklypear than daytime applications, but the treatments were not evaluated at other seasons. We presume that night applications of herbicides during spring through early summer may have resulted in greater penetration of spray solutions through the stomata compared to that achieved with daytime applications at the same season. It is important to notice in Figure 4 that night applications of the herbicide mixture in June were no more effective than daytime applications in August or October. It seems unlikely that commercial applicators will be interested in nighttime aerial applications at any season.

Our data strongly suggests that pricklypear is most susceptible to late summer and early autumn herbicide applications and least susceptible to late spring-early summer applications (Figures 3 and 4). Winter treatments were intermediate in effectiveness.

Picloram (Grazon PC) was registered for use on Texas rangeland in 1983 after the registration of 2,4,5-T was cancelled. We have evaluated the effects of various rates and formulations of picloram on pricklypear in numerous experiments since 1981 (Table 1). Our results document clearly that pricklypear response to a herbicide treatment is highly variable. This variability occurs within a range site treated with the same batch of herbicide, and there is usually a great deal of variability in results where the same treatment is applied on different dates at one location or at different locations. Our results from 21 field experiments document that the greatest

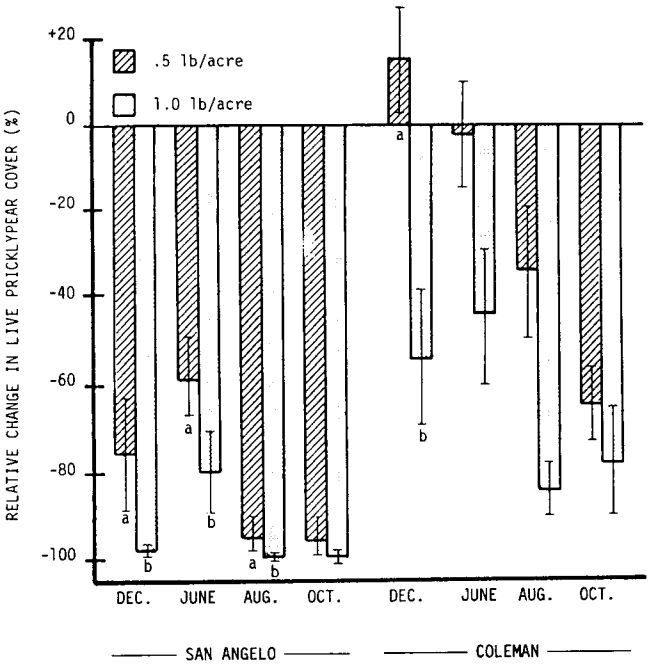


Figure 3. Relative changes (% ± S.E.) in live pricklypear cover 3 years after broadcast applications of a 1:1 mixture of 2,4,5-T and picloram at .5 and 1.0 lb/acre in December, June, August, and October at study sites near San Angelo and Coleman, Texas. Data are averaged over daytime and nighttime treatments. Different lower case letters within a treatment date and site indicate significant ($P \leq 0.05$) difference between rates according to LSD tests.

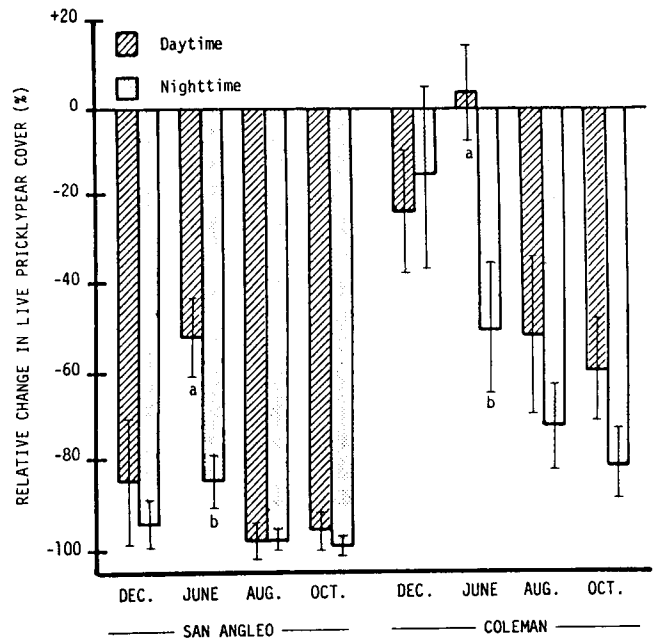


Figure 4. Relative changes (% ± S.E.) in live pricklypear cover 3 years after broadcast applications of a 1:1 mixture of 2,4,5-T and picloram at daytime and nighttime in December, June, August, and October at study sites near San Angelo and Coleman, Texas. Data are averaged over .5 and 1.0 lb/acre rates of application. Different lower case letters within a treatment date and site indicate significant ($P \leq 0.05$) difference between day and night treatments according to LSD tests.

Table 1. Average Reduction of Live Pricklypear Cover 3 Years after Broadcast Applications of Various Herbicides in West Texas[a].

Herbicide	Rate	No. Tests[b]	Reduction in live pricklypear cover Avg.	(Range)[c]
	(lb/acre)		----- (%) -----	
Liquid sprays				
Picloram	.13	6	67	(60 to 76)
Picloram	.25	12	65	(−1 to 97)
Picloram	.5	8	87	(78 to 98)
2,4,5-T + picloram (1:1)	.5	14	65	(−15 to 95)
2,4,5-T + picloram (1:1)	1.0	8	80	(45 to 99)
2,4,5-T + picloram (1:2)	.75	1	89	—
Silvex	.5	4	31	(−44 to 72)
Silvex	1.0	4	35	(−9 to 66)
Silvex	2.0	4	58	(44 to 68)
Pellets				
Picloram 10%, 3/32" diam.	.13	6	38	(17 to 73)
Picloram 10%, 3/32" diam.	.25	6	43	(12 to 65)
Picloram 10%, 3/32" diam.	.5	6	62	(45 to 80)
Picloram 10%, 3/32" diam.	.56	1	53	—
Picloram 10%, 3/32" diam.	.90	1	92	—
Picloram 10%, 5/64" diam.	.65	1	62	—
Picloram 10%, 5/64" diam.	.92	1	82	—
Picloram 2%	.13	4	37	(7 to 69)
Picloram 2%	.25	4	61	(52 to 67)
Picloram 2%	.5	4	78	(57 to 90)

[a] Data from 21 different field evaluations during 1981-87.
[b] Reflects the number of experiments/locations in which each herbicide treatment was evaluated.
[c] Lowest and highest values observed for each treatment. Negative values indicate no control and an increase in live pricklypear cover.

average pricklypear control was achieved with broadcast sprays containing picloram at .5 lb/acre (80% to 89% control) (Table 1). It was not uncommon for pricklypear to actually increase in abundance on rangeland sprayed with picloram at .25 lb/acre or with 2,4,5-T + picloram (1:1) at .5 lb/acre. Silvex applied at rates as great as 2.0 lb/acre did not effectively control pricklypear (Table 1).

Several formulations of pelleted picloram were evaluated, but pelleted formulations were never as effective as equivalent rates of picloram applied as broadcast sprays (Table 1). We presume the greater efficacy of broadcast sprays, compared to pelleted picloram, is related to absorption of some picloram in sprays by the pricklypear pads and/or to more effective coverage of sprays on the soil surface for uptake by pricklypear roots. Pelleted picloram formulations are no longer commercially available.

Our current recommendation for producers who prefer herbicidal control of pricklypear is to apply aerial sprays of picloram at .5 lb/acre in a total volume of 2 to 3 gallons/acre of a diesel fuel- water emulsion containing at least one quart of diesel fuel/acre and a drift control additive during late August through October. If concommitant control of honey mesquite is desired, we recommend spraying 40 to 90 days after mesquite bud break, when soil temperatures at 12 to 18 inches deep are 75 degrees F or greater, with picloram at .5 lb/acre + clopyralid (Reclaim), triclopyr (Grazon ET) or dicamba. Producers should recognize that pricklypear control occurs slowly over a 3-to- 4-year period after spraying (Figure 2) and that results will be variable. We have also observed that her-

bicide treatments often increase the palatability of prickly-pear to livestock.

Fire

It has been known for several years that pricklypear is damaged or killed by grass fires. Fire is more damaging to small pricklypear plants than to larger plants or "pear colonies," and fires in heavy grass fuel types (e.g., tobosagrass) are more damaging than those in shortgrasses (e.g., buffalograss). Bunting, et al. (2) reported that pricklypear mortality was only about 20% at 6 months after fires, but increased to about 70% after 4 years. They felt the gradual increase in plant mortality over time after fire was because fire weakened the plants and increased their susceptibility to damage by insects, rodents, and rabbits.

We have monitored the effects of numerous fires on live pricklypear canopy cover in the Edwards Plateau and southern Rolling Plains since 1978. Pricklypear cover has been reduced 80% to 95% within 2 to 3 years after burning tobosagrass rangeland, but the pricklypear generally begins a slow recovery after 4 years (Figure 5). In lighter fine fuel types, such as Texas wintergrass, sideoats grama, or buffalograss, pricklypear cover is usually reduced 70% to 80% within 1 to 2 years after fires (Figure 6), but the pricklypear canopies recover much more quickly than where tobosagrass is burned (Figure 5). Intense fires in tobosagrass rangeland can provide effective pricklypear control for about 10 years or longer. Intense fires in mixed grass rangeland may not reduce pricklypear abundance sufficiently to satisfy the management objectives of sheep and goat producers, but the degree of control may be sufficient for 5 or 6 years to satisfy cattle producers. Controlled burns are relatively inexpensive compared to most other range improvement practices. Costs are $2 to $5/acre to construct fire guards and for labor and materials to burn rangeland, but there are direct and indirect risks involved, and a grazing deferment prior to and following the fire is normally needed to ensure an effective fire and recovery of desirable forage plants.

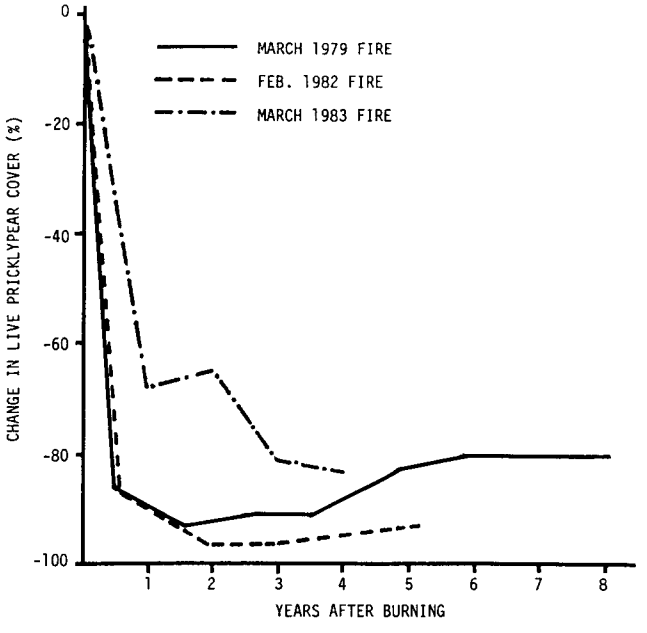


Figure 5. Response of pricklypear to prescribed fire in a tobosagrass community in northern Crockett County, Texas.

Fire/Picloram Pricklypear Control System

No brush or weed management practice is without its unique strengths and weaknesses, thus single-treatment approaches have rarely maximized long-term benefits to ranching enterprises. Integrated brush management systems, i.e., the application of two or more brush management practices in a well-designed, long-range plan, have been shown to be more effective than "single-treatment" approaches and appear essential for economical range improvement systems for western Texas (16). With knowledge of the inherent strengths and weaknesses of the available pricklypear control practices, as discussed in the preceeding sections of this report, we initiated research in 1977 to investigate the possibility that sequential applications of fire and herbicides might provide more effective pricklypear control. In a pilot study, picloram and tebuthiuron were applied at .5, 1.0, and 2.0 lb/acre rates in April 1977 to pricklypear and mesquite-infested rangeland at the Texas A&M University Agricultural Research and Extension Center at San Angelo that had been burned in March 1977. Fire + picloram at .5 lb/acre killed 96% of the pricklypear plants, while fire + tebuthiuron at 2.0 lb/acre killed only 16% and fire as a single treatment caused no pricklypear mortality (19). Additional small-plot studies were initiated at two locations with 1981 winter burns and herbicide applications in April or June 1981. Large-plot, critical experiments with pasture-size burns and aerial applications of herbicide were conducted at six locations in 1983.

Fire reduced live pricklypear cover an average of 65% in these experiments, but a fire pre-treatment increased the efficacy of all herbicide treatments evaluated (Table 2). The sequential application of fire + broadcast sprays of picloram at .13 lb/acre reduced pricklypear cover by 98%, compared to 73% and 88% for picloram sprays applied at .25 and .5 lb/acre rates, respectively, to unburned rangeland (Table 2). The efficacy of silvex treatments was increased by as much as 47% and that of pelleted picloram treatments was increased by as much as 59% when fire preceded the herbicide applications. Most of the pricklypear was dead 18 months after the

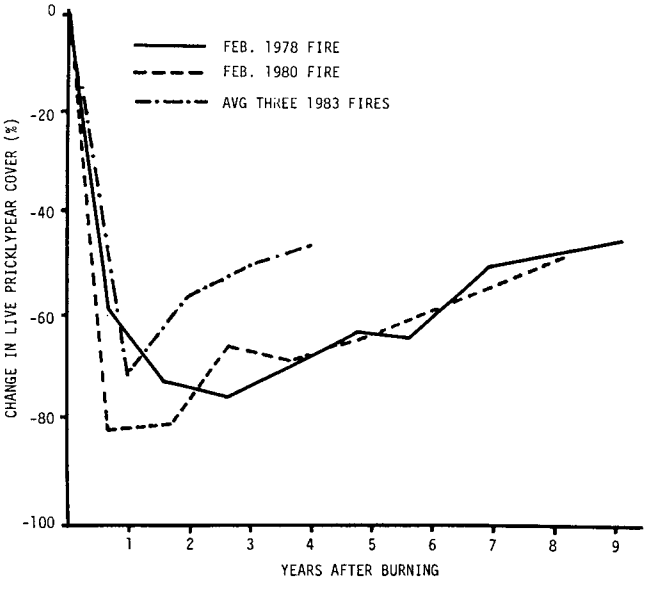


Figure 6. Response of pricklypear to prescribed fire in mixed-grass communities in the Edwards Plateau and southern Rolling Plains.

Table 2. Average Reduction of Live Pricklypear Cover 3 to 4 Years After Prescribed Fire, Broadcast Applications of Selected Herbicides, and Fire + Herbicides in West Texas[a].

Treatment	Herbicide Formulation	Rate	Reduction in live pricklypear cover					
			Unburned Rangeland			Burned Rangeland		
			Avg.	(Range)	No. Tests	Avg.	(Range)	No. Tests
		(lb/acre)	----- (%) -----			----- (%) -----		
Fire			—	—	—	65	(20-89)	8
Picloram	liquid	.13	69	(60-76)	4	98	(84-100)	10
Picloram	liquid	.25	73	(40-97)	8	99	(96-100)	10
Picloram	liquid	.5	88	(80-91)	4	99	(96-100)	4
2,4,5-T + picloram (1:1)	liquid	.5	79	(75-85)	4	97	(91-100)	4
Silvex	liquid	.5	47	(29-65)	2	89	(82-96)	2
Silvex	liquid	1.0	43	(20-66)	2	90	(81-99)	2
Silvex	liquid	2.0	61	(53-68)	2	100	—	2
Picloram	3/32", 10% pellets	.13	38	(20-73)	4	88	(82-94)	4
Picloram	3/32", 10% pellets	.25	40	(12-62)	4	95	(92-98)	4
Picloram	3/32", 10% pellets	.5	56	(45-76)	4	93	(84-98)	4
Picloram	2% pellets	.13	31	(7-55)	2	90	(82-98)	4
Picloram	2% pellets	.25	62	(58-66)	2	96	(93-99)	4
Picloram	2% pellets	.5	74	(57-90)	2	97	(95-100)	4

[a]Data from 10 field experiments installed during 1981 and 1983. Prescribed fires were installed during winter and herbicides were applied in mid-to-late April (8 experiments) or mid-June (2 experiments).

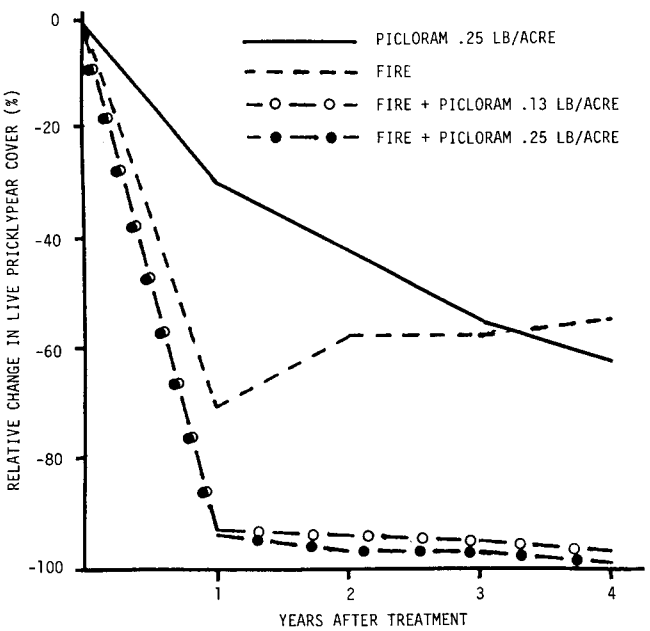


Figure 7. Changes in live pricklypear cover for 4 years following applications of prescribed fire, aerial applications of picloram, and prescribed fire + aerial applications of picloram in 1983 at six locations in the Edwards Plateau and southern Rolling Plains.

sequential applications of fire and herbicides, whereas control was not fully manifested for 3 to 4 years after herbicides are applied to unburned rangeland (Figure 7).

Our current recommendation for the fire/picloram pricklypear control system is to install intense, controlled burns during December through March, then aerially apply picloram at .13 to .25 lb/acre during mid-April through May. The higher rate should be used where it is obvious there was less-than-optimal direct heat damage to the pricklypear from the fire as evidenced by the failure of the fire to completely "brown out" the pricklypear infestation, or by prolific resprouting of the burned plants following spring rains. Remember, spring rains stimulate resprouting of burned pricklypear.

The fire/picloram system clearly offers economic advantages over the picloram single-treatment approach. Picloram should be applied at .5 lb/acre to unburned rangeland, preferably during late-August through October for most effective pricklypear control (Figures 2, 3). Cost for this practice is about $16.50/acre. Cost for aerially applying the .13 lb/acre rate to burned rangeland is about $7.50/acre, while the .25 lb/acre rate costs about $10.25/acre. The sequential application of fire and the low rates kill pricklypear much faster and kill a greater proportion of the pricklypear than picloram applied at the high rate as a single treatment. Furthermore, the fire/picloram system greatly reduces the variability in treatment efficacy (Table 2), and hence reduces the risk of treatment failure. Herbicide costs are $6 to $9/acre less where the lower rates are applied after burning. The .13 and .25 lb/acre rates of picloram can also be effective when opportunistically utilized following intense wildfires. It appears the effective treatment life of our fire/picloram system may be at least 15 years.

Literature Cited

1. Bement, R.E. 1968. Plains pricklypear: Relation to grazing intensity and blue grama yield on central Great Plains. J. Range Manage. 21:83-86.
2. Bunting, S.C., H.A. Wright, and L.F. Neuenschwander. 1980. Long-term effects of fire on cactus in the southern mixed prairie of Texas. J. Range Manage. 33:85-88.
3. Chow, P.N., O.C. Burnside, and T.L. Lavy. 1966. Physiological studies with prickly pear. Weeds 14:58-62.
4. Chow, P.N., O.C. Burnside, T.L. Lavy, and H.W. Knoche. 1966. Absorption, translocation, and metabolism of silvex in prickly pear. Weeds 14:38-41.

5. Dameron, W.H., and H.P. Smith. 1939. Pricklypear eradication and control. Texas Agr. Exp. Sta. Bull. 575.
6. Hoffman, G.O. 1975. Control and management of mesquite on rangeland. Texas Agr. Ext. Serv. Misc. Pub. 386.
7. Houston, W.R. 1963. Plains pricklypear, weather, and grazing in the northern Great Plains. Ecology 44:569-574.
8. Hyder, D.N., R.E. Bement, E.E. Remmenga, and C. Terwilliger, Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. J. Range Manage. 19:11-17.
9. Lundgren, G.K., R.E. Whitson, D.N. Ueckert, F.E. Gilstrap, and C.W. Livingston, Jr. 1981. Assessment of the pricklypear problem on Texas rangelands. Texas Agr. Exp. Sta. Misc. Pub. 1483.
10. Merrill, L.B., C.A. Taylor, Jr., R. Dusek, and C.W. Livingston. 1980. Sheep losses from range with heavy pricklypear infestation. p. 91. *In:* D.N. Ueckert and J.E. Huston (eds.). Rangeland Resources Research. Texas Agr. Exp. Sta. Consol. Prog. Rep. 3665.
11. Migaki, G., L.E. Hinson, G.D. Imes, Jr., and F.M. Garner. 1969. Cactus spines in tongues of slaughtered cattle. J. Amer. Vet. Med. Assoc. 155:1489-1492.
12. Petersen, J.L., D.N. Ueckert, and R.L. Potter. 1988. Herbicidal control of pricklypear cactus in western Texas. J. Range Manage. 41:313-316.
13. Potter, R.L., J.L. Petersen, and D.N. Ueckert. 1986. Seasonal trends of total nonstructural carbohydrates in Lindheimer pricklypear *(Opuntia lindheimeri)*. Weed Sci. 34:361-365.
14. Price, D.L., R.K. Heitschmidt, S.A. Dowhower, and J.R. Frasure. 1985. Rangeland vegetation response following control of brownspine pricklypear *(Opuntia phaecantha)* with herbicides. Weed Sci. 33:640-643.
15. Schuster, J.L. 1971. Night applications of phenoxy herbicides on plains pricklypear. Weed Sci. 19:585-587.
16. Scifres, C.J., W.T. Hamilton, J.R. Conner, J.M. Inglis, G.A. Rasmussen, R.P. Smith, J.W. Stuth, and T.G. Welch. 1985. Integrated brush management systems for South Texas: development and implementation. Texas Agr. Exp. Sta. Bull. 1493.
17. Shoop, M.C., E.J. Alford, and H.F. Mayland. 1977. Plains pricklypear is a good forage for cattle. J. Range Manage. 30:12- 17.
18. Thomas, G.W., and R.A. Darrow. 1956. Response of pricklypear to grazing and control measures. Texas Range Station, Barnhart. Texas Agr. Exp. Sta. Prog. Rep. 1873.
19. Ueckert, D.N., and S.G. Whisenant. 1980. Susceptibility of honey mesquite and pricklypear to burning/herbicide control system. p. 23. *In:* D.N. Ueckert and J.E. Huston (eds.). Rangeland Resources Research. Texas Agr. Exp. Sta. Consol. Prog. Rep. 3665.

PR-4571

The Efficacy of Various Anthelmintics in Lambs[1]

T. D. Willingham, J. M. Shelton, and A. D. Herring

Summary

During the summer of 1987, two experiments were conducted on naturally parasitized lambs to evaluate the efficacy of various anthelmintics on internal parasites. An additional experiment was conducted to measure the time required after dosing for cessation of egg passage to occur. Chemicals evaluated include morantel tartrate, ivermectin, thiabendazole, levamisole hydrochloride, phenothiazine, and fenbendazole. Under the conditions of the first experiment, it was found to be extremely difficult to obtain a favorable level of control from any of the products evaluated. Better control of internal parasites was obtained in the second experiment for most of the anthelmintics used. This difference may be a result of differing dosage levels in the case of thiabendazole, method of administration (Ivomec oral) or a different parasite population. Fecal egg counts reached their lowest level 6 days after treatment with oral ivermectin and 5 days with levamisole hydrochloride (Tramisol). However, most of the drop in the number of eggs passed occurred within the first 3 days.

Introduction

Internal parasite damage to sheep results in an estimated annual income loss of between $45 million (1) and $98 million (2). These estimates vary greatly due to the difficulty of accurately quantifying production losses. These losses can occur in many forms, including death, illness, reduced weight gain, or delay in attainment of physiological breeding size. Whatever the result of parasitism may be, it poses a serious economic loss to the U.S. sheep industry.

Several methods or combinations have been suggested for reducing or controlling internal parasites, but the practice of administering drugs (anthelmintics) has been the most widely used. The continued use of anthelmintics for the control of internal parasites results in the development of resistant strains. Thus, there is a continual need for newer anthelmintics. The purpose of this study was to evaluate the efficacy of several anthelmintics for use with sheep. An additional objective was to determine how soon after treatment the animals stopped passing eggs as a guide in efforts to design more efficient management schemes to avoid losses to internal parasites. The term "internal parasites" used in this study relates to gastrointestinal nematodes which usually constitute the greatest problem; but there are other types of internal parasites such as coccidia, tapeworms, etc.

Experimental Procedure

Experiment #1. During the summer of 1987, 137 naturally infected crossbred wether and ewe lambs were weighed and randomly sorted into an untreated group and

[1]Several drugs evaluated (fenbendazole, ivermectin, and morantel tartrate) are not approved for use in sheep and the use of these experimental drugs is not advocated by the authors.

five treated groups. These animals were left over (poor doing) lambs from a much larger group which had been run on a oat field throughout the spring. They had not previously received any treatment for internal parasites, and these tail-end lambs had been allowed to become parasitized for the purpose of this study. Treatments and dosage rates were morantel tartrate (4.4 mg/lb.), ivermectin (90.7 mcg/lb.), thiabendazole (20 mg/lb.) levamisole hydrochloride (3.65 mg/lb), and phenothiazine (250 mg/lb.). Dosage of the respective chemical was based on the animals actual body weight at time of treatment. Morantel boluses were reduced to powder for use. Morantel and thiabendazole (TBZ) powder was weighed and placed in gelatin capsules for oral administration. Ivermectin was injected subcutaneously while levamisole and phenothiazine were given as an oral drench.

All animals were placed in a 20-acre sorghum haygrazer field after treatment. An attempt was made to determine the cause of all animal deaths. However, this became increasingly difficult because of turkey vultures. One week after treatment, and because the animals were in poor condition, all animals were given access to a salt limiting ration containing a coccidiostat, although coccidiosis had not been diagnosed as a problem.

Fecal samples were taken from all animals prior to treatment and 8 days after treatment by the rectal phalangeal technique. Samples were frozen until eggs per gram determinations could be performed. The McMaster egg counting technique was used. Blood samples were taken from half the animals in each group at the time of fecal collections for Wintrobe macrohematocrit determination. Animals were retreated 15 days after initial treatment with one product to prevent further death losses.

Experiment #2. A second experiment was conducted using 86 grade finewool ewe lambs which had been raised with their mothers on the range. It was obvious that these lambs were also highly parasitized. This was not intentional, and mirrors the problem that many producers experienced in the summer of 1987, which was characterized by greater than normal summer rains. Lambs were randomly sorted into a control group and six treatment groups. The treatments and related dosages were as follows: 3.65 mg/lb levamisole hydrochloride, 40 mg/lb thiabendazole, 90.7 mcg ivermectin (subcutaneous injection), 90.7mcg/lb ivermectin (oral administration), 2.5 mg/lb fenbendazole (Panacur), 250 mg/lb of phenothiazine.

Initial fecal samples were collected randomly from 20 animals prior to treatment and from all animals 7 days after treatment. Fecal collection, storage, and examination were performed the same as in the first experiment. Packed cell determinations were made only for the 20 lambs in which initial fecal samples were collected.

Statistical analysis for both studies included use of linear regression examining for main effects and Tukey Least Significant Difference procedure for multiple comparisons. Natural logarithmic transformation was necessary for analysis of fecal egg counts to overcome the heterogeneity of variance.

Experiment #3. The third study consisted of daily collection of fecal samples for 7 days from 10 animals from the groups which received levamisole and oral ivermectin in the second experiment. This was undertaken to determine how soon after treatment for internal parasites the sheep stop passing ova. Many producers treat sheep for parasites before turning to clean pastures or rotating pastures. However, it should be obvious that they do not immediately stop passing ova. Daily fecal egg counts were made on these animals for a period of 7 days.

The procedures used in these studies do not provide information on the species of gastro-intestinal nematodes involved. It is generally assumed that Haemonchus or barberpole worm is the major problem for sheep. However, in retrospect, the results suggest that this may not have been the case in these studies, or the failure to make an effort at speciation of the parasites involved appears as a confusing element in explaining the results obtained.

Results and Discussion

The animals used in Experiment 1 showed visible signs of

Table 1. Treatment, Weight Gain, Fecal Egg Count, and Hematologic Summary Data.

Treatment Drug Rate	Control —	Morantel Tartrate 4.4 mg/lb	Ivermectin Injectible 90.7 mcg/lb	Thiabendazole 20 mg/lb	Levamisole Hydrochloride 3.65 mg/lb	Phenothiazine 250 mg/lb
No. Sheep observed						
Initial	21	20	22	20	23	22
Final	15	18	21	20	21	21
Mean Body weights (lb)						
Initial	54.2[a]	53.3[a]	53.7[a]	53.7[a]	53.6[a]	53.5[a]
Final	56.0[a]	59.5[a]	60.7[a]	56.8[a]	63.1[a]	60.0[a]
A.D.G.	−0.06[c]	0.15[b]	0.24[ab]	0.14[b]	0.35[a]	0.23[ab]
Mean eggs per gram feces						
Initial	4,105[a]	5,337[a]	3,527[a]	4,285[a]	3,643[a]	4,072[a]
Final	8,273[a]	5,678[a]	2,414[b]	4,780[a]	586[c]	1,848[b]
% Change	+101.5	+6.4	−31.5	+11.5	−83.9	−54.6
Mean packed cell volume (%)						
Initial	25.9[a]	21.0[a]	20.9[a]	25.6[a]	23.2[a]	25.5[a]
Final	21.1[a]	24.6[a]	26.7[a]	26.4[a]	28.7[a]	28.6a

Means within rows without the same letters are significantly different (P<.05).

Table 2. Weight Gain, Fecal Egg Count, and Hematocrit Values for Second Experiment.

Treatment Drug Rate	Control —	Fenbendazole 2.3 mg/lb	Thiabendazole 40 mg/lb	Ivermectin injected 90.7 mcg/lb	Ivermectin oral 90.7 mcg/lb	Levamisole Hydrochloride 3.65 mg/lb	Phenothiazine 250 mg/lb
No. of Sheep observed							
Initial	11	13	13	12	13	13	11
Final	11	13	13	12	13	12	11
Mean body weights (lb)							
Initial	62.9[ab]	66.1[a]	57.0[b]	61.0[ab]	65.1[ab]	59.8[ab]	60.5[ab]
Mean initial packed cell[1]							
Volume (%)	25.78	25.78	25.78	25.78	25.78	25.78	25.78
Mean eggs per gram of feces							
Initial[a]	8,345.0	8,345.0	8,345.0	8,345.0	8,345.0	8,345.0	8,345.0
Final	3,000.0[a]	507.7[bc]	1,076.9[ab]	650.0[c]	481.8[c]	2,533.3[ab]	445.4[bc]
Change							
% of Initial	−64.0	−93.9	−87.1	−92.9	−94.2	−69.6	−94.7
% of Control	0.0	16.9	35.9	21.7	16.1	84.4	14.9

Means within rows without a common superscript are significantly different ($P<.05$).
[1]Initial eggs per gram and packed cell volume (%) were derived from a random sample of 20 lambs.

parasitism such as diarrhea, general weakness, pale color of mucous membranes, and in a few cases, submandibular edema. The results in Tables 1 and 2 confirm that the animals were suffering from parasitism with initial eggs per gram (EPG) in the 3,000 to 5,000 range which would indicate acute parasitism. Initial packed cell volumes (PCV) were at or below the lower end of the normal range (25-35) for sheep (2) indicating anemia. In addition, several animals, mostly from the control group, were lost during the experimental period. These losses appeared to be due primarily to their weakened condition.

The different anthelmintics produced a variety of results with none of those used showing the desired level of control. All of the drugs appeared to provide some response as indicated by body weight gains, change in EPG and PCV. Each of the treatment regimes showed significant differences over the control, in body weight gains. All the treatment groups had lower EPGs at the final observation as compared to the control group, but only levamisole, ivermectin, and phenothiazine treated groups were significantly different. It should be pointed out that resistant strains have been known to develop for a number of anthelmintics as well as phenothiazine. Phenothiazine hasn't been used in over a decade in the flocks from which the lambs originated. All the treatment groups had improved PCV compared to the control group, but none were statistically significant. In this trial only levamisole appeared to give even a reasonable level of control (indicated by an 83.9% reduction in EPG).

The data obtained from the second experiment is shown in Table 2. These lambs were also heavily parasitized as indicated by initial EPGs, however, the PCV values were higher than in the first experiment. Only one lamb was lost during the experiment. The overall results differ markedly from the first experiment. In this experiment, most of the anthelmintics used appeared to give reasonably good results. It should be recalled that thiabendazole was given at a rate of twice the recommended level. Levamisole and thiabendazole gave the poorest results. Oral ivermectin appeared to give slightly better results than the injectible form, but the difference was small and not greater than might have been expected due to chance.

In view of the marked difference in the results of these two experiments, it may be of interest to look at the origin of the animals involved. The animals in the first experiment came from a flock maintained at San Angelo. This flock had not received intensive treatment for parasitism. Also, the early weaned lambs involved in the experiment had been heavily stocked on a grain field through the late spring months. In addition, some diarrhea was present suggesting that the animals had a parasite burden of the smaller round worms such as Trichostrongyles, instead of Haemonchus contortus. There is also no reason to suspect that the flock (or the nematode population) from which these animals were derived had developed a resistance to levamisole.

A large portion of the ewe lambs involved in the second study came from the flock maintained on the leased Hill Ranch in Edwards County. This flock had been repeatedly drenched with levamisole over a period of several years. Thus, some degree of parasite resistance to levamisole could be evidenced in this flock.

Thus, perhaps the variation between the flocks and perhaps differences between species of roundworms may partially explain the erratic results obtained. These results are not out of line with producer experience in the summer of 1987. A number of producers report drenching with a variety of drugs as often as every 2 weeks before they were able to straighten out lambs and reduce or stop death losses.

The third experiment was designed primarily to answer the question of how long it might be necessary to hold animals after drenching before turning to clean pastures to reduce the threat of contamination of the clean pasture. The results are shown in Figure 1. The results suggest that the EPG count is reduced over a 5- to 6-day period, and that is still some level of contamination if treated lambs are turned immediately to a clean pasture.

In this case, the recovery observed starting on the sixth and seventh day likely reflects unfavorably on the treatments employed. It was not considered possible for the animals to have become reinfested with the new complement of parasites producing eggs this quickly. Thus an alternative explanation is required for the upturn of the EPG starting on days six and seven. Several possibilities may be suggested. One

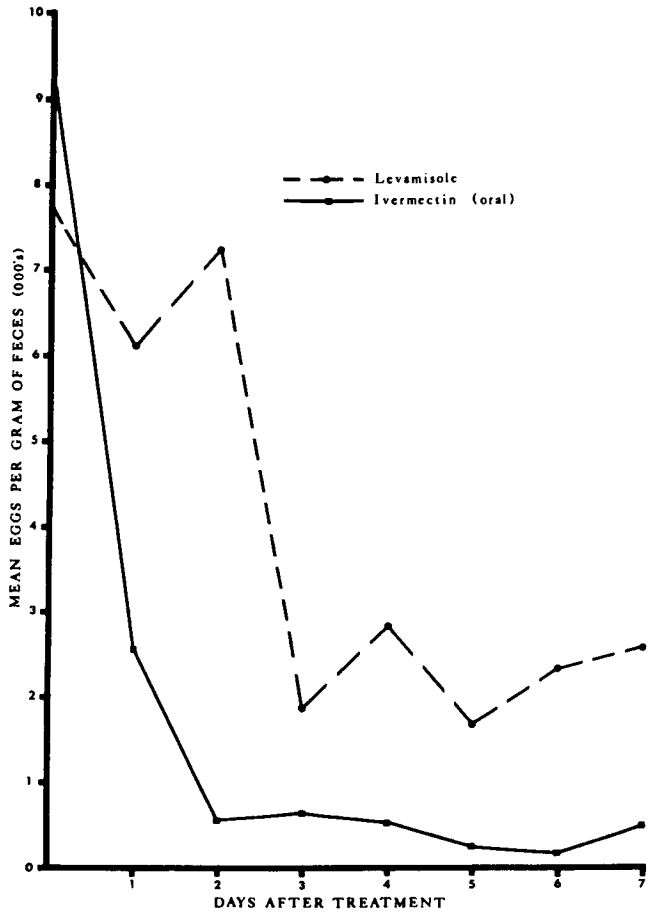


Figure 1. Fecal egg count patterns over a 7-day period for two anthelmintics.

of these is that the larvae or parasites which were in the immature state escaped the effects of the anthelmintics and have started producing eggs. Another is that the parasites which were not removed by the drug were affected to the extent that they temporarily stopped producing eggs, but that they then started producing eggs, perhaps at a higher rate, following a short delay.

Literature Cited

1. Drummond, R.O., G. Lambert, H.E., et al. 1981. Estimated losses in livestock to pest, in Pimental D Cedj: CRC Handbook of Pest Management in Agriculture. 1:111. Original not available for examination; cited in Research needs and priorities for ruminant internal parasites in the United States. Am. J. Vet. Res. 44:1836.
2. McFarlane, W.V. 1975. Distribution and dynamics of body fluids in sheep. *In:* M.H. Blund (Ed.) The Blood of Sheep - Composition and function. p. 7. Springer-Verlag, New York.
3. U.S. Dept. of Agriculture. 1976 Control of sheep and other animal diseases - infectious, non-infectious, and parasitic. ARS National Research Program. NRP No. 20440. Washington, D.C. ARS, USDA.

PR-4572

Evaluation of the Efficacy of Bovatec® for Controlling Experimentally Induced and Naturally Occurring Coccidiosis in Angora Goats[1]

M.C. Calhoun, B.C. Baldwin, Jr., T.M. Craig, and R.L. Huey

Summary

Lasalocid included in a complete diet at levels ranging from 10 to 30 g/ton improved live weight gains and feed intakes of castrated, male Angora kid goats experimentally infected with 20,000 sporulated coccidial oocysts. However, lasalocid at 30 g/ton did not prevent the rise in fecal oocyst numbers observed at 42 days in response to the coccidial oocyst challenge. The challenge was administered 16 days after lasalocid was first included in the diet. In three field studies lasalocid at 20 g/ton also increased live weight gains relative to controls, but there was a substantial natural infection present and large numbers of coccidial oocysts continued to be shed by goats receiving 20 g of lasalocid/ton of feed. Based on these results, it is concluded that 30 g of lasalocid/ton in a complete feed is not adequate to prevent coccidiosis problems in susceptible Angora goats.

Introduction

Coccidiosis, a disease caused by large numbers of protozoan parasites called coccidia, is a serious problem that limits the performance of Angora goats. Kids kept in close confinement under unsanitary and(or)stressful conditions such as weaning, shearing, or moving accompanied by change of diets are particularly susceptible to coccidiosis (4,5). Large numbers of coccidial oocysts may be found in the feces of infected animals. Clinical signs include loss of weight, diarrhea and unthriftiness.

Lasalocid is approved for use in sheep feeds to prevent coccidiosis (2,6,7), and preliminary studies have demonstrated its efficacy as a coccidiostat for goats (5). The purpose of this study was to provide information on the efficacy of lasalocid for treating experimentally induced (dose-titration study) and naturally occurring (field studies) coccidial infections in Angora goats.

Experimental Procedure

A dose-titration study was conducted at the Texas A&M University Agricultural Research and Extension Center at San Angelo, Texas, with 100 castrated, male Angora kid goats maintained in 20 pens containing 5 goats each. A 20-day preliminary period was used to allow goats to adapt to their new surroundings and the diet (Table 1). The diet was initially restricted to .5 pounds per goat per day and then increased daily until full feeding was achieved.

Following the preliminary period, all goats were started on diets containing lasalocid. Four levels of lasalocid were used

[1]Bovatec®—Lasalocid sodium is a product of Hoffmann-LaRoche Inc., Nutley, New Jersey. It is an experimental drug and is not approved for use with Angora goats.

Table 1. Ingredient and Nutrient Composition of the Basal Diet.

Ingredient	% in diet
Sorghum grain, milo[a]	46.5
Dehydrated alfalfa meal	10.0
Peanut hulls	20.0
Cottonseed meal, 41% crude protein	15.0
Sugarcane molasses	6.0
Vitamin-mineral premix[b]	2.5
Nutritional values[c]	
Dry matter, %	89.6 ± .4
Crude protein, %	17.4 ± .4
Acid detergent fiber, %	28.6 ± 1.4
Calcium, %	.84 ± .07
Phosphorus, %	.39 ± .01
Magnesium, %	.19 ± .01
Potassium, %	1.38 ± .02
Copper, ppm	5.9 ± .14
Manganese, ppm	28.6 ± 1.2
Zinc, ppm	48.1 ± 2.1

[a]Dry rolled.
[b]Calcium carbonate, 42.872%; salt, 28.531%; ammonium sulfate, 19.510%; potassium chloride, 7.754%; zinc oxide, .1875%; manganese oxide, .1318%; vitamin A (13,607,700 IU/lb), .2889%; vitamin D_3 (90,718,000 IU/lb), .00507%; vitamin E (125,000 IU/lb), .7196%.
[c]Values are on a dry matter basis.

(0, 10, 20 and 30 g/ton, as fed basis). Goats in four pens received each lasalocid level, and goats in four additional pens were selected to receive the diet with no lasalocid and served as uninoculated controls.

An inoculum containing sporulated coccidial oocysts was prepared from feces collected from naturally infected Angora goats in the Edwards Plateau region of Texas and the major *Eimeria* species were identified. Sixteen days after the start of lasalocid feeding, all goats in the dose-titration study, except uninoculated controls, were orally administered 20,000 sporulated oocysts from this collection. The inoculum contained *E. arlongi,* 50%; *E. ninakohlyakimovae,* 37%; *E. alijevi,* 12% and *E. christenseni, 1%.*

The field studies were conducted at the Joe David Ross Ranch (Ross Ranch), Sutton County; The Texas A&M University Agricultural Research Station (Sonora Ranch), Edwards County; and the Texas A&M University Agricultural Research and Extension Center (San Angelo), Tom Green County.

Angora kid goats used for field studies were a mixture of females and castrated males. Forty kid goats were selected from both the Ross Ranch and San Angelo and were maintained in two pens containing 20 goats each, balanced with respect to sex. Forty-four kid goats were used at the Sonora Ranch and were maintained in two pens containing 23 and 21 goats, respectively.

The field studies did not include a preliminary feeding period; however, goats were started on feed in the same manner as those used for the dose-titration study. Two levels of lasalocid were used (0 and 20 g/ton of diet, as fed basis). Each ranch had one pen of goats on each diet.

The lasalocid feeding period (experimental period) for both studies was 56 days in duration. During this time, the diets were fed daily, and feed refusals were collected at 7-day intervals. During the experimental period (both studies), observations for clinical signs of coccidiosis were made daily. Fecal samples for determination of coccidial oocyst numbers were collected from representative goats in each treatment group initially and every 14 days thereafter.

Results and Discussion

Initially, all goats sampled were shedding coccidial oocysts in their feces. There was considerable variation among animals in oocyst numbers as evidenced by the range of values reported in Tables 2 and 3. *Eimeria* species most frequently encountered in fecal samples collected from goats in the dose-titration and field studies were *E. arlongi, E. christenseni,* and *E. ninakohlyakimovae. Eimeria alijevi* was infrequently observed. Although the pathogenicity of most species of goat coccidia is not well known, *E. arloingi, E. christenseni* and *E. ninakohlyakimovae* are frequently observed and are considered to be pathogenic (4,5).

The adverse effect of confinement on coccidial problems with Angora kid goats is apparent from the increase in oocyst numbers during the first 14 days of the experimental period (Table 2). During this period, oocyst numbers were actually greater for the non-inoculated than the inoculated control group indicating a substantial natural infection was present in goats purchased for the dose-titration study. The rise in oocyst counts at 42 days in inoculated goats was as expected based on the numbers of sporulated oocysts administered at 16 days to these animals. The fact that a substantial rise in the number of oocysts shed by goats receiving 30 g/ton of lasalocid also occurred at this time indicates this level of lasalocid was ineffective in controlling coccidiosis (Table 2). Similarly, at the field locations, there was a substantial natural infection present and elevated oocyst discharage into the feces persisted throughout the study in goats receiving 20 g of lasalocid/ton of feed (Table 3).

Foreyt reported the effective prevention of coccidiosis in goats when lasalocid was fed at levels of .23 to .45 mg/lb of body weight (5). The highest level of lasalocid used in this study was 30 g/ton in a complete diet. Since the goats receiving this diet averaged 45 lb during the study and consumed an average of 1.52 lb of feed per day, actual daily lasalocid intake was .5 mg/lb body weight. The inability of lasalocid to control coccidiosis in Angora goats in this study as compared to the work of Foreyt may be due to differences in the relative susceptibility of Angoras relative to other goats, age of the goats used and stressful factors, such as, penning, weaning, shearing, and moving.

In the dose-titration trial live weight gains and feed intakes were improved throughout the trial for all lasalocid levels compared with either control group. Thus a positive response to feeding lasalocid was evident even though fecal coccidial oocysts were not reduced (Table 4). Live weight gains were also increased in goats fed lasalocid at the three field locations, but in this case, feed intakes were not different for the control and lasalocid-treated goats (Table 5).

The inability of lasalocid fed at 30 g/ton to control the rise in fecal coccidial oocysts is considered evidence this level of lasalocid would not prevent problems with coccidiosis in susceptible young kid goats naturally exposed to a high level of infection. Since, in this study, 30 g/ton was the highest level used, information is not available to predict a level that would prevent coccidiosis in kid goats. However, based on studies

Table 2. Summary of Effects of Lasalocid on Fecal Coccidial Oocyst Numbers of Castrated, Male Angora Kid Goats Experimentally Infected with 20,000 Sporulated Coccidial Oocysts[a].

Sample time (Days)	Item	Non-Inoculated Control	Inoculated Control	Lasalocid, g/ton		
				10	20	30
0	Goats, No.	8	8	8	8	8
	Ave. oocysts/g ($\times 10^3$)	12.3	4.9	3.6	6.9	5.3
	Range oocysts/g ($\times 10^3$)	2.5-47.8	.9-13.6	.3-11.0	.8-30.5	.4-16.3
14	Goats, No.	8	8	8	8	8
	Ave. oocysts/g ($\times 10^3$)	311.1	47.6	9.8	31.0	85.6
	Range oocysts/g ($\times 10^3$)	1.0-1,151.2	4.0-165.0	1.7-30.5	.5-147.1	.8-427.8
28	Goats, No.	8	8	8	8	8
	Ave. oocysts/g ($\times 10^3$)	51.8	45.9	15.2	13.3	13.2
	Range oocysts/g ($\times 10^3$)	3.9-185.8	1.8-198.9	1.0-61.6	.4-52.5	.5-48.6
42	Goats, No.	5	7	8	7	8
	Ave. oocysts/g ($\times 10^3$)	15.8	41.3	191.7	15.1	154.2
	Range oocysts/g ($\times 10^3$)	2.7-48.6	3.6-134.8	.9-819.9	.7-45.8	.5-877.8
56	Goats, No.	5	7	8	8	8
	Ave. oocysts/g ($\times 10^3$)	9.4	6.4	32.7	3.6	2.9
	Range oocysts/g ($\times 10^3$)	1.3-24.4	1.0-11.1	.4-219.3	0-11.8	.3-11.6

[a]Values in table multiplied by 1,000 gives actual oocysts/g of feces.

Table 3. Effects of Lasalocid on Fecal Coccidial Oocyst Numbers of Angora Kid Goats Naturally Infected with Coccidia at Three Field Locations[a].

	Ross Ranch		San Angelo		Sonora Ranch	
	Lasalocid, g/ton		Lasalocid, g/ton		Lasalocid, g/ton	
Criterion	0	20	0	20	0	20
0-days						
Ave. oocysts/g ($\times 10^3$)	2.5	6.3	8.9	4.7	2.1	9.3
	.4-7.1	1.5-16.8	.1-40.1	.1-15.0	.6-3.0	3.6-17.8
14-days						
Ave. oocysts/g ($\times 10^3$)	140.0	9.7	24.6	29.7	5.1	206.1
	6.0-641.8	7.0-14.3	8.0-74.2	.1-128.5	.5-9.4	8.9-924.0
28 days						
Ave. oocysts/g ($\times 10^3$)	33.3	2.9	80.3	16.3	98.6	31.4
	5.0-74.2	.1-6.8	5.2-260.3	1.3-51.4	9.6-361.8	2.3-88.1
42 days						
Ave. oocysts/g ($\times 10^3$)	45.0	15.7	50.3	10.7	244.5	11.2
	11.0-70.7	.7-60.3	3.1-159.9	.6-38.4	56.8-416.2	3.0-23.5
56 days						
Ave. oocysts/g ($\times 10^3$)	77.4	124.5	728.9	68.3	33.3	4.5
	5.3-218.8	3.2-314.4	22.0-3,340.8	1.1-201.7	20.4-57.9	1.9-8.8

[a]Values in table multiplied by 1,000 gives actual oocysts/g of feces.

with sheep the level required might be as high as 50 g/ton in a complete diet (9).

Lasalocid is currently approved for use in prevention of coccidiosis in feedlot lambs at a level of 20 to 30 g/ton. Although some questions remain about its efficacy as a coccidiostat when used at these levels, numerous studies have shown an improvement in performance of feedlot lambs when lasalocid was added to the diet. This effect generally is due to the effects of lasalocid on altering rumen fermentation and unrelated to its role in controlling coccidiosis.

Lasalocid is widely available in complete feeds for cattle and sheep at concentrations of 20 to 30 g/ton. Although it is not approved for use with goats, the ready availability of these feeds might tempt producers to feed them to goats in hopes of preventing problems with coccidiosis. In most cases, some benefit could be expected, but death losses might still be encountered in cases of severe exposure with susceptible animals.

In recent years, two other modern-day coccidiostats have been evaluated for prevention of coccidiosis in goats (Rumensin® and Deccox® (1,6,8). The active ingredient in Rumensin® is monensin sodium and in Deccox® it is decoquinate. Monensin is effective at levels of 10 to 20 g/ton and final approval by the United States Food and Drug Administration (FDA) for use of this drug in complete goat feeds at a level of 20 g/ton is pending. At present, decoquinate is the only feed additive approved by the FDA for prevention of coccidiosis in goats. The approved dosage is 22.7 mg/100

Table 4. Effects of Lasalocid on Performance of Castrated, Male Angora Kid Goats Experimentally Infected with 20,000 Sporulated Coccidial Oocysts.

Criterion	Non-inoculated control	Inoculated control	Lasalocid, g/ton			SEM[a]
			10	20	30	
Initial live weight, lb	42.1	42.6	44.5	42.0	42.1	.70
1-14 days						
Live weight gain, lb/d	.110	.196	.253	.272	.253	.067
Feed intake, lb/d	1.17	1.43	1.62	1.58	1.37	.12
1-28 days						
Live weight gain, lb/d	.049[b]	.119[bc]	.256[d]	.284[d]	.191[cd]	.042
Feed intake, lb/d	1.12	1.43	1.72	1.67	1.45	.12
1-42 days						
Live weight gain, lb/d	.057[b]	.064[b]	.217[c]	.233[c]	.168[bc]	.041
Feed intake, lb/d	1.08	1.32	1.69	1.65	1.44	.12
1-56 days						
Live weight gain, lb/d	.000[b]	.035[bc]	.106[bc]	.146[c]	.112[bc]	.038
Feed intake, lb/d	1.10	1.39	1.73	1.68	1.52	.12

[a]Standard error of the mean.
[b,c,d]Means in the same row without a common superscript are significantly different ($P<.05$).

Table 5. Effects of Lasalocid on Live Weight Gains, and Feed Intakes of Angory Kid Goats Naturally Infected with Coccidia at Three Field Locations.

Criterion	Ross Ranch		San Angelo		Sonora Ranch	
	Lasalocid, g/ton		Lasalocid, g/ton		Lasalocid, g/ton	
	0	20	0	20	0	20
Initial live weight, lb	37.5	34.2	41.0	41.4	34.0	37.5
1-28 days						
Live weight gain, lb/d	.154	.325	.106	.148	.112	.161
Feed intake, lb/d	1.84	1.72	1.39	1.41	2.14	2.26
1-56 days						
Live weight gain, lb/d	.163	.245	.123	.163	.071	.160
Feed intake, lb/d	1.80	1.88	1.44	1.53	1.76	2.32

lb body weight. Decoquinate is an effective coccidiostat with a wide margin of safety. It is palatable and can be used in complete feeds, supplements, or salt mixtures at levels to provide the drug intake desired. A recent article in *Ranch Magazine* gives information on feeding decoquinate to goats (3).

Literature Cited

1. Baldwin, B.C., Jr., M.C. Calhoun, R.L. Huey, and T.M. Craig. 1986. Evaluation of the efficacy of Rumensin® for controlling coccidiosis in Angora goats. Tex. Agr. Exp. Sta. Prog. Rpt. 4408.
2. Calhoun, M.C. 1984. Bovatec® cleared for coccidiosis prevention. Ranch Mag. 66(1):15.
3. Calhoun, M.C. 1987. Deccox®: A new coccidiostat for goats. Ranch Mag. 68(11):30.
4. Craig, T.M. 1986. Epidemiology and control of coccidia in goats. Vet. Clin. North America: Food Anim. Pract. 2:389.
5. Foreyt, W.J. 1987. Coccidiosis in sheep and goats. Vet. Hum. Toxicol. 29(Suppl. 1):60.
6. Foreyt, W.J., N.L. Gates, and R.B. Wescott. 1979. Effects of lasalocid and monensin against experimentally induced coccidiosis in confinement reared lambs from weaning to market weight. Amer. J. Vet. Res. 40:97.
7. Foreyt, W.J., N.L. Gates, and J.E. Rich. 1981. Evaluation of lasalocid in salt against ovine coccidia. Amer. J. Vet. Res. 42:54.
8. Foreyt, W.J., D. Hancock, and R.B. Wescott. 1986. Prevention and control of coccidiosis in goats with decoquinate. Amer. J. Vet. Res. 47:333.
9. Horton, G.M.J., and P.H.G. Stockdale. 1981. Lasalocid and monensin in finishing diets for early weaned lambs with naturally occurring coccidiosis. Amer. J. Vet. Res. 42:433.

Acknowledgment

This research was supported in part by funds provided by Rutgers University/New Jersey Agricultural Experiment Station, IR-4 Project. The cooperation of Dr. Joe David Ross and Don Spiller in assisting with the field trials is appreciated.

PR-4573

An Outbreak of Arthrogryposis and Hydrocephalus in Lambs Due to Cache Valley Virus

J.F. Edwards, C.W. Livingston, Jr., E.W. Collisson, S.I. Chung, J.K. Olson, and J.L. Norman

Summary

Evidence strongly suggests infection of ewes early in gestation with Cache Valley virus (CVV) was responsible for the outbreak of arthrogryposis and hydrocephalus in lambs in Texas in 1986-1987. Potential insect vectors for CVV have been identified and several isolates of CVV have been made in the area of the outbreak. Increased infection rate for CVV in the flocks in San Angelo during the year of the outbreak was documented by an epidemiology study and the period of the breeding season when pregnant ewes would be at risk for CVV infection (September and October) was established by using sentinel animals during the 1987-1988 breeding season. However, a preliminary experiment to reproduce the syndrome with a laboratory strain of CVV was unsuccessful. More work is needed to establish the potential pathogenicity of CVV for all domestic species and to successfully reproduce the disease so that prophylactic measures can be formulated.

Introduction

During the 1986 lambing season in San Angelo, Texas, there was a dramatic loss of newborn lambs with severe congenital malformations. Three adjacent institutional flocks (two at the Texas Agricultural Experiment Station and one at Angelo State University) were involved in the outbreak, and in the most severely affected flock, 69 of 366 ewes lost lambs. Lambs were born at term but were stillborn or so weak that they died shortly after birth without nursing. Most of these lambs had arthrogryposis (joints fixed in flexion) and an associated scoliosis (twisted back). Often, the lambs also had small malformed brains and spinal cords. Because of the malpositioning of fetal limbs, there were many difficult births and several ewes died in dystocia. Malformed lambs were sometimes born twin with mummified fetuses. Lambs with milder lesions only had a reduced amount of muscle and resembled the "spider lamb" condition described in Suffolk sheep. The outbreak occurred at the beginning of the lambing season and lasted for 6 weeks, at which time there was a 3-week period when no ewes lambed. In March, when the flock began to lamb again, no malformed lambs were observed and the incidence of mummified, stillborn, or weak lambs was negligible. However, many ewes were barren in this lambing season. Because the syndrome affected lambs usually involved arthrogryposis and some degree of hydrocephalus, the condition was described as AGH.

A search for a cause of this lamb mortality was instituted. There was no evidence for involvement of toxic plants in the problem, and trace mineral concentrations in tissues of affected lambs were normal. Because bacterial, cultural, and viral isolation efforts yielded no diagnosis, antibody testing was done for bluetongue (BT) and bovine virus diarrhea/border disease (BVD/BD), two viral diseases endemic in the U.S. reported to cause sporadic AGH in lambs. No antibodies to BT or BVD/BD were found in heart blood from stillborn lambs. Because the outbreak was identical to that described for Akabane (AK), a disease exotic to the U.S., antibody testing of ewes and lambs for AK was performed and the flocks were quarantined. Antibody testing for AK was negative, but all ewes with affected lambs and nine stillborn lambs had antibodies to Cache Valley virus (CVV), a virus related to AK but endemic to North America.

It has recently become apparent that ovine AGH associated with CVV has occurred in Michigan in 1986 and Nebraska in 1987 and possibly Oklahoma and Illinois in 1987.

The activity of CVV in the area had been under study since the isolation of CVV from a sick ram in 1981, 30 miles from the area of this AGH outbreak. This virus is a common arthropod-borne virus isolated from several sick ruminants and horses in the U.S. and it has been shown to infect a variety of large wild ruminants. Although it had never been shown to cause outbreaks of disease in cattle or sheep, efforts were begun to establish the role played by CVV or other arthropod-borne viruses in AGH in sheep.

Experimental Procedure

Insect vector studies. During the spring, summer, and fall of 1987, flying insects were collected with traps located in and around the study site (the pastures used by the affected flocks). The insects were pooled by species on each collection date and each pool was assayed for virus by mouse inoculation and tissue culture.

Sentinel animals. Five yearling wethers, seronegative for CVV, were pastured on the study site. They were bled weekly and tested for CVV antibody as well as for CVV viremia.

Inoculation of pregnant ewes. Thirty-three pregnant ewes seronegative for CVV were inoculated with a mouse-passaged strain of CVV isolated in 1981. The virus was given by intravenous injection at either 30-35 days (n=29), or 50-51 days (n=4) of gestation. The ewes were housed in isolation and their blood was monitored for the appearance of a CVV antibody and viremia. They were sacrificed at 100 to 110 days of gestation and their fetuses were examined for CVV antibody and virus titer as well as for gross and histologic lesions.

Flock seroepidemiology. Yearlings raised in the area around the study site were bled and the prevalence of CVV antibodies in the flock were studied from 1986 to 1987. This has been done in conjunction with the ram testing program at the research center in Sonora, Texas.

Results and Discussion

The insects prevalent at the study site and the period in the year when each is most active have been established. The arthropods collected include 10 known vectors of CVV (Table 1). The insect pools have been cultured and only mosquitoes collected in September and October have yielded viral isolates. Viral isolates (at least three) are being characterized inorder to establish their identity as CVV or another bunyavirus.

Three of the five sentinal animals seroconverted for CVV in the early fall and a bunyavirus was isolated from the blood of each of the sentinels that became seropositive. The isolates

Table 1. Arthropods Collected at the San Angelo Study Site.

Aedes dorsalis*
A. nigromaculis*
A. solicitans*
A. trivittatus*
A. vexans*
A. zoosophus
Anopheles pseudopunctipennis*
A. punctippenis*
Culex erythrothorax
C. restuans*
C. tarsalis*
Culicoides spp
Psorophora ciliata
P. continnis
P. cyanescens
P. discolor*
P. signippenis

*Known vectors of Cache Valley Virus

were all derived from samples taken during the second week of October. All three isolates were typed specifically as CVV in Dr. Collisson's laboratory and by Dr. C. Calisher of the Division of Vector-Borne Viral Diseases at the Center for Disease Control in Fort Collins, CO.

None of the pregnant ewes inoculated with CVV became ill nor did any ewe have an affected fetus. The ewes did seroconvert for CVV but the virus did not cross the placenta as evidenced by the failure of the fetuses to produce CVV antibodies.

There was a dramatic increase in the number of animals seropositive for CVV in the area around the study site. Five percent of the yearlings tested in 1986 were seropositive for CVV, but 78% of the animals tested in 1987 were seropositive. The survey of sera from 1988 has not been completed.

Results to date indicate that at the time of the outbreak of AGH, there was a burst of activity by CVV in the sheep population in San Angelo. In addition, we have serologic evidence that some affected lambs (that is, all those tested) in the 1987 lambing season were infected with CVV. The heavy rains of 1986 caused an increase in the arthropod population in the study site, and now we know that there are potential vectors of CVV active in the San Angelo area. If a parallel can be drawn between the AGH syndrome known to be caused by Akabane and the syndrome presumed to be caused by CVV, the ewes with affected lambs in 1987 should have been infected in early gestation during the months of September and October in 1986 in order to have affected lambs in January and February. Our results with sentinel animals and virus isolation from insects indicate that CVV is most active in the area of the study site in the early fall. All of these data supported our hypothesis that CVV caused the outbreak; however, we were unable to reproduce the disease experimentally. Our interpretation of the experimental infection study was that the virus used had lost its virulence. A more recent isolate that had not undergone modification by multiple passages outside of the ovine host would probably be more pathogenic. Indeed, our data showed the 1981 isolate failed to cross the placenta of the ewes. Insect transmission may also be needed to establish disease. In order to reproduce the disease, direct inoculation into the pregnant uterus, a technique used in bluetongue disease research, will be attempted in future studies.

Literature Cited

1. Calisher, C.H., D.B. Francy, G.C. Smith, D.J. Muth, J.S. Lazurck, N. Karabatsos, W.L. Jokob, and R.G. McLean. 1986. Distribution of Bunyamwera serogroup viruses in North America, 1956-1984. Am. J. Trop. Med. Hyg. 35:429-443.
2. Crandell, R.A., and C.W. Livingston. Laboratory investigation of a naturally occurring outbreak of arthrogryposis-hydranencephaly in Texas sheep. J. Vet. Diag. Invest. In Press.
3. Konno, S., M. Moriwaki, and M. Nakagawa. 1982. Akabane disease in cattle: congenital abnormalities caused by viral infection. Spontaneous disease. Vet. Pathol. 19:246-266.
4. Livingston, C.W., R.A. Crandell, E. Collisson, and J.F. Edwards. 1987. Sheep arthrogryposis and hydranencephaly. Foreign Animal Dis. Reports 15:2-3.
5. McConnell, S., C. Livingston, Jr., C.H. Calisher, and R.A. Crandell. 1987. Isolations of Cache Valley virus in Texas, 1981. Vet. Microbiol. 13:11-18.
6. Parsonson, I.M., A.J. Della-Porta, W.A. Snowdon, and M.D. Murray. 1975. Congenital abnormalities in foetal lambs after inoculation of pregnant ewes with Akabane virus. Aust. Vet. J. 51:585-586.
7. Rook, J.S., B. Yamini, and B. Steficek. 1988. AGH syndrome: Cooperation answers questions. Natl. Wool Grower, pp. 24-25.

PR-4574

Resistance of Sheep and Goat Nematodes in Texas to Anthelmintics

D.K. Miller and T.M. Craig

Summary

A survey of flocks of commercial sheep raisers and dairy goat and range goat producers showed that there are populations of internal parasites in Texas that are resistant to the anthelmintics Levasole[1] and Panacur[2]. This resistance was related more to the past history of use than to the geographical region or species of host.

Introduction

Sheep and goat producers recognize gastrointestinal nematodes as a major constraint on production. Since the advent of phenothiazine, the first effective, relatively safe anthelmintic, producers have relied on drugs as their first line of defense. New safer and more effective drugs are continually appearing on the market and are coming into widespread use. Occasionally, anthelmintic treatment failures occur in which treated animals continue to suffer from parasitism.

[1]Levamisole hydrochloride: Pittman-Moore, Washington Crossing, NJ
[2]Fenbendazole: Hoechst-Roussel, Somerville, NJ

One reason may be that reinfection occurs immediately after treatment when the sheep or goats are released onto pastures that contain numerous infective larvae.

Another reason for treatment failure is that the internal parasites, after repeated exposure to a particular anthelmintic, develop resistance to that anthelmintic or class of anthelmintics. The present investigation was undertaken to discover the patterns of resistance to two specific anthelmintics and to products the producer had been using.

Materials and Methods

Groups of 10 animals were randomly selected from flocks belonging to commercial sheep or goat raisers. The types and number of enterprises included dairy goats (11), lamb and wool production (17), mohair production (Angora goats) (3), and Spanish goat (cabrito) production (1).

In each flock, one group was designated the untreated control group. The other groups were treated with either fenbendazole (10 mg/kg), levamisole (8 mg/kg), or the product that the rancher had been using at the same dosage and route of administration.

Fecal samples were collected at the time of treatment and 7 to 10 days later. The number of eggs per gram of feces (epg) was determined by the modified McMaster's technique. The epgs were logrithmically converted and group mean rises or falls in epg were calculated. An analysis of variance with Duncan's multiple range test determined if there were significant differences amont the treatment groups.

Results

The results indicated that there was a significant amount of resistance to the anthelmintics that had been in use for a period of time. Table 1 indicates the number of flocks of sheep, dairy goats, and range goats in which each drug tested was significantly better than the control group and was effective in reducing the epg by at least 90%.

In some of the flocks, the percent reduction of some anthelmintics, even though it was significantly different from the controls, was still less than 90%; whereas, other flocks that showed a 90% reduction in epg also had deceptive results in that they were not significantly different from the controls.

Table 1. No. of Flocks in Which the Anthelmintic Both Reduced EPG More Than 90% and Was Significantly Different from the Controls.

	Sheep	Dairy Goats	Range Goats
Fenbendazole (Panacur[1])	9/15	3/10	1/4
Levamisole (Levasole[2])	8/16	3/7	1/4
Ivermectin (Ivomec[3])	6/8	1/1	4/4
Mebendazole (Telmin[4])	0/0	0/1	0/0
Oxfendazole (Benzelmin[5])	0/2	0/0	0/0
Morantel (Rumatel[6])	0/1	0/0	0/0

[1]Levamisole hydrochloride: Pittman-Moore, Washington Crossing, NJ
[2]Fenbendazole: Hoechst-Roussel, Sommerville, NJ
[3]Ivermectin: Merck and Co., Rahway, NJ
[4]Mebendazole: Pittman Moore, Washington Crossing, NJ
[5]Oxfendazole: Syntex, Palo Alto, CA
[6]Morantel: Pfizer, New York, NY

The flock in which morantel resistance occurred also had a significant resistance to levamisole, an anthelmintic with similar biological effects on nematodes. Another instance of cross-resistance was between mebendazole and fenbendazole. In both of these flocks, one of the drugs had been in constant use while its chemical cousin had never been used on the premises.

Discussion

Anthelmintic resistance has been investigated by several means. One laboratory test, an egg hatchability index, measures the percent of eggs that hatch in a dilute solution of an anthelmintic and is useful for screening large numbers of samples in the lab (1). It is useful only for chemicals that are at least slightly water soluble, and some of the newer anthelmintics are not (4). The test also requires that the feces be delivered to the laboratory within a few hours after sampling and be maintained at a constant temperature.

Larval motility measurement has also been used but has similar drawbacks to the egg-hatch technique. Another problem is the subjectivity of that test in determining the extent to which motility has been reduced (2). It does have the advantage that the drug is being tested against a stage that may more closely resemble the parasitic stages metabolically.

Field rather than laboratory evaluation of anthelmintic resistance was used in this trial because it was thought to be a more consistent measurement under the circumstances. It gave a straightforward measurement of the ability of each anthelmintic to affect the parasite problem in a way that had some value to the producer, a reduction in epg, and therefore reduced pasture contamination.

Since use of an anthelmintic acts as a selection factor in inducing development of resistant populations of nematodes, it may follow that using an anthelmintic with a different mechanism of action will induce reversion to susceptibility. unfortunately, this does not occur to any useful extent. When parasites resistant to thiabendazole were treated instead with levamisole, it was found that any reversion was due to the decreased competitiveness of the resistant strain when exposed to the natural environment in the absence of thiabendazole(3).

A similar study done in New South Wales using the same methodology found that on 40 commercial sheep farms thiabendazole was less than 90% effective in reducing epg on 21 farms and levamisole was less than 90% effective on 4 farms, while both of them were less than 90% effective on another 4 farms (5). Even though clinical improvement may be seen with only 50%-60% reduction in parasite numbers, activity of an anthelmintic of less than 90% efficacy will soon lead to populations of parasites which may cause clinical signs.

Our results showed several patterns of resistance/nonresistance. In operations where anthelmintic use in sheep has been relatively constant year after year, benzimidazoles and levamisole were much less effective than on ranches that had less selective pressure. Among those goat flocks that had been frequently dewormed, resistance appeared to have developed, but in general, the problem was less than in sheep. The length of time that anthelmintics had been in use was also less in goat flocks than in sheep.

Ivermectin was the most commonly used non-approved an-

thelmintic. It seemed to work when administered either orally or subcutaneously. In one herd of Spanish goats there was a less-than-satisfactory response to injection on one occasion, but a subsequent trial on the same ranch comparing oral vs. injected ivermectin did not show clearcut differences. Both methods of treatment were greater than 90% effective.

In several flocks that previously had problems with non-response to anthelmintics, it was found that the product being used was effective. The history indicated that the animals were being returned to the same pasture where they had obtained the original infection. Another mismanagement practice that in the long-run will result in anthelmintic resistance is saving money by underdosing the animals. It seems that while anthelmintic resistance does cause problems, management errors will negate the effects of even the best anthelmintic.

Literature Cited

1. Coles, G.C., and K.G. Simpkin. 1977. Resistance of nematode eggs to the ovicidal activity of benzimidazoles. Res. Vet. Sci. 22:386.
2. Dobson, R.J., A.D. Donald, P.J. Walker, and K.L. Showdon. 1986. An egg hatch assay for resistance to levamisole in trichostrongyloid nematode parasites. Vet. Parsitology 19:77.
3. Martin, P.J., N. Anderson, T.H. Brown, and D.W. Miller. 1988. Changes in resistance of *Ostertagia* spp. to thiabendazole following natural selection or treatment with levamisole. Internat. J. Parasitology. 18:333.
4. Schiltz, R.A. 1986. Personal communication.
5. Webb, R.F., and S.J. Ottaway. 1986. The prevalence of anthelmintic resistance in sheep nematodes on the central tablelands of New South Wales. Aust. Vet. J. 63:13.

Acknowledgment

This research was supported in part by funds provided by Hoechst-Roussel, Somerville, New Jersey. The cooperation of all the participating producers is gratefully appreciated.

PR-4575

Effects of Rangeland Environment on Growth and Fiber Quality of Angora Goats

J. E. Huston, J. W. Holloway, and C. J. Lupton

Summary

A study involving 200 adult Angora mutton goats was conducted to determine a possible genetic x environmental interaction within the Angora goat population. The experimental goats were selected from a large heterogeneous flock and divided into two subgroups of 100 each. One subgroup consisted of goats visually described as "fine" and the other as "coarse." Half of each subgroup was transported to the Winters Ranch (McCulloch county) and the other half to the Lyles Ranch (Zavala county). Data after 1 year indicated no effect of location on weight changes or fleece characteristics. Angora muttons described as "fine" were smaller and had finer mohair at the beginning of the study compared with the "coarse" group. Although both groups gained weight and became coarser during the 12-month period, differences between the groups remained. The study will conclude after an additional year of data collection.

Introduction

The Angora goat is generally considered to be in a state of marginal nutrient deficiency during most periods. Evidence of this includes low and variable reproductive rates, high susceptibility to parasitism, and comparatively high death losses from a variety of nutrition-related causes. Also, there is considerable disagreement on the description of a "desirable" Angora goat. A cooperative study involving the Texas A&M University Agricultural Research and Extension Centers at San Angelo and Uvalde was initiated in August 1986 to determine the relative performance of two phenotypic types of goats (presumably differing in requirements) in different locations (environments). These research installations are situated in the Edwards Plateau and Rio Grande Plains resource region of Texas, respectively. Diets of goats in the Edwards Plateau are high in "oak-type browse" (3), whereas goats in the Rio Grande Plains select large amounts of "leguminous-type browse" (4) expected to be higher in nutritional value (1,2).

Experimental Procedure

The experimental animals were selected from a single flock of yearling billies (approximately 18 months of age) that contained considerable phenotypic variation in body size and fiber diameter. The selected goats included 100 described as "fine" and 100 described as "coarse" in reference to estimated mohair fiber diameter. Side samples of fleeces were obtained just prior to shearing and neutering in mid-August 1986. Fifty goats from each group were selected randomly and were transferred to the Winters Ranch in McCulloch county. The other two subgroups were transferred to the Lyles Ranch in Zavala county (south of Uvalde). Both flocks were managed similarly in order that any differences in performance would be the results of differences in regional environment, not management. Weights were taken upon arrival at the two locations and at subsequent spring and fall shearings. Fleeces were bagged separately, identified for each goat and transported to the Wool and Mohair Testing Laboratory at the Texas A&M University Agricultural Research and Extension Center at San Angelo for weighing and testing.

Results and Discussion

The goats identified as "fine" were smaller and had slightly finer mohair compared with the "coarse" group (Tables 1 and 2). These weight and fiber diameter differences remained rather constant at both locations although all goats gained weight and grew mohair that increased in fiber diameter during the 12-month period. The other measured fleece characteristics (medullated fibers; colored fibers) were highly variable among individual goats within the different groups. The mean differences were not sufficiently large to indicate any effects of location on body weight, mohair production or fiber quality.

Table 1. Effect of Rangeland Type and Location on Body Weight Change and Mohair Production in Angora Muttons.

Location (county)	Body weights			Clean fleece weights		
	Fall 1986	Spr. 1987	Fall 1987	Spr. 1987	Fall 1987	Total
	---------- Pounds ----------					
McCullouch						
Fine	61.8	66.8	77.0	4.3	4.2	8.5
Course	71.1	73.9	86.1	4.5	4.4	8.9
Avg	66.4	70.4	81.6	4.4	4.3	8.7
Zavala						
Fine	61.4	63.6	78.4	4.0	4.5	8.5
Course	68.7	70.3	86.2	4.2	4.6	8.8
Avg	65.0	67.0	82.3	4.1	4.5	8.6

Table 2. Effects of Rangeland Type and Location on Fleece Characteristics in Angora Muttons.

Location (county)	Fiber diameter			Medullated fibers		Colored fibers	
	Initial	Spr.	Fall	Spr.	Fall	Spr.	Fall
	--- Microns ---			------- No/1000 fibers ------			
McCulloch							
Fine	30.1	33.1	37.2	14.6	17.2	2.7	1.0
Course	32.8	36.4	40.1	19.7	22.7	1.7	1.3
Avg	31.4	34.8	38.6	17.2	20.0	2.2	1.2
Zavala							
Fine	30.7	34.5	38.3	15.5	21.2	1.2	3.1
Course	33.1	36.5	40.2	20.9	24.5	1.0	2.3
Avg	31.9	35.5	39.2	18.2	22.8	1.1	2.7

Since differences in the response criteria were not observed, our preliminary conclusion is that the diets that differ in botanical composition between the two locations do not differ substantially in nutrient content. Moreover, the two phenotypic groups of goats were not sufficiently different genetically to test for the presence of a genetic x environmental interaction. At completion of the study (after 2 years) an assessment of the results will help to determine procedures for a new study in an attempt to discover whether there is a genetic x environmental interaction within the Angora goat population in Texas.

Literature Cited

1. Huston, J. E., B. S. Rector, L. B. Merrill, and B. S. Engdahl. 1981. Nutritional value of range plants in the Edwards Plateau region of Texas. Tex. Agric. Exp. Sta. Bull. 1357.
2. Varner, L. W., and L. H. Blankenship. 1979. Seasonal changes in nutritive value of deer food plants in south Texas. Proc. 31st Annu. Conf. SE Assoc. of Fish and Wildlife Agencies. 31:99.
3. Warren, L. E., D. N. Ueckert, and J. M. Shelton. 1984. Comparative diets of Rambouillet, Barbado, and Karakul sheep and Spanish and Angora goats. J. Range Manage. 37:172.
4. Warren, L. E., D. N. Ueckert, M. Shelton, and A. D. Chamrad. 1984. Spanish goat diets on mixed-brush rangeland in the South Texas Plains. J. Range Manage. 37:340.

PR-4576

Growth, Slaughter, and Carcass Characteristics of Wether, Recently Castrated, or Uncastrated Lambs

J.M. Shelton and T.D. Willingham

Summary

An experiment was conducted utilizing 99 lambs to investigate the growth, slaughter, and carcass characteristics of wether lambs (castrated at marking) versus intact ram lambs or ram lambs castrated by knife or burdizzo as they were placed in the feedlot. The data collected included rate of gain on feed, pelting difficulty, yield grades, and factors contributing to yield grade.

The animals ranged up to 9 months of age and 134 pounds at slaughter. Gains were very poor on lambs castrated as they were placed on feed, and thus castration at this time would not be indicated. As expected, ram lambs gained more than wether lambs, but these data only cover the last 6 weeks before slaughter. Ram lambs had significantly lower dressing percent than the other groups. They also had significantly less backfat thickness. Ram lambs had lower (more desirable) yield grades. Late castrate animals were intermediate. All of the animals in the experiment graded Choice, thus in this experiment, there was no downgrading due to "buckiness." Pelting difficulty or pelting damage scores were not consistent or significant, but there was a tendency for males or late castrates to score higher (less desirable) in this respect.

In this study, the only basis for discrimination against ram lambs was their lower dressing percent. Improvements in yield grades and the sale value of the testis could more than offset this difference. On the basis of this one experiment, the writers encourage the feeders and packers to be more open-minded in respect to ram lambs. Large lots of only ram lambs might more likely present a problem. However, there is a need for further research under different conditions such as lambs of different breeding or those carried to heavier weights. The animals in this experiment were slaughtered at lighter weights than most of those being marketed at the present time. In the meantime, packer buyers should be able to identify ram lambs likely to be downgraded or they might be purchased subject to quality grade.

Introduction

It has been well-established in prior research that ram lambs grow faster and more efficiently and produce leaner carcasses than wether or female lambs. However, feedlot operators and packers are often negative about the utilization of ram lambs. The objections of feeders trace largely to rutting activity in the feed lot and to the threat of ewe lambs becoming pregnant while on feed. The latter has an obvious solution in that the two should be fed separately. Packer objections to ram lambs trace to complaints that they are difficult to pelt, that there is damage to the pelt and/or carcass from the use of mechanical pelt pullers and that carcasses from ram lambs are downgraded (fail to make Choice) in the cooler as a result of "buckiness."

In the summer of 1987, the Texas A&M University Agri-

cultural Research and Extension Center at San Angelo had on hand approximately 70 ram lambs which were culled from breeding programs, or were surplus from other experiments. An additional group of lambs from the same flocks were available which had been castrated shortly after birth and were used for comparison. An experiment was undertaken to evaluate the influence of date and method of castration on alleged problems resulting from use of ram lambs by the industry.

Experimental Procedure

A total of 99 lambs were used to compare ram versus wether lambs and ram lambs castrated by either knife or burdizzo at the time they were placed on feed. All lambs were straight Rambouillet or crossbred lambs out of Rambouillet ewes. The lambs were born on variable dates in February and March 1987. They were slaughtered over the period November 12 to December 2, 1987. Thus, the lambs were between 8 and 9 months of age at time of slaughter. Slaughter weights ranged from 78 to 134 pounds. Only three lambs weighed less than 90 pounds at slaughter. These were lambs which had performed poorly and were included in the 12/2 slaughter date to clear experimental pens. On 10/12, the animals were allotted to one of four groups as follows:

1. Control wethers—castrated at marking (14 days of age or less).
2. Castrated by knife on 10/12 as they were placed on feed.
3. Castrated by burdizzo on 10/12 as they were placed on feed.
4. Left as intact males.

The latter three groups are directly comparable. The control wethers had not been managed in the same group as the males up to the treatment date. Data reported include gain from 10/12 to slaughter and various slaughter information. A small number of lambs are included in the slaughter data which had been castrated by one of the two methods prior to 10/12. Lambs were fed in a single group and no feed efficiency data are available. The number of animals in the growth and slaughter data are not exactly the same because some animals went directly to slaughter on 10/12 and were not in the feedlot during the period gains were measured. Growth data are reported by weeks, but the number present each week is variable as animals were slaughtered at periodic intervals.

At the abbatoir, a researcher stood near the point on the processing line where the lambs were being pelted or fisted (ventral side and legs) and asked the workers to report pelting difficulty as easy (1), average (2), or difficult (3). The animals were also observed as they passed the pelt puller and notes made on carcass damage. Warm carcass weights were collected on the floor. USDA quality grade (assigned by an official grader) and scores or measures necessary for yield grading (assigned by a researcher) were obtained in the cooler approximately 24 hours later.

Results and Discussion

Feedlot gain data for the period 10/12 to slaughter are shown in Table 1. Large and significant differences in gain were observed between feedlot groups. As expected, ram lambs gained faster. In this study, castration by either method would be considered undesirable for animals of this age going into the feedlot because of reduced feedlot performance.

Slaughter data are shown in Table 2. Although slaughter weights were different for the four groups, the carcass weights did not differ significantly because of treatment-related dressing percentages. This no doubt influenced the results, but it is not thought to be germaine to the intent of the study.

The intact males had a significantly lower dressing percentage. This agrees with other studies (1,2), but this study may not be a good estimate of the expected magnitude of this difference. A part of this difference would be explained by removal of the testis which is a saleable product. Wether lambs had a significantly higher kidney and pelvic fat percentage, and intact rams has less fat cover over the rib. These differences follow the expected pattern. Leg conformation scores did not differ significantly, but such differences as did

Table 1. Average Daily Gains by Weeks and for the Total Period.

		Average Daily Gains (lb) by weeks after 10/12						Overall
Control	1	.447(33)	.480(22)	.326(22)	.738(18)	.428(18)	.564(9)	.432
Knife	2	−.800(10)	.984(9)	.017(9)	.902(6)	.807(6)	—	.198
Burdizzo	3	.164(13)	.535(12)	.117(12)	.623(7)	.817(7)	.620(3)	.329
Intact Males	4	.984(14)	.886(14)	.608(14)	.923(11)	.754(11)	1.314(5)	.822

Table 2. Slaughter and Carcass Data by Treatment Groups.

Treatment	n	Slaughter Weight lb	Carcass Weight lb	Dressing %	Kidney Pelvic Fat %	Fat Thickness in	Leg Conform. Score	Yield Grade Score	Pelting Difficulty Score	Pelting Damage Score
Control	41	106.0^{a}	55.15^{a}	51.98^{a}	2.91^{a}	.26^{a}	2.05^{a}	3.82^{a}	2.02^{a}	1.34^{ab}
Knife	13	105.9^{a}	54.50^{a}	51.45^{a}	1.94^{b}	.22^{a}	2.00^{a}	3.34^{bc}	2.31^{a}	1.15^{b}
Burdizzo	14	113.4^{b}	58.14^{a}	51.33^{a}	2.14^{b}	.26^{a}	2.07^{a}	3.62^{ab}	2.29^{a}	1.57^{a}
Intact Males	31	112.8^{b}	55.57^{a}	48.94^{b}	2.04^{b}	.17^{b}	2.16^{a}	2.96^{c}	2.16^{a}	1.45^{ab}

Column means without a common superscript are significantly different ($P<.05$).

exist favored the ram lambs. Ram lambs had significantly lower (more desirable) yield grades than wethers. Late castrate animals were intermediate.

USDA quality grades are not shown in Table 2 because every carcass graded Choice; thus, no variation existed in this trait. This is perhaps the most significant part of the study because there was no downgrading due to "buckiness." Slaughter occurred over a period of weeks and during this time, at least two different USDA graders were involved in grading the carcasses. It is of interest that this was the most serious complaint by packers against ram lambs. Perhaps it is also of interest that these lambs were between 8 and 9 months of age when slaughtered, and that live body weights did not exceed 134 pounds. The mean weight of the lambs in this experiment was below that of many of the animals being marketed out of feedlots at the present time. It has been generally believed that if rams were slaughtered at less than 6 months of age, no problems would be encountered. In this study, this problem was not encountered on rams as old as 9 months of age. One can only speculate what might have happened if an earlier maturing breed had been included or if the animals had been heavier. It is expected that weight as well as age would effect sexual development and thus "buckiness."

Scores or conclusions relating to pelting difficulty or pelting damage are not very clear. There was no significant difference in pelting difficulty score, but such differences that did exist favored the wether lambs. It was not possible to obtain these values with a great deal of precision because at least four different workers were doing this work, and they differed in experience level and degree of cooperation. At least with the number of animals involved in this study, workers did not complain. Increased time in skinning out the testes appeared to be a greater time constraint than pelting difficulty. There were some complaints in attempting to skin out the testis from ram lambs and especially those which had been castrated by burdizzo. Testis from this latter group should probably not have been saved.

It is recognized that ram lambs are more difficult to pelt. In this study, workers would often state that "for ram lambs" this one was easy to pelt. Workers often referred to dry lambs, and appeared to think that other factors such as holding off water during marketing may be a factor contributing to difficult pelting. None of the carcasses showed sufficient damage to the carcass to present problems in marketing. Four (4) of the 99 were recorded as having some slight damage. Three (3) of these were ram lambs and one was in the burdizzo group. Several of the carcasses showed slight pulls in the fat over the shoulders. This was essentially unrelated to treatment as 33.3% of the wether lambs showed such pulls, whereas the frequency in the total experiment was 29.6%.

Literature Cited

1. Shelton, Maurice, and A.L. Carpenter. 1972. Influence of sex, stilbestrol treatment and slaughter weight on performance and carcass traits of slaughter lambs. J. Anim. Sci. 34:203.
2. Thompson, T.M., and G.T. Lee. 1984. Management systems to produce leaner lambs. The production of ram lambs. Wool Tech. and Sheep Breeding. 32:141.

PR-4577

Chemical Castration in Angora Goats

T.D. Willingham, P.V. Thompson and J.M. Shelton

Summary

An experiment was conducted in the spring of 1986 to evaluate Chem- Cast[1] as compared to traditional methods of castration for eliminating testicular growth and fleece stain associated with rutting in Angora billies. Growth rates, fleece weights, and horn lengths were also monitored. Dosage rates and time of administration were varied in an attempt to determine an optimal level and time of treatment.

The use of ½ cc of Chem-Cast shortly after birth reduced scrotal circumference in Angora billies. This level of chemical, however, resulted in death of kids. Chemical injections caused adhesions in the scrotum and deformation of the testes that resulted in reduced fertility; however, evidence of rutting or sexual activity was only marginally reduced, except in those animals given ½ cc shortly after birth, with only 44% of those billies rutting. Body weight, fleece weight and horn length were not affected by Chem-Cast injections. These results indicate that, for the various times and dosage rates examined, chemical castration does not adversely effect growth traits, but fails to prevent rutting and to eliminate testicular development.

Introduction

Angora muttons have played a major role in the production of mohair for years, and with current interest in Angoras increasing, demand for muttons may increase.

Castration of Angora males has been performed traditionally using a knife or burdizzo when the animals reached 1 year of age. Delaying castration until animals are 1 year of age is done to allow for additional body growth, to produce a heavier shearing animal free from the stain associated with rutting, and to allow for added horn growth, thereby preventing animals from hanging in fences and providing a means of defense against predators. The use of a knife in castration at this age can result in death losses resulting from blood loss, infection, or general stress, while improper use of the burdizzo can cause incomplete castration or necrosis. Thus, a simple sterile method which allows for earlier castration without adversely affecting body and horn growth should be of interest.

Experimental Procedure

Seventy Angora billy kids were randomly assigned to three groups in the spring of 1986; Control, ¼ cc Chem-Cast, and ½ cc Chem-Cast. hours after birth. Animals were confined together at the Winters ranch near Brady, Texas. At weaning, control animals were further divided to create two additional treatment groups; ¼ cc Chem-Cast, and ½ cc Chem-Cast. An additional division of the control group occurred as the animals approached 1 year of age in order to form a treatment of burdizzo and knife castrates. Body weights and scrotal circumference were measured periodically over a 19-month

[1]The term Chem-Cast, which contains lactic acid, is a trade name product of the Bio-centic company. This product is not approved for use in goats.

period. In addition, records were made on horn length and observation of rutting at their first season (approximately 18 months of age). Statistical analysis involved Tukey's Least Significant Difference multiple comparisons and one way Analysis of Variance. Due to several animals having testicles too small to measure, scrotal circumference data was not obtained for these animals. A value of 9 cm was assigned to those missing values, as this was the minimum obtainable value. Any values missing due to the absence of the animal were treated as missing and not assigned a value. Five control animals were inadvertently lost, reducing the sample size for this group at 18 months or later.

Results and Discussion

Figure 1 and Table 1 show the effects of various castration methods on testicular growth. With the exception of knife and burdizzo castration, the use of ½ cc Chem-Cast at birth was the only method that significantly reduced testicular growth at all time periods examined. The mean testicle circumference for this group was greater than would be the actual mean as a result of arbitrarily assigning minimal measurable values to those animals which had testicles of unmeasureable size. This was necessary for 37% of the animals that were measured in the ½ cc group which were treated at birth, and 1 control animal at weaning. No other values required this adjustment. The use of ½ cc at birth reduced the total number of animals rutting with only 44% showing any evidence of sexual activity. However, two animals died within two days of treatment at this level which may deem this practice inadvisable. The exact cause of death was unknown but was believed to be treatment related.

The other dosage levels and time of treatment did not significantly reduce testicular growth. Edema and the development of scar tissue in the testicles tended to increase testicle circumference in billies injected at weaning. Of those testicles surgically removed from animals (3) for evaluation severe adhesions were found binding the testicle to the scrotum complicating removal. Deformation of the testicle was believed to be sufficient to interfere with sperm transport because the epididymis was either absent or blocked. No sperm was found to be present in any of the animals examined. The

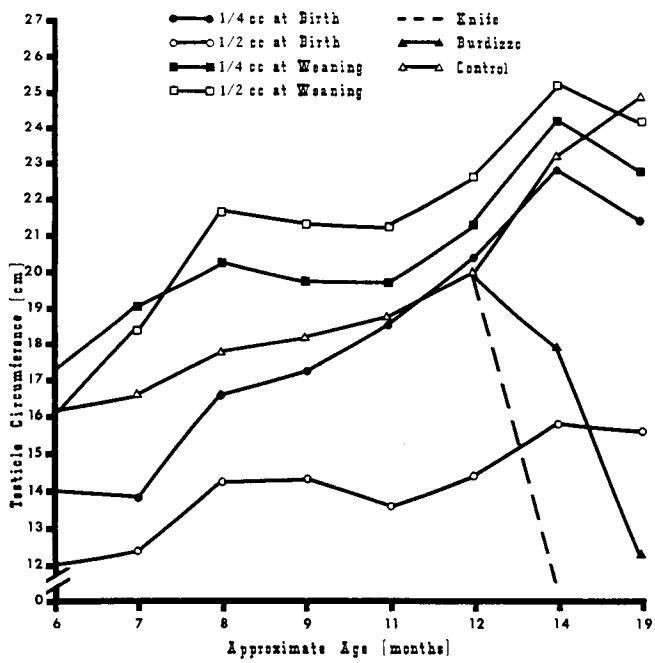


Figure 1. Testicle Circumference at Various Ages after Treatment.

Table 1. Circumference of Angora Billies and Percentage of Animals Rutting at Various Times Following Injections of Chem-Cast or Traditional Castration Methods.

Treatment group	Testicle circumference (cm)				
	Weaning	Yearling	14 mos.	19 mos.	% Rutting
Control	15.80^{ab} (21)	19.48^{ab} (9)	23.29^{a} (8)	24.83^{a} (3)	66 (3)
¼ cc Birth	14.02^{bc} (13)	20.55^{ab} (11)	22.99^{a} (11)	21.49^{a} (10)	64 (10)
½ cc Birth	12.14^{c} (9)	14.56^{c} (9)	15.97^{b} (9)	15.64^{b} (7)	44 (7)
¼ cc Weaning	17.42^{a} (13)	21.46^{ab} (13)	24.19^{a} (13)	22.96^{a} (13)	93 (13)
½ cc Weaning	16.06^{ab} (14)	22.69^{a} (14)	25.24^{a} (13)	24.22^{a} (13)	85 (13)
Burdizzo	*	20.40^{ab} (7)	17.90^{b} (7)	12.39^{b} (7)	0 (7)
Knife	*	20.32^{ab} (6)	0.0^{c} (6)	0.0^{c} (6)	0 (6)

*These animals were included in the control group on this date.
Numbers in parenthesis represent number of animals observed.
Within column means without a common superscript are significantly different (P<.05).

Table 2. Body Weights of Angora Males at Various Times after Injections of Chem-Cast or Traditional Castration Methods.

Treatment group	Weaning	Yearling	16 mos.	19 mos.
Control	39.7^{a} (22)	49.4^{ab} (9)	78.5^{ab} (8)	76.0^{ab} (3)
¼ cc Birth	41.2^{ab} (16)	53.0^{ab} (12)	80.9^{ab} (12)	80.2^{ab} (11)
½ cc Birth	47.1^{b} (8)	54.1^{ab} (8)	82.4^{ab} (9)	78.8^{ab} (9)
¼ cc Weaning	44.5^{ab} (13)	54.1^{ab} (13)	85.5^{a} (13)	83.4^{a} (13)
½ cc Weaning	46.3^{ab} (14)	55.1^{a} (13)	87.8^{a} (13)	81.6^{ab} (13)
Burdizzo		49.8^{ab} (7)	75.6^{b} (7)	73.1^{ab} (7)
Knife		45.3^{b} (6)	73.2^{b} (6)	70.7^{b} (6)

Numbers in parenthesis represent the number of animals observed.
Means within columns without a common superscript are significantly different (P<.05).

production of testosterone did not appear to have been significantly reduced as evidenced by the percentage of animals rutting (Table 1) and normal horn growth (Table 3).

Chemical castration had no significant effect on body weights except at weaning of those animals that were given ½ cc at birth, with this difference diminishing as the kids matured (Table 2). There was however, a trend for a slight improvement in body weights for those animals chemically castrated. This increase cannot readily be explained at present. However, this gain in body weight is also evident in fleece weights (Table 3), though not significantly.

Table 3. Effect of Chem-Cast Injections and Traditional Castration Methods on Fleece Weights and Horn Lengths of Male Angora Goats.

Treatment group	Yearling fleece wt. 2nd shearing (lbs)	18 months fleece wt. 3rd shearing (lbs)	Horn length (cm)
Control	3.15^{ab} (9)	6.92^{ab} (8)	34.54^{a} (3)
¼ cc Birth	3.17^{ab} (12)	7.33^{a} (12)	33.62^{ab} (11)
½ cc Birth	3.45^{ab} (8)	6.78^{ab} (9)	33.05^{ab} (9)
¼ cc Weaning	3.60^{a} (13)	7.66^{a} (13)	35.49^{a} (13)
½ cc Weaning	3.65^{a} (13)	7.39^{a} (13)	34.02^{a} (13)
Burdizzo	2.90^{b} (7)	6.64^{b} (7)	29.19^{ab} (7)
Knife	2.95^{b} (6)	6.10^{b} (6)	27.73^{c} (6)

Numbers in parenthesis represent the number of animals observed. Means within columns without a common superscript are significantly different ($P<.05$).

Fleece weights were not significantly affected by chemical castration at various times and dosage levels. There appeared to be a slight advantage for using the lower dosage of ¼ cc compared to ½ cc. However, neither proved totally effective in preventing sexual activity. Thus the presence of rutting stain was not eliminated. A similar trend was found for horn growth with only the knife castrates having significantly smaller horns.

These data suggest that chemical treatment as used in this study is not effective in preventing sexual activity in Angora billies. While injection of the chemical appeared to render the animals infertile, the number of testicles evaluated are insufficient to support the hypothesis that this would occur in all animals chemically treated.

PR-4578

Grazing Fourwing Saltbush with Angora Goats

D.N. Ueckert, J.E. Huston, J.L. Petersen, and J.D. Whipple

Summary

Results from a grazing trial during winter suggested that fourwing saltbush was a good source of nutrients for yearling Angora muttons. However, Angora weanlings were reluctant to feed on fourwing saltbush in a grazing trial during September-October, and weanling kids did not receive adequate nutrition from fourwing saltbush to maintain their weight during this period. Yearling Angora goats fed fresh, succulent spring growth of fourwing saltbush in a metabolism trial had a negative nitrogen balance (-1 g/day) and a daily total feed intake of only 29 g/kg metabolic body weight (mbw), whereas those fed saltbush and a concentrate had a positive nitrogen balance (+5 g/day) and a daily total feed intake of 52 g/kg mbw. We theorize that Angora weanlings may have to "learn" to feed on saltbush and that the nitrogen in fourwing saltbush forage in certain seasons may be rapidly hydrolized in the Angora goat rumen and lost as ammonia. Additional research is needed to determine the value of fourwing saltbush in Angora goat production systems.

Introduction

The propensity of Angora goats to readily utilize browse and the high laboratory-determined nutritional value of fourwing saltbush (2) suggested that plantings of this drought-tolerant, evergreen shrub would be valuable in Angora goat production systems. Our laboratory analyses have indicated that the leaves of western Texas ecotypes of fourwing saltbush contain at least 16% crude protein, 0.12% phosphorus, and 59% digestible organic matter during summer through winter (2). These nutrients are often not present in sufficient quantities in native forages to satisfy the nutritional requirements of Angora goats, necessitating the use of expensive supplemental feeds. We recently documented the value of fourwing saltbush for revegetating disturbed rangeland and the high forage yield potential for the species in western Texas (1). We initiated research in 1984 to determine the value of fourwing saltbush for grazing Angora goats. This report summarizes three experiments.

Experimental Procedure

Winter 1984 Grazing Trial. Thirty yearling Angora mutton goats were divided randomly into three groups of 10 head each and assigned to three small plantings of fourwing saltbush during January 27-February 23, 1984. A monoculture of saltbush at the Texas A&M University Agricultural Research and Extension Center at San Angelo was stocked at 25 goats/acre, a monoculture in northern Crockett County was stocked at 15 goats/acre, and a saltbush-grass-kochia mixture in Reagan County was stocked at 9 goats/acre. The goats were weighed at initiation of the grazing trial, after 2 weeks, and at the end of the trial. Our scales were not properly adjusted at the initial weighing so weight changes presented reflect differences during the last 2 weeks of the trial. Four saltbush plants were caged in each plot prior to the grazing trial. Degree of utilization of saltbush forage by the goats was visually estimated in each plot when the goats were removed by comparing the amounts of available forage on grazed and caged shrubs.

Late-Summer/Early-Autumn Grazing Trial. Sixty weanling Angora kids were utilized in a grazing trial during September 4-October 8, 1985, to evaluate fourwing saltbush pastures for weaning Angora kids. The kids were divided into 12 uniform groups of 5 head each and the groups were randomly assigned to two replications of each of the following treatments:

1. Dry grass.
2. Dry grass + 32% crude protein (C.P.) concentrate.
3. Fourwing saltbush.
4. Fourwing saltbush + 32% C.P. concentrate.

5. Fourwing saltbush-grass-forb mixture.
6. Fourwing saltbush-grass-forb mixture + 32% C.P. concentrate.

The dry grass plots were a mixture of kleingrass, buffalograss, and threeawns at the Research Center near San Angelo. The fourwing saltbush plots were at the Research Center and in Crockett County, and the saltbush-grass-forb mixture plots were in Reagan County. Grasses in the latter plots included kleingrass, King Ranch bluestem, Lehmann lovegrass, threeawns, and buffalograss and forbs included kochia and native forbs. The concentrate feed included cottonseed meal (65%), milo (22%), dehydrated alfalfa meal (10%), molasses (2%), and salt (1%). The feed was provided *ad libitum* in self feeders. The kids were fasted 15 hours prior to taking initial and final weights. The data were subjected to analysis of variance and means were separated by Duncan's multiple range test.

1985 Metabolism Trial. Eight yearling Angora goats were utilized in a metabolism trial during April 22-May 11, 1985. Four were fed fresh, succulent spring growth of fourwing saltbush and four were fed saltbush *ad libitum* + 300 g/day of the 32% C.P. concentrate described above. The goats were pre-conditioned on the experimental diets for 14 days prior to initiation of the metabolism trial. Fourwing saltbush was hand-harvested daily from western Texas ecotypes of saltbush growing at the Research Center. Daily intake of saltbush, concentrate, and water and daily output of feces and urine were recorded for each goat. Nitrogen balances for the two treatments were determined by standard metabolism trial procedures. The data were subjected to analyses of variance.

Results and Discussion

Winter 1984 Grazing Trial. The yearling Angora muttons readily browsed fourwing saltbush in all experimental plots during the January 27-February 23 trial. Saltbush browse utilization averaged 98%, 96%, and 98% at the Research Center, Reagan County, and Crockett County plots, respectively. The muttons gained weight at two of the three locations (Table 1). A small decline in body weight occurred in the plot stocked at 25 goats/acre. These data suggested that fourwing saltbush was suitable as a source of nutrients for yearling Angora goats.

Late-Summer/Early-Autumn Grazing Trial. The weanling Angora kids obviously preferred grasses and forbs over fourwing saltbush in plots where a choice was available. Furthermore, the low degree of utilization of saltbush forage observed in saltbush monoculture plots suggested that food intake may have been very low where saltbush was the only forage available.

Weanling kids grazing dry grass and those grazing saltbush lost about 3 lb/head during the 34-day trial while those grazing the saltbush-grass-forb mixture gained 0.4 lb/head (Table 2). Kids receiving concentrate feed in grass plots and in saltbush-grass-forb mixture plots gained 9 and 7.9 lb/head, respectively, whereas those in fourwing saltbush plots receiving concentrate gained only 3.7 lb/head (Table 2).

The apparent low palatability of fourwing saltbush to Angora weanlings was unexpected even though the kids had never been exposed to saltbush or other palatable browse plants. Is it possible that Angora kids have to "learn" to browse? Our laboratory analyses (2) suggested that saltbush leaves during late-summer/early-autumn should have provided a diet of sufficient quality for growth of Angora weanlings (16% C.P., 0.12% P, 60% digestibility). We theorized that the weight loss in Angora weanlings grazing fourwing saltbush was due to (a) low palatability and hence inadequate intake, (b) presence of secondary plant compounds in the forage that interfered with protein utilization, or (c) loss of saltbush protein as ammonia in the goat rumen.

1985 Metabolism Trial. The spring growth (leaves and stems) of fourwing saltbush (16% crude protein; 62% dry matter digestibility) was readily eaten by yearling Angoras in

Table 1. Performance of Yearling Angora Mutton Kids Grazing Fourwing Saltbush During January 27-February 23, 1984.

Treatments	Stocking rate	No. goats	Average gain[a]	
	(goats/acre)		lb	(S.D.)
Fourwing saltbush	25	10	−0.1	(1.4)
Fourwing saltbush	15	10	1.9	(2.0)
Fourwing saltbush/grass/kochia	9	10	2.6	(1.1)

[a]Weight changes reflect differences in last two weeks of the grazing trial.

Table 2. Weight Changes of Weanling Angora Kids Grazing Fourwing Saltbush, Grass, or Saltbush-Grass-Forb Mixtures with or without Supplemental Feed during September 4-October 8, 1984.[a]

Treatments				
Pasture type		Feed	No. goats	Average weight change
				(pounds)
Dry grass		—	10	−3.1 d
Dry grass		+ 32% C.P.	10	9.0 a
Fourwing saltbush		—	10	−3.2 d
Fourwing saltbush		+ 32% C.P.	10	3.7 b
Fourwing saltbush-grass-forbs		—	10	.4 c
Fourwing saltbush-grass-forbs		+ 32% C.P.	10	7.9 a

[a]Means followed by similar lower case letters are not significantly different at P≤0.05 according to Duncan's multiple range test.

Table 3. Results from Metabolism Trial with Yearling Angora Goats Fed Fresh Fourwing Saltbush Alone or with 32% Crude Protein Concentrate During April 22-May 11, 1985[a].

Criterion	Diet	
	Fourwing saltbush	Fourwing saltbush + concentrate
Weight change (pounds)	−2.5 a	0.5 a
Intake		
Concentrate ($g/kg^{.75}$)	0 a	19 b
Fourwing saltbush ($g/kg^{.75}$)	29 a	33 a
Total ($g/kg^{.75}$)	29 a	52 b
Water ($g/kg^{.75}$)	139 a	192 a
Dry matter digestibility		
Fourwing saltbush (%)	62 a	60 a
Total (%)	62 a	63 a
Nitrogen intake (g/head/day)	8 a	23 b
Fecal nitrogen (g/head/day)	2 a	5 b
Urine nitrogen (g/head/day)	7 a	13 b
Nitrogen balance (g/head/day)	−1 a	5 b

[a]Means within a row followed by similar lower case letters are not significantly different at P≤0.05.

metabolism stalls, but total feed intake was significantly lower in goats fed saltbush alone compared to those fed saltbush + concentrate (Table 3). The amount of saltbush eaten daily was similar in goats fed only saltbush and in those fed saltbush + concentrate. Angora yearlings fed saltbush only had a nitrogen balance of −1 g/head/day whereas those fed saltbush + concentrate had a nitrogen balance of +5 g/head/day (Table 3). These results appear to help explain those from the September-October 1984 grazing trial discussed above. At this time our theory is that the nitrogen in fourwing saltbush forage at certain growth stages is rapidly hydrolized and lost as ammonia in the Angora goat rumen. Additional research will be conducted to test this theory and to determine if fourwing saltbush can be useful in selected seasons for use by Angora goats.

Literature Cited

1. McFarland, M.L., D.N. Ueckert, and S. Hartmann. 1987. Revegetation of oil well reserve pits in west Texas. J. Range Manage. 40:122- 127.
2. Petersen, J.L., D.N. Ueckert, R.L. Potter, and J.E. Huston. 1987. Ecotypic variation in selected fourwing saltbush populations in western Texas. J. Range Manage. 40:361-366.

PR-4579

Performance of Sheep Grazing Fourwing Saltbush During Winter

D.N. Ueckert, M.W. Wagner, J.L. Petersen, and J.E. Huston

Summary

Grazing trials with yearling Rambouillet ewe lambs were conducted during the winters of 1987 and 1988 to evaluate the potential value of fourwing saltbush *(Atriplex canescens)* as a supplemental grazing resource for range livestock in western Texas. Small groups of lambs were grazed during January-March on either fourwing saltbush, WW-Spar bluestem, 1-2 days on fourwing saltbush alternating with 1-2 days on WW-Spar bluestem, a mixture of fourwing saltbush and sideoats grama, or on mixed-grass pasture where protein supplement (23% crude protein) was provided. Lambs provided supplemental feed gained more in both years than those grazing dry grass or dry grass + fourwing saltbush. Lambs grazing dry grass + fourwing saltbush gained about 6 to 10 lb per head while those grazing dry grass lost about 3 lb per head during the 1987 trial. Lambs grazing dry grass + fourwing saltbush in 1988 lost about 2 to 4 lb per head while those grazing only dry grass lost 11 lb per head.

Introduction

Fourwing saltbush *(Atriplex canescens)* is a native shrub that occurs from northern Mexico to southern Canada and from the Central Plains westward into California. It has been recognized as a valuable plant for rangeland livestock for many years because of its abundance, wide area of adaptation, evergreen habit, palatability, and nutritive value (6). It is salt tolerant and very drought tolerant, occurring and thriving in arid regions with less than 10 inches annual precipitation. Fourwing saltbush is usually an important dietary component of livestock on rangelands where the shrubs are abundant (3,4,5), and less supplemental feed is required for livestock which have access to fourwing saltbush (1). Average winter values for the leaves of four western Texas ecotypes of fourwing saltbush were 17.9% crude protein, 0.14% phosphorus, and 59% *in vitro* digestible organic matter (2). Our research suggests that an acre of fourwing saltbush might provide the supplemental crude protein requirements for about one animal unit of livestock for a 3-month period (2). Small plantings of fourwing saltbush were established at the Texas A&M University Agricultural Research and Extension Center at San Angelo in 1981-84. Research was initiated in 1987 to determine the value of fourwing saltbush for supplemental grazing for sheep during winter.

Experimental Procedure

1987 Trial. Fifty-two yearling Rambouillet ewe lambs from the Texas Agricultural Experiment Station's San Angelo flock were randomly assigned to the following treatment pastures at the Research Center near San Angelo:

1. Fourwing saltbush (one .25-acre plot).
2. WW-Spar bluestem (two 2.5-acre pastures).
3. Fourwing saltbush (two 5-acre pastures) + WW-Spar bluestem (two 2.5-acre pastures) (1-2 days on saltbush alternating with 1-2 days on bluestem).
4. Fourwing saltbush + sideoats grama (mixed stand) (one 4-acre pasture).
5. Mixed-grass pasture with abundance of forbs (80-acres) + 23% crude protein (C.P.) supplement fed at 0.3 pound/head/day.

Numbers of lambs assigned to a treatment group varied from 3 to 14. The grazing trial began on January 8, 1987 and ended March 9, 1987. Lambs were fasted 15 hours prior to taking initial and final weights. Salt and a mineral supplement containing 12% phosphorus and 12% calcium were provided *ad libitum*. Percentage of fourwing saltbush forage utilized by the sheep in each plot was visually estimated on March 9, 1987.

1988 Trial. Ninety-two yearling Rambouillet ewe lambs from the Station's San Angelo flock were randomly assigned to the following treatment pastures at the Research Center or at the Carlsbad Research Area:

1. Fourwing saltbush (one 0.25-acre plot).
2. WW-Spar bluestem (two 2.5-acre pastures).
3. Fourwing saltbush (two 5-acre pastures) + WW-Spar bluestem (two 2.5-acre pastures) (1-2 days on saltbush alternating with 1-2 days on bluestem).
4. Fourwing saltbush + sideoats grama (mixed stand) (one 5-acre pasture).
5. Kleingrass + WW-Spar bluestem + Wilmann lovegrass mixture (one 15-acre pasture).
6. Kleingrass + WW-Spar bluestem + Wilmann lovegrass mixture (one 19-acre pasture) + 23% C.P. supplement fed at 0.3 pound/head/day.

Treatments 5 and 6 were at the Carlsbad Research area. Numbers of lambs assigned to treatments varied from 3 to 20. The grazing trial began on January 12, 1988, and ended on March 14, 1988. Lamb weights were taken and salt and mineral were provided as in the 1987 experiment. Mean weight changes and standard deviations (SD) were calculated.

Table 1. Weight Changes of Yearling Rambouillet Ewe Lambs During Winter Grazing Trials in 1987 and 1988.

Treatments			Jan. 8-Mar. 9, 1987			Jan. 12-Mar. 14, 1988		
Pasture		Feed	No. sheep	Average weight change[a]		No. sheep	Average weight change[a]	
				lb	(SD)		lb	(SD)
Fourwing saltbush		—	3	9.0	(2.2)	3[b]	−2.0	(3.9)
WW-Spar bluestem		—	14	−3.2	(2.4)	20	−11.0	(4.9)
Fourwing saltbush & WW-Spar bluestem		—	14	5.8	(6.0)	20	−4.4	(3.4)
Fourwing saltbush & sideoats grama		—	7	10.2	(2.8)	9	−2.1	(3.8)
Mixed grasses & forbs	+	23% CP[c]	14	14.1	(2.7)	—	—	—
Kleingrass, Wilmann lovegrass, WW-Spar bluestem mixture (shredded)		—	—	—	—	20	−0.1	(2.3)
Kleingrass, Wilmann lovegrass, WW-Spar bluestem mixture (shredded)	+	23% CP[b]	—	—	—	20	4.4	(2.8)

[a]Values in parentheses are standard deviations.
[b]These lambs were removed from the 0.25-acre pasture after 37 days because forage availability was limited.
[c]Supplemental feed containing 45% cottonseed meal, 40% milo, and 15% salt was fed at 0.3 pound/head/day.

Results and Discussion

Ewe lambs grazing bluestem pastures lost 3.2 lb/head during the 60-day grazing trial in 1987 (Table 1). The bluestem forage available was dormant, but there was some new basal growth during the latter 30 days of the trial. Lambs grazing the fourwing saltbush monoculture gained 9 lb/head and utilized about 95% of the available browse in the 60-day period. Lambs rotated among the fourwing saltbush and bluestem pastures gained 5.8 lb/head in the 1987 trial (Table 1). Annual forbs (tallow weed, etc.) were abundant in the 5-acre fourwing saltbush pastures and were heavily grazed by the lambs. Lambs obviously preferred the forbs over fourwing saltbush. Only about 2.5% of the available fourwing saltbush browse was utilized in the 1987 trial by sheep rotated among the shrub and bluestem pastures. However, forbs were rare in the 4-acre pasture of sideoats grama and fourwing saltbush, and sheep readily consumed the browse, utilizing an estimated 40% of the avilable browse. These lambs gained 10.2 lb/head in the 1987 trial. Lambs on the adjacent pasture of mixed grasses with an abundance of forbs and provided a 23% C.P. supplement gained 14.1 lb/head (Table 1).

Forage quality and resultant lamb performance were much lower for all treatments in the 1988 experiment (Table 1). Lambs grazing bluestem pastures lost 11 lb/head, whereas those grazing the mixture of fourwing saltbush and sideoats grama lost only 2.1 lb/head. Lambs rotated among bluestem and saltbush pastures lost 4.4 lb/head during the 62-day trial in 1988. Lambs grazing the small plot of fourwing saltbush were removed after 37 days because they had consumed 95% of the available browse. These lambs lost 2 lb/head in the 37-day period. Lambs grazing the mixed-grass pasture at Carlsbad lost only 0.1 lb/head and those on the mixed-grass pasture and provided 23% C.P. supplement gained 4.4 lb/head. Neither forbs nor green grass were available in any of the treatment pastures in the 1988 trial. The large difference in performance of lambs grazing dormant bluestem grass at San Angelo and dormant mixed-grasses at Carlsbad was attributed to later growth of the grasses at Carlsbad. The Carlsbad grass pastures were planted in April 1987 and shredded twice in the 1987 growing season to control weeds, hence the forage available for grazing in winter 1988 was largely produced in early autumn 1987. Bluestem pastures at the San Angelo Center were planted in April 1986, fertilized with 75 pounds of nitrogen/acre in June 1987, but not grazed or shredded in the 1987 growing season. The forage available for lambs in these pastures during the 1988 trial was primarily produced in early summer 1987.

These data suggest that fourwing saltbush planted in pure stands, in mixtures with perennial grasses, or used in a rotation system with grass pastures can be very valuable for supplemental grazing for sheep during winter. The value of fourwing saltbush forage to livestock will apparently vary from year to year in western Texas, even though native ecotypes of the shrub retain green foliage every winter. Intake of fourwing saltbush forage by sheep during winter varies with availability and relative palatability of associated forages.

Literature Cited

1. Gonzales, M.H. 1972. Manipulating shrub-grass plant communities in arid zones for increased animal production. P. 429-434 In C.M. McKell, J.P. Blaisdell and J.R. Goodin (eds.). Wildland shrubs - their biology and utilization. U.S. Dept. Agric. Forest Service Gen. Tech. Rep. INT-1. Intermountain For. & Range Exp. Sta., Ogden, Utah.
2. Petersen, J.L., D.N. Ueckert, R.L. Potter, and J.E. Huston. 1987. Ecotypic variation in selected fourwing saltbush populations in western Texas. J. Range Manage. 40:361-366.
3. Shoop, M.C., R.C. Clark, W.A. Laycock, and R.M. Hanson. 1985. Cattle diets on shortgrass ranges with different amounts of fourwing saltbush. J. Range Manage. 38:443-449.
4. Soltero, G.S., and L.C. Fierro G. 1980. Contenido y fluctuacion de nutrientes del chamizo *(Atriplex canescens)* durante el periodo de sequia, en un matorral microfilo de *Atriplex-Prosopis*. Pastizales 11:2-7.
5. Soltero, G.S., and L.C. Fierro. 1981. Importancia del chamizo *(Atriplex canescens)* en la dieta de bovinos en pastoreo en un matorral desertico de *Atriplex-Prosopis* durante la epoca de sequia. Pastizales 12:2-7.
6. U.S. Forest Service. 1937. Range plant handbook. U.S. Dept. Agric., Washington, D.C.

PR-4580

Littleleaf Leadtree: A Potential Forage Crop for Sheep and Goats

D.N. Ueckert, J.L. Petersen, M.W. Wagner, C.W. Livingston, and M.J. Allison

Summary

Rambouillet ewe lambs and Angora kids were used in grazing trials to evaluate the potential value of littleleaf leadtree *(Leucaena retusa),* a native, deciduous, woody legume, as supplemental grazing for sheep and goats during summer and autumn. Mimosine, a toxic amino acid, was present at low concentrations in the foliage, but it occurred at lower concentrations than that reported for the tropical forage legume *Leucaena leucocephala.* Lambs and kid goats gained weight in most grazing trials and there was no evidence of mimosine toxicity.

Introduction

Littleleaf leadtree *(Leucaena retusa)* is a deciduous legume closely related to koa haole *(Leucaena leucocephala),* a forage plant widely used in the tropics. The species is endemic to dry, well-drained, rocky soils in central and western Texas and in Coahuila, Mexico (2,6). The plants, which can grow to a height of 15 feet, are readily browsed by livestock and wildlife (4,6,7) and can be maintained in the shrub growth form by frequent heavy browsing or periodic pruning. It is much more drought tolerant than our warm-season grasses and forbs. Some of the leaves are shed during extended hot, dry periods, but new flushes of foliage are produced following significant rainfall events throughout the growing season. The species loses its leaves after frost in the autumn, but its high palatability and laboratory-determined nutritional value suggest it could be valuable for range sheep and goats during spring, summer, and autumn. The forage of littleleaf leadtree is similar in quality to good-quality alfalfa hay (8). Crude protein contents of the forage averaged 21% (range 15% to 33%) and *in vitro* digestible organic matter averaged about 67% (range 64% to 72%) during May through November. The forage of koa haole contains up to 12% mimosine, a toxic amino acid that has caused livestock toxicity problems in penned animals fed diets containing a high proportion of koa haole. The objective of this research was to determine if littleleaf leadtree could be safely grazed by sheep and goats and to gain some insight relative to its potential value as a source of supplemental grazing during summer and autumn.

Experimental Procedure

A few rows of littleleaf leadtree were planted in the observation nursery at the Texas A&M University Agricultural Research and Extension Center at San Angelo in 1979-80 from seed grown at the Soil Conservation Service Plant Materials Center at Knox City, Texas. The original source of seed was a native stand near Junction, Texas. A .25-acre plot was established at the Center in 1985 from seed grown at San Angelo.

Samples of immature and mature leaves from the San Angelo Center plants were collected in early April 1984 and subsamples were oven dried at 37°C, air dried at room temperature, or freeze dried. This material, and a sample of seeds from the autumn 1983 harvest were sent to the National Animal Disease Center (U.S. Dept. Agric., Agric. Res. Service) in Ames, Iowa, for mimosine analysis. Mimosine contents were determined by high-performance liquid chromatography by a method similar to that of Acamovic, et al. (1).

Angora Goat Grazing Trials. Three Angora billy kids were grazed on littleleaf leadtree plants during September 12 through October 11, 1984. The kids were fasted 15 hours prior to taking initial and final weights. Observations were made twice each week for clinical signs of mimosine toxicity. Blood samples were taken on October 12 and analyzed by the Texas Veterinary Medical Diagnostic Laboratory System at College Station. The kids were killed by electrocution and a post-mortem examination was conducted October 12. Samples of organ and thyroid tissues were collected for histopathological examination.

Twenty-five Angora nanny kids were utilized in a grazing trial during October 14 through November 1, 1987. Two groups of six kids were grazed on different littleleaf leadtree plots and one group of six kids and one group of seven kids were grazed on different WW-Spar bluestem pastures. The kids were fasted 15 hours prior to taking initial and final weights. The kids were observed twice weekly for signs of clinical toxicity. Blood samples were taken on October 14 and on November 1 for laboratory analyses.

Sheep Grazing Trials. A group of four Rambouillet ewe lambs randomly selected from the Station's flock was grazed on live littleleaf leadtree foliage during October 23-November 12, 1986. A frost occurred on November 12, killing the foliage. The frost-killed forage was hand harvested, air dried, then fed *ad libitum* to the lambs during November 13-25, 1986. The lambs were examined for signs of clinical toxicity twice weekly. The lambs were fasted for 15 hours prior to taking initial and final weights. Blood samples were taken on November 26, 1986, from the four lambs and from four randomly selected from the same flock that was on bluestem pasture.

A group of 4 Rambouillet ewe lambs were grazed on littleleaf leadtree during June 30-July 29, 1987. Initial and final weights were taken subsequent to 15-hour fasting periods.

Results and Discussion

Immature littleleaf leadtree foliage collected in April contained about 2.15% (dry weight basis) mimosine (Table 1). Mature foliage contained about .6% mimosine and dry seeds contained 2.5% mimosine. Concentrations of mimosine in the tropical koa haole are as high as 12% in the growing tips, and average 3% to 5% in young leaves and 4% to 5% in dry

Table 1. Mimosine Contents of Littleleaf Leadtree Leaves and Seed.

Date harvested	Material	Mimosine content
		(%, dry weight basis)
April 8, 1984	Mature leaves (oven dried 37°C)	.51
	Mature leaves (air dried)	.72
	Mature leaves (freeze dried)	.61
	Young leaves (oven dried 37°C)	2.36
	Young leaves (air dried)	2.39
	Young leaves (freeze dried)	1.70
Autumn 1983	Seeds	2.52

seeds (3). Our data suggest that the potential for toxicity problems would be lower for littleleaf leadtree compared to that for koa haole. Livestock toxicity problems normally do not occur where animals graze koa haole in association with other forages (3). Rumen microbes present in many parts of the world break mimosine down into non-toxic compounds. Diets containing moderate amounts of koa haole (30% or less) are safe even where the microbes are absent (5).

The Angora billy kids grazed littleleaf leadtree very readily in the initial trial September 12 - October 11, 1984. Forage availability became limiting by October 1 and taller branches were bent or partially broken daily to provide forage for the goats. The goats began eating bark from the basal stems on October 7, suggesting that inadequate quantities of the leaves and twigs were available to satisfy appetites. No clinical signs of toxicity were observed. The three billy kids lost an average of .5 lb (range −1.5 to .5 lb) during the 30-day trial. No signs of toxicity were evident from the post-mortem or histopathological examinations. Concentrations of most serum constituents in blood samples (Table 2) appeared within the ranges we have observed in healthy Angora kids (Table 3).

The Angora nanny kids grazing littleleaf leadtree during October 14 – November 1, 1987, gained 2.8 lb/head compared to a gain of 1.8 lb/head for those grazing bluestem pastures. No clinical signs of toxicity were observed. Blood analyses did not suggest health problems associated with the 2-week diet of littleleaf leadtree (Table 3).

Rambouillet ewe lambs grazed littleleaf leadtree vary readily and gained 7.8 lb/head during the October 23 - November 26, 1986 grazing trial. No clinical signs of toxicity were observed and blood analyses of ewe lambs grazing littleleaf leadtree were similar to those of ewe lambs from the same flock grazing bluestem pasture (Table 4).

Rambouillet ewe lambs grazing littleleaf leadtree during June 30 - July 29, 1987 gained 3.4 lb/head and no clinical signs of toxicity were observed.

Data from these short-term grazing trials suggest that littleleaf leadtree has excellent nutritional qualities for sheep and Angora goats. There is no indication that mimosine toxicity will be a problem when sheep or goats are grazed on monocultures of the shrubs or mixed plantings of grasses and littleleaf leadtree for periods of at least a month. We have found littleleaf leadtree quite difficult to establish because of the slow early growth rate of seedlings. The results presented in this report appear to suggest that additional research on planting, establishing, and managing littleleaf leadtree could benefit western Texas sheep and goat producers.

Table 2. Concentrations of Serum Constituents in Blood of Angora Billy Kids after Grazing on Littleleaf Leadtree September 12-October 11, 1984.

Criterion	Kid No. 216	219	225	Avg
Triiodothyronine (T_3) (ng/ml)	—	.5	.5	.5
Thyroxine (T_4) (μg/dl)	4.2	5.3	5.5	5.0
Total protein (g/dl)	6.5	6.2	6.7	6.5
Albumen (g/dl)	3.7	4.2	4.9	4.3
Albumen:globulin ratio	1.3	2.1	2.7	2.0
Calcium (mg/dl)	11.8	13.2	14.3	13.1
Inorganic phosphorus (mg/dl)	5.1	7.5	4.9	5.8
Glucose (mg/dl)	85	95	95	92
Blood urea nitrogen (mg/dl)	15	17	15	16
Creatinine (mg/dl)	1.0	0.9	1.3	1.1
Total bilirubin (mg/dl)	0.3	0.3	0.4	0.3
Alkaline phosphatase (IU/1)	220	195	205	207
Creatine phosphokinase (IU/1)	240	200	180	207
Lactic dehydrogenase (IU/1)	300	320	320	313
Alanine aminotransferase (IU/1)	15	15	20	17
Aspartate aminotransferase (IU/1)	155	145	155	152

Table 3. Concentrations of Serum Constituents in Blood of Angora Nanny Kids before and after Grazing Littleleaf Leadtree and WW-Spar Bluestem During October 14-November 1, 1987.

Criterion	Diet: Littleleaf leadtree Before	After	WW-Spar bluestem Before	After
Triiodothyronine (T_3) (ng/ml)	2.2	0.7	2.1	1.1
Thyroxine (T_4) (μg/dl)	7.9	3.9	8.4	6.4
Total protein (g/dl)	6.2	7.3	6.2	6.8
Albumen (g/dl)	3.1	3.3	3.3	2.9
Calcium (mg/dl)	8.6	9.9	8.8	9.2
Inorganic phosphorus (mg/dl)	7.4	7.3	7.7	7.8
Glucose (mg/dl)	58	39	62	55
Blood urea nitrogen (mg/dl)	13	29	14	20
Creatinine (mg/dl)	.9	1.3	.9	.9
Total biliruben (mg/dl)	.2	.2	.3	.3
Alkaline phosphatase (IU/1)	182	141	203	68
Creatine phosphokinase (IU/1)	240	92	281	75
Lactice dehydrogenase (IU/1)	406	99	394	102
Alanine aminotransferase (IU/1)	16	28	13	27
Aspartate aminotransferase (IU/1)	91	57	97	53
Albumen:globulin ratio	1.0	0.8	1.1	0.8

Table 4. Concentrations of Serum Constituents in Blood of Rambouillet Ewe Lambs after Grazing Littleleaf Leadtree or WW-Spar Bluestem during October 23, 1986-November 25, 1986.

Criterion	Sheep Diets: Littleleaf leadtree	WW-Spar bluestem
Total protein (g/dl)	6.6	6.9
Albumen (g/dl)	3.4	3.5
Calcium (mg/dl)	10.6	10.6
Inorganic phosphorus (mg/dl)	6.2	6.1
Glucose (mg/dl)	65	69
Blood urea nitrogen (mg/dl)	25	25
Creatinine (mg/dl)	1.0	1.1
Total biliruben (mg/dl)	.4	.4
Alkaline phosphatase (IU/1)	182	111
Creatine phosphokinase (IU/1)	66	65
Lactice dehydrogenase (IU/1)	205	224
Alanine aminotransferase (IU/1)	15	18
Aspartate aminotransferase (IU/1)	68	77
Albumen:globulin ratio	1.1	1.1

Literature Cited

1. Acamovic, J.P., F. D'Mello, and K.W. Fraser. 1982. Determination of mimosine and 3-hydroxy-4(1H)-pyridone in Leucaena, avian excreta and serum using reversed-phase ion-pair high-performance liquid chromatography. J. Chromatography 236:169-179.

2. Correll, D.S., and M.C. Johnston. 1970. Manual of the vascular plants of Texas. Tex. Res. Found., Renner. 1881 p.

3. Jones, R.J. 1979. The value of Leucaena leucocephala as a feed for ruminants in the tropics. World Animal Rev. 31:13-23.

4. Lamb, S.H. Woody plants of the Southwest. Sunstone Press, Santa Fe, N.M. 177 p.

5. National Research Council. 1984. Leucaena: promising forage and tree crop for the tropics. Second Edition. National Academy Press, Washington, D.C. Univ. Texas Press, Austin. 1104 p.

7. Warnock, B.H. 1977. Wildflowers of the Davis Mountains and Marathon Basin, Texas. Sul Ross State Univ., Alpine, TX. 274 p.

8. Whisenant, S.G., D.N. Ueckert, and J.E. Huston. 1985. Evaluation of selected shrubs for arid and semiarid game ranges. J. Wildl. Manage. 49:524-527.

PR-4581

Effect of Ionophores on Copper Accumulation and Potential Toxicity in Sheep

M.C. Calhoun, S.R. Sappington, and G.R. Engdahl

Summary

This study demonstrates that ionophores (monensin, lasalocid, and lysocellin) can increase the accumulation of copper in the liver of sheep. The greatest effect was with monensin. This effect of monensin could reduce requirements for supplemental copper in diets marginally deficient and accentuate problems with chronic copper toxicity. Since sheep are very susceptible to copper toxicity and a narrow range exists between dietary requirements and toxic levels, careful attention to copper levels should be exercised when sheep are fed diets containing ionophores.

Introduction

The carboxylic polyether ionophores monensin and lasalocid are used widely in ruminant diets. They improve efficiency of production by altering rumen fermentation and controlling coccidial infections (3, 8, 11). Their primary mode of action is to alter the movement of ions across cell membranes (2). This may have practical importance in the mineral nutrition of ruminant livestock (1, 4).

Anderson, et al. (1) reported monensin increased blood glutathione peroxidase activity and selenium retention in sheep fed a diet marginally deficient in selenium and Elsasser (4) found monensin increased accumulation of copper in livers of sheep. In other research, monensin increased apparent absorption and retention of magnesium, indicating monensin may be of value in reducing the potassium-related depression of magnesium absorption in ruminants (5, 6). Retention of phosphorus and zinc also increased when monensin was added to diets of sheep (6).

Copper is the most critical trace element in sheep diets because of the very narrow range between adequate and toxic levels. For example, sheep require 5 to 8 ppm of copper in their diets and levels above 8 ppm can be toxic depending upon copper availability in the diet and molybdenum and sulfur levels (7, 13).

Experimental Procedure

Fifty-six female and castrated male crossbred sheep were used in this study. They were assigned randomly to pens and fed a basal diet for a 37-day uniformity period. Following the uniformity period, eight sheep were slaughtered and blood and tissues collected to ascertain their initial body stores of copper. The remaining 48 sheep were assigned at random to 24 pens with two sheep per pen and each pen was randomized to one of eight dietary treatments for a 70-day comparison period.

The treatments consisted of a basal diet and the basal diet with 10 ppm of additional copper (Table 1). Each diet contained either no ionophore or 25 g/ton of monensin[1], lasalocid[2] or lysocellin[3]. The overall experiment was a 2 x 4 factorial arrangement of treatments in a completely random design with three replications. Daily feed intake was restricted to 2.2 lb/sheep.

Table 1. Percentage Composition of Basal Diet.

Ingredient	%
Sorghum grain, milo	58.0
Alfalfa meal, dehydrated	10.0
Peanut hulls, ground	20.0
Cottonseed meal	5.0
Sugarcane molasses	5.0
Calcium carbonate	1.0
Ammonium chloride	.5
Salt, plain	.5
Vitamins A, D and E[a]	+

[a]To add per lb of diet: 996 IU of vitamin A, 126 IU of vitamin D_2 and 6.8 IU of vitamin E.

Blood copper concentrations were measured at 0 and 70 days and liver and kidney copper levels were measured at the end of the 70-day comparison period to assess the effects of ionophores on copper accumulation. In addition, serum levels of aspartate aminotransferase were measured at 0 and 70 days. Increases in the level of this enzyme occur several weeks prior to the onset of chronic copper toxicity (14).

The analysis of variance for a factorial arrangement of treatments was used for the statistical analysis of the data. Diets, ionophores, and the diet x ionophore interaction were tested for significance. Comparisons among ionophores were tested by partitioning the sums of squares for ionophores into a set of orthogonal contrasts as follows: control vs. all ionophores, monensin vs. lasalocid, and lysocellin and lasalocid vs. lysocellin (12).

Results and Discussion

The nutrient composition of the basal diet is given in Table 2. With the exception of zinc, the levels of all nutrients ex-

[1]Monensin sodium, Rumensin®, Eli Lilly and Company, Indianapolis, Indiana.

[2]Lasalocid sodium, Bovatec®, Roche Chemical Division, Hoffmann-LaRoche, Inc., Nutley, New Jersey.

[3]Lysocellin sodium, International Minerals and Chemical Corporation, Terre Haute, Indiana.

Table 2. Nutrient Composition of Basal Diet[a].

Item	Mean
Dry matter, %	88.1
Crude protein, %	10.3
Acid detergent fiber, %	21.3
Calcium, %	.92
Phosphorus, %	.20
Magnesium, %	.18
Potassium, %	.75
Sulfur, %	.30
Copper, ppm	4.4
Iron, ppm	245.0
Manganese, ppm	25.3
Selenium, ppm	.10
Zinc, ppm	17.4

[a]All values except dry matter are on a dry matter basis.

ceeded the recommended maintenance requirements of sheep (7). The level of zinc (17.4 ppm, on a dry matter basis), although slightly less than the minimum requirement (20 ppm) suggested by the National Research Council, should be adequate for body growth and maintenance of normal appetite (7).

A summary of live weights, organ weights, and blood and tissue constituents of the sheep slaughtered initially are given in Table 3. The values for blood, liver and kidney copper concentrations and serum aspartate aminotransferase activity were within the normal range for all sheep. The normal concentration of copper in whole blood is maintained at 70 to 130 μg/dl over a wide range of dietary intakes and is not a good indication of the copper status of sheep (9). In normal sheep, the concentration of copper in the liver is generally less than 5 mg/100 g (wet weight). Since dietary copper in excess of requirements is stored in the liver, the concentration of copper in the liver gives a reliable indication of the copper status of sheep (14). The normal value for the copper content of kidney is about .48 mg/100 g (wet weight) and only increases during copper toxicosis (9, 14). Serum aspartate aminotransferase activity in normal sheep is generally less than 100 Sigma-Frankel units/ml.

There were no significant diet x ionophore interactions for any of the criteria measured in this study. This means that the

Table 3. Live Weights, Organ Weights, and Blood and Tissue Constituents of the Eight Sheep Slaughtered Initially.

Item	Mean	SE[a]
Live weight, lb	125.4	5.3
Liver weight, lb	1.16	.03
Kidney weight, lb	.22	.004
Whole blood copper, μg/dl	117.0	5.9
Liver copper, mg/100g[b]	1.6	.15
Kidney copper, mg/100 g[b]	.51	.03
Serum AST, SF units/ml[c]	77.0	6.4

[a]Standard error of the mean.
[b]Wet tissue weight.
[c]Aspartate aminotransferase (Sigma-Frankel units/ml of serum).

Table 4. Live Weights, Gains, Organ Weights, Blood and Tissue, Copper and Serum Aspartate Aminotransferase (AST) of Lambs Fed Diets with or without Added Copper for a 70-Day Period.

	Diet[a]		
Item	Basal	Basal + Cu	SD[b]
Initial live weight, lb	123.4	127.9	8.4
Live weight gain, lb	13.2	11.7	2.0
Liver weight, lb	1.33	1.36	.10
Kidney weight, lb	.22	.22	.020
Whole blood copper, μg/dl			
0 d	108.7	107.2	10.8
70 d	109.7[c]	120.6[c]	11.6
Liver copper, mg/100 g wet wt.	11.0[c]	17.3[d]	3.4
Kidney copper, mg/100 g wet wt.	.43	.48	.08
Serum AST, SF units/ml			
0 d	70.5	70.5	6.2
70 d	66.7	69.8	11.0

[a]Basal diet contained 4.4 ppm Cu. Basal diet + Cu contained 14.4 ppm Cu.
[b]Standard deviation.
[c,d]Means in the same row without a common superscript are significantly different at P< .05.

Table 5. Live Weights, Gains, Organ Weights, Blood and Tissue, Copper and Serum Aspartate Aminotransferase (AST) of Lambs Fed Diets Containing Monensin, Lasalocid, or Lysocellin for a 70-Day Period.

	Inophore[a]				
Item	Control	Monensin	Lasalocid	Lysocellin	SD[b]
Initial live weight, lb	126.3	131.2	124.1	121.2	8.4
Live weight gain, lb	11.5	12.8	12.1	13.7	2.0
Liver weight, lb	1.32	1.40	1.33	1.33	.10
Kidney weight, lb	.22	.22	.21	.22	02
Whole blood copper, μg/dl					
0 d	109.4	112.0	110.3	100.2	10.8
70 d	123.3	124.2	107.9	105.2	11.6
Liver copper, mg/100 g wet wt.	11.9	17.8	14.1	12.8	3.4
Kidney copper, mg/100 g wet wt.	.43	.54	.44	.45	.08
Serum AST, SF units/ml					
0 d	69.3	73.1	72.5	67.3	6.2
70 d	62.9	80.0	66.6	63.6	11.0

[a]25 g/ton of ionophore was added to each diet
[b]Standard deviation.

effects of ionophores were similar regardless of the copper concentration in the diet. Therefore, the data presented shows only the main effects of diets and ionophores.

There were no significant treatment effects on live weight gains, feed intakes and liver and kidney weights (Tables 4 and 5). Since feed intake was restricted to 2.2 lb/sheep per day and all of the sheep ate the feed offered and none of the sheep were sick during this experiment, no differences were anticipated in any of these criteria.

The main effects of diets on blood and tissue concentrations of copper and serum aspartate aminotransferase enzyme activities are shown in Table 4. The addition of 10 ppm of copper to the basal diet increased blood copper concentrations at 70 days ($P<.05$). Liver copper concentrations of sheep fed the basal diet were markedly higher than liver copper levels of the initial slaughter group (11.0 vs 1.6 mg/100 g wet wt.) indicating copper was being stored in the liver when sheep were fed a diet containing only 4.4 ppm of copper. Sheep fed the basal diet with additional copper had higher copper levels in the liver than those fed the basal diet ($P<.05$). The added copper increased liver copper stores by 57.3% compared with the basal diet during the 70-day feeding period. The addition of 10 ppm of copper to the basal diet was without effect on either copper concentration in the kidney or aspartate aminotransferase activity in serum.

The main effects of ionophores on blood and tissue copper concentrations and serum aspartate aminotransferase activities are given in Table 5. There were no significant differences in initial whole blood copper concentrations among sheep assigned to the different groups. Averaged across all treatment groups the initial (0 day) copper levels in the blood were 108.0 ± 6.2 μg/dl. Upon completion of the 70- day feeding period, there was a significant ionophore effect on whole blood copper concentrations ($P<.10$). Sheep fed monensin had higher blood copper levels than sheep fed lasalocid or lysocellin ($P<.01$). However, there was not a significant difference between lasalocid and lysocellin. The reason whole blood copper levels were as high in the control group as in the group fed monensin is unknown; however, all of the blood copper values were within the normal range (9).

Compared with the control sheep, all ionophores increased liver copper levels ($P<.10$); however, the response with monensin was greater than for lasalocid and lysocellin ($P<.01$; Tables 5 and 6). There was not a significant difference between lasalocid and lysocellin. Although not shown in Table 5, the treatment group with the highest liver copper values at 70 days was the group fed monensin and the basal diet with 10 ppm added copper. Their liver copper concentration was 22.7 ± 2.0 mg/100 g wet wt. Pope (9) reported a range of 6.4 to 70.5 mg copper/100 g liver (wet wt.) during copper toxicosis. All the treament groups had liver copper concentrations in excess of 6.4 mg/100 g at the end of the 70-day comparison period. However, there were no signs of copper poisoning. Kidney copper values did not increase during the study and were not affected by ionophore treatments. Although sheep receiving monensin had the highest serum aspartate aminotransferase levels, the values for all treatment groups were still within the normal range.

During copper accumulation in the liver, blood, and kidney, copper levels remain normal. It is only when high liver stores are rapidly released as a result of some stress factor that blood and kidney levels increase several-fold producing signs of copper poisoning (9, 14).

Table 6. Statistical Summary of the Comparisons Among Ionophore Treatments.

Item	Control vs all Ionophores	Monensin vs Lasalocid and Lysocellin	Lasalocid vs Lysocellin
Whole blood copper, g/dl			
0 d	NS[a]	NS	NS
70 d	P< .10	P< .01	NS
Liver copper, mg/100 d wet wt.	P< .10	P< .05	NS
Kidney copper, mg/100 g wet wt.	NS	NS	NS
Serum AST, SF units/ml			
0 d	NS	NS	NS
70 d	NS	P< .05	NS

[a]No significant difference for treatment means included in this comparison.

This study demonstrates that ionophores can increase the accumulation of copper in the liver of sheep. The greatest effect was with monensin. This effect of monensin could reduce requirements for supplemental copper in diets marginally deficient and accentuate problems with chronic copper toxicity. Since sheep are very susceptible to copper toxicity and a narrow range exists between dietary requirements and toxic levels, careful attention to copper levels should be exercised when sheep are fed diets containing ionophores. In particular, one should be extremely cautious when using feeds or minerals formulated for cattle with sheep. Many of these contain monensin, as well as excessive levels of copper, and have been shown to be an important cause of copper poisoning in sheep (10).

Literature Cited

1. Anderson, P.H., S. Berrett, J. Catchpole, M.W. Gregory, and D.C. Brown. 1983. Effect of monensin on the selenium status of sheep. Vet. Rec. 113:498.
2. Bergen, W.G., and D.B. Bates. 1984. Ionophores: their effect on production efficiency and mode of action. J. Anim. Sci. 58:1465.
3. Bergstrom, E.C., and L.R. Maki. 1976. Coccidiostatic action of monensin fed to lambs: Body weight gains and feed conversion efficiency. Am. J. Vet. Res. 37:79.
4. Elsasser, T.H. 1984. Potential interactions of ionophore drugs with divalent cations and their function in the animal body. J. Anim. Sci. 59:845.
5. Greene, L.W., G.T. Schelling, and F.M. Byers. 1986. Effects of dietary monensin and potassium on apparent absorption of magnesium and other macroelements in sheep. J. Anim. Sci. 63:1960.
6. Kirk, D.J., L.W. Greene, G.T. Schelling, and F.M. Byers. 1985. Effects of monensin on Mg, Ca, P and Zn metabolism and tissue concentrations in lambs. J. Anim. Sci. 60:1485.
7. National Research Council. 1985. Nutrient Requirements of Sheep. National Academy Press, Washington, D.C.

8. Owens, F.N. 1980. Ionophore effect on utilization and metabolism of nutrients-ruminants. Proc. Georgia Nutrition Conference.
9. Pope, A.L. 1971. A review of recent mineral research with sheep. J. Anim. Sci. 33:1332.
10. Reagor, J.C., and A.K. Eugster. 1986. Copper poisoning in sheep. Southwest Vet. 37:107.
11. Schelling, G.T. 1984. Monensin mode of action in the rumen. J. Anim. Sci. 58:1518.
12. Steel, R.G.D., and J.H. Torrie. 1980. Principles and Procedures of Statistics, a Biometrical Approach. McGraw-Hill, New York.
13. Suttle, N.F. 1986. Copper deficiency in ruminants; recent developments. Vet. Rec. 119:519.
14. Todd, J.R. 1969. Chronic copper toxicity of ruminants. Proc. Nutr. Soc. 28:189.

Acknowledgment

Appreciation is expressed to Dr. Brian Schricker and Dr. Glen Wolfrom, International Minerals and Chemical Corporation, for providing the lysocellin and sheep used in this study.

PR-4582

Effect of the Polyether Antibiotic Lysocellin on Performance of Growing-Finishing Lambs

M.C. Calhoun, B.C. Baldwin, Jr., and G.W. Wolfrom

Summary

One hundred eighty white-faced wether lambs were used in a 56-day growing-finishing experiment to evaluate two salts of the polyether antibiotic lysocellin, and monensin-sodium (Na). The dietary treatments were: control; monensin-Na, 15 g/t; lysocellin-Na, 15 g/t; lysocellin-Na, 30 g/t; lysocellin-manganese (Mn), 15 g/t and lysocellin-Mn, 30 g/t. Overall, feed intake was not decreased by monensin or lysocellin-Na. Feed intake was reduced during the first 14-day period when lysocellin-Na was fed at 30 g/t and when lysocellin-Mn was fed at either 15 or 30 g/t. Lysocellin-Mn at 30 g/t reduced feed intake throughout the 56-day study. Cumulative live weight gains were significantly greater than the control for both levels of lysocellin-Na, and for the 15 g/t level of lysocellin-Mn. Monensin-Na and the 30 g/t level of lysocellin-Mn did not significantly increase gains. During the first 14-day period, there were no significant effects of polyether antibiotics on feed efficiency (feed:gain ratio). Subsequently, with the exception of lysocellin-Mn for the period from 1 to 28 days, cumulative feed:gain ratios were significantly less than the control for all polyether treatments. Both forms of lysocellin increased the molar percentages of propionic acid and decreased butyric acid at 21 and 49 days. Monensin-Na produced similar changes, but the magnitude tended to be less. There were no treatment effects on total rumen volatile fatty acid concentrations. All polyether antibiotic treatments decreased fecal coccidial oocyst numbers. However, there were no signs of clinical coccidiosis in any of the groups during the experiment.

Introduction

Polyether antibiotics have been successfully used for many years to control coccidiosis in poultry. More recently, they have been shown to be effective for control of coccidiosis in cattle, sheep and goats. An additional advantage has been the improvement in fermentation efficiency when this class of compounds is fed to ruminants. Generally, this is related to a decrease in the relative proportions of acetic and butyric acids and an increase in propionic acid. Concurrently, methane production is inhibited. Since less energy is lost as methane and because propionate may be used more efficiently than acetate as a source of energy, animals fed polyether antibiotics grow more efficiently (5, 6).

The purpose of this research was to determine the effects of a new polyether antibiotic (lysocellin) on performance, rumen volatile fatty acids, and fecal coccidial oocyst numbers of growing-finishing lambs.

Experimental Procedure

Two hundred unshorn Rambouillet wether (wethers) lambs were obtained from a ranch near Big Lake, Texas. Initial weight, including wool, averaged 74 lb. Lambs were shorn and transported to Texas A&M University's Agricultural Research Center at San Angelo. On arrival, they were placed in experiment pens[1] and given alfalfa hay and water. The following day all lambs were weighed, ear-tagged, drenched[2], and vaccinated[3].

The lambs were adapted to a growing-finishing diet by gradually increasing the amount of diet and decreasing the amount of alfalfa hay fed. At the end of 7 days the growing-finishing diet was being fed *ad libitum* and alfalfa hay was no longer fed. The ingredient composition of the growing-finishing diet is given in Table 1.

All lambs were weighed (unshrunk) on 2 consecutive days at the end of a 14-day preliminary feeding period; then, 180 were ramdonly assigned to pens (5 lambs per pen, 36 pens). Six pens of lambs were assigned at random to each of six treatments and started on their experimental diet. Treatments were: control; monensin-Na, 15 g/t; lysocellin-Na, 15 g/t; lysocellin-Na, 30 g/t; lysocellin-Mn, 15 g/t and lysocellin-Mn, 30 g/t.

Experimental diets were fed for 56 days. Lambs were weighed (unshrunk) bi-weekly during the 56-day experiment. Initial and final weights were the average of weights obtained on two consecutive days. Experimental diets and water were provided *ad libitum*. Feeds were weighed and fed daily and feed refusals were weighed and discarded at 7- day intervals.

A representative sample was collected from each batch of feed mixed. These were composited by 14-day periods and subsequently analyzed for dry matter, ash, crude protein,

[1]Pens were 7.9 x 2.8 ft with a dirt floor and 4.3 x .7 ft feed trough; one-third of pen surface (over feeder) was covered by an open shed roof.
[2]Levamisole hydrochloride, American Cyanamid Co., Tramisol® -.25 g of levamisole hydrochloride was given to each lamb in 20 ml of water, using an automatic drench gun.
[3]*Clostridium perfringens* Type D toxoid, Anchor Laboratories, Inc. Lamb-Vax, 2 ml per lamb was injected subcutaneously in the neck.
[4]Feed samples were analyzed by Agri-Services Laboratory, 2178-A Gladstone Court, Glendale Heights, IL 60137.

Table 1. Ingredient and Nutrient Composition of the Complete Growing-Finishing Diet[a].

Ingredient	% in diet
Sorghum grain, milo	52.5
Dehydrated alfalfa	9.5
Cottonseed hulls	20.0
Cottonseed meal, 41% crude protein	10.0
Sugarcane molasses	5.0
Vitamin-mineral premix[b]	3.0
(Nutrient values)[c]	
Dry matter, %	88.2 ± .12
Ash, %	4.9 ± .06
Crude protein, %	13.8 ± .26
Acid detergent fiber, %	21.6 ± .86
Calcium, %	.36 ± .01
Phosphorus, %	.17 ± .01
Magnesium, %	.20 ± .01
Potassium, %	.84 ± .02
Sulfur, %	.28 ± .01
Iron, ppm	110 ± 2.2
Copper, ppm	44.2 ± 2.4
Manganese, ppm	26.0 ± .48
Zinc, ppm	48.9 ± 8.0

[a]Diets were mixed at the research center in a 500 lb capacity horizontal mixer. The mixer was thoroughly cleaned prior to minimize the possibility of contamination from antibiotic containing feeds.
[b]The percentage ingredient composition of the vitamin-mineral premix was as follows: calcium carbonate, 33.34; salt, 33.34; dehydrated alfalfa, 19.12; ammonium chloride, 8.34; sulfur, 3.34; sugarcane mollasses, 2.0; zinc oxide, .139; manganese sulfate, .122; cobalt carbonate, .0007; ethylenediamine dihydroiodide, .00041; vitamin A acetate (13,607,700 IU/lb), .244 and vitamin D_3 (13,607,700 IU/lb), .0172.
[c]Nutrient values are reported on a dry matter basis.

acid detergent fiber, calcium, phosphorus, magnesium, potassium, sulfur, iron, copper, manganese and zinc.[4]

Fecal samples were collected from three lambs per pen initially and then again from the same lambs on days 24 and 52 of the experimental period. These were used for determination of coccidial oocyst numbers using a saline flotation technique and the McMasters Counting Chamber (2).

Rumen fluid was collected from three lambs in each pen on days 21 and 49 of the experimental period. Lambs sampled were selected at random and the same lambs were sampled on each date. Concentrations (μM/ml) and molar percentages (moles/100 moles) of rumen volatile fatty acids (VFA) were determined by gas-liquid chromatography (8).

Procedures outlined by Steel and Torrie (7) for a completely random design were followed in the statistical analyses of the data. Dunnett's procedure (one-sided) was used to compare means of all treatments with the negative control. The complete analysis involved testing cumulative treatment effects at 14-day intervals over the 56-day study.

Results and Discussion

In general the health of the lambs appeared excellent during this study; however, minor problems were encountered. Two lambs were observed limping. One had a swollen left front hoof and the other a swollen left rear hoof. These lambs were started on an antibiotic treatment.[5] Material was collected from the site of the infection, cultured and a *pseudomonas* bacteria was isolated. Antibiotic sensitivity tests revealed growth inhibition by tetracycline antibiotics but not by either penicillin or streptomycin; therefore, the treatment was changed to an injectable oxytetracycline solution.[6] Another lamb observed imping on day 27 was also given oxytetracycline. All lambs recovered in 7 to 14 days.

One of the lambs with *Pseudomonas* infection was on the control ration; the other two were receiving lysocellin-Mn at 30 g/t. Although there were reductions in live weight gains during the period of infection, overall weight gains for the experiment were consistent with those for other lambs in the same pens. The hoof infections were believed to be unrelated to treatments and have been ignored in the summary of the data.

Three lambs developed urinary calculi during the week following completion of the study. These lambs had all received lysocellin-Mn; two at 15 g/t and one at 30 g/t. Two of these lambs lost weight after the 42-day weighing and one gained very little. Urinary calculi is a common problem with lambs fed high grain rations containing cottonseed meal. Adjustment of the calcium to phosphorus ratio to 2:1 to 2.5:1 and addition of either ammonium chloride or ammonium sulfate to the diet generally prevents calculus formation. However, selective eating of ration ingredients by individual sheep could result in a small number of calculi cases as occurred in this instance. It was probably coincidental these lambs were receiving the lysocellin-Mn treatments.

Because of poor performance, during the last 14-day period, of lambs subsequently exhibiting urinary calculi, the following procedures were used to adjust the data. Linear regression was used to estimate the 56-day live weights of the three lambs. These estimated weights were then used along with actual weights for the other periods to calculate live weight gains for the experiment. Feed consumption was adjusted for each lamb using a formula that considers weight of lamb, weight gain or loss, days in the period, energy level of the diet and the National Research Council's (4) recommended energy requirements for maintenance and gain of growing-finishing lambs.

Initially, 92.6% of the lambs sampled were shedding coccidial oocysts. The numbers ranged from 0 to 44,600 oocysts per gram of feces. Oocyst numbers were less initially for all treatment groups than for the control group. However, because of the variation in oocyst counts among lambs within treatment groups, the initial differences between groups were not significant. All polyether antibiotic treatments significantly reduced oocyst numbers at 21 and 49 days compared with the control. Monensin (15 g/t) appeared more efficacious than either form of lysocellin regardless of level (Table 2).

The effects of monensin and lysocellin on the feedlot performance of growing-finishing lambs are shown in Table 3. Feed intake was not decreased by monensin. However, feed intake was reduced during the first 14-d period when lysocellin-Na was fed at 30 g/t ($P<.05$) and when lysocellin-Mn was

[5]Combiotic® — 2 ml by intramuscular injection per day — each 2 ml contained 400,000 units procaine penicillin G and dihydrostrept — omycin sulfate equivalent to 0.5 g dihydrostreptomycin base. Pfizer Agr. Div., New York, N.Y. 10017
[6]Terramycin® Injectable Solution — 6 ml by intramuscular injection was administered, followed 3 days later by an additional 6 ml. Each ml contained 50 mg of oxytetracycline hydrochloride. Pfizer Agr. Div., New York, N.Y. 10017.

Table 2. Effects of Polyether Antibiotics on Coccidial Oocyst Numbers in Fecal Samples.

Criterion	Control	Monensin 15 g/t	Lysocellin-Na 15 g/t	Lysocellin-Na 30 g/t	Lysocellin-Mn 15 g/t	Lysocellin-Mn 30 g/t
Oocyst numbers[a]						
Initial	5.1	2.3	3.7	3.4	1.8	.7
21 days	17.8	.1**	1.3**	.4**	1.1**	.6**
49 days	6.3	.1**	.4**	.3**	.5**	.1**

**Indicates significantly different from control at P<.01 using Dunnett's t.
[a] Tabular values must be multiplied by 1,000 to obtain actual oocyst numbers per gram of feces.

Table 3. Effects of Polyether Antibiotics on Performance of Growing-Finishing Lambs.

Criterion	Control	Monensin 15 g/t	Lysocellin-Na 15 g/t	Lysocellin-Na 30 g/t	Lysocellin-Mn 15 g/t	Lysocellin-Mn 30 g/t
Lambs, No.	30	30	30	30	30	30
Initial weight	73.7	73.9	74.1	72.3	71.0	71.9
Feed intake, lb/day						
1 to 14 days	4.01	3.97	4.10	3.68*	3.72*	3.68*
1 to 28 days	3.99	3.92	4.08	3.72	3.81	3.62**
1 to 42 days	4.01	3.94	4.10	3.79	3.90	3.66*
1 to 56 days	4.08	4.01	4.14	3.86	3.99	3.72*
Liveweight gain, lb/day						
1 to 14 days	.589	.697	.745	.688	.652	.608
1 to 28 days	.467	.531	.562*	.569*	.575*	.481
1 to 42 days	.454	.509	.542**	.542**	.551**	.487
1 to 56 days	.448	.514	.540**	.538*	.564**	.483
Feed:gain ratio						
1 to 14 days	7.15	5.75	5.74	5.89	5.73	6.14
1 to 28 days	8.66	7.44*	7.35*	6.71**	6.66**	7.66
1 to 42 days	8.91	7.74**	7.56**	7.04**	7.09**	7.58**
1 to 56 days	9.20	7.84**	7.71**	7.26**	7.12**	7.77**

*Indicates significantly different from control at P<.05 using Dunnett's t.
**Indicates significantly different from control at P<.01 using Dunnett's t.

fed at either 15 or 30 g/t (P<.05). Lysocellin-Mn at 30 g/t reduced feed intake throughout the 56-day experiment.

During the first 14-day period there were no significant effects of either form of lysocellin or monensin on live weight gains. Subsequently, cumulative live weight gains were significantly greater for both levels of lysocellin-Na and the 15 g/t level of lysocellin-Mn. Live weight gains of lambs fed either monensin or 30 g/t of lysocellin-Mn were not different from the control (Table 3).

During the first 14-day period there were no significant effects of lysocellin or monensin on feed efficiency (feed:gain ratio). Subsequently, with the exception of lysocellin-Mn at 30 g/t for the period from 1 to 28 days, cumulative feed:gain ratios were significantly less for all treatments than for the control. Overall (1 to 56 days) feed requirements per lb of gain were reduced 14.8, 16.2, 21.1, 22.6, and 15.5% for monensin and the 15 and 30 g/t levels of lysocellin-Na and lysocellin-Mn, respectively.

The effects of lysocellin and monensin on concentrations (μM/ml) and molar percentages (moles/100 moles) of rumen volatile fatty acids (VFA) are summarized in Table 4. Concentrations of propionic acid tended to be higher and concentrations of butyric acid lower for all treatments compared with the control, regardless of sampling time (21 or 49 days). There was not a treatment effect for total VFA concentrations. Molar percentages of acetic acid tended to be less for all treatments when compared with the control group; however, the differences were only significant for lysocellin-Mn (both levels) for rumen fluid collected on day 49. Both salts of lysocellin increased molar percentages of propionic acid and decreased butyric acid at both collection times. Monensin produced similar changes but the magnitude tended to be less.

In a previous study in which varying levels of monensin were fed to growing-finishing lambs, monensin had significant quadratic effects on live weight gain and feed efficiency (1). Optimum improvement in live weight gain and feed efficiency occurred at monensin levels in the feed of 11.5 and 15.2 g/t, respectively. Results obtained in the present study indicates the sodium (Na) and manganese (Mn) salts of lysocellin fed at 15 g/t were as effective as monensin fed at 15 g/t in improving performance of growing-finishing lambs.

Although these data are not suitable to determine the optimum levels of lysocellin for improving performance of lambs, it appears the optimum level is lower for lysocellin-Mn than for lysocellin-Na. In the case of lysocellin-Na, feed:gain ratios decreased as the level increased from 15 to 30 g/t suggesting the optimum level for improvement in feed efficiency may be greater than 30 g/t. In fact, the feed:gain ratio was similar for lambs fed the 30 g/t level of lysocellin-Na and the 15 g/t level of lysocellin-Mn and these values were lower than for the other ionophore treatments. In contrast, feed:gain ratios were higher for the 30 g/t level of lysocellin-Mn than for the 15 g/t level of lysocellin-Mn, indi-

Table 4. Effects of Polyether Antibiotics on Rumen Volatile Fatty Acids of Growing-Finishing Lambs.

Criterion	Control	Monensin 15 g/t	Lysocellin-Na 15 g/t	Lysocellin-Na 30 g/t	Lysocellin-Mn 15 g/t	Lysocellin-Mn 30 g/t
(21st day)						
Acetic acid, μM/ml	39.8	36.3	31.3	33.1	33.5	33.5
Propionic acid, μM/ml	19.3	27.2	24.4	25.9	27.4*	26.1
Butyric acid, μM/ml	8.2	5.2*	5.4*	3.9**	4.7**	3.6**
Total VFA, μM/ml	67.5	68.9	61.1	63.0	65.7	63.2
Acetic acid, moles/100 moles	58.6	52.6*	51.4**	52.6*	50.7**	53.1*
Propionic acid, moles/100 moles	28.7	39.5**	39.6**	41.2**	42.3**	41.1**
Butyric acid, moles/100 moles	12.4	7.7*	9.0	6.1**	6.9**	5.8**
A:P ratio[a]	2.0	1.3	1.3	1.3	1.2	1.3
(49th day)						
Acetic acid, μM/ml	42.4	39.5	37.5	37.1	29.5*	32.7
Propionic acid, μM/ml	19.4	20.8	24.2	24.2	20.9	24.1
Butyric acid, μM/ml	8.6	5.9**	4.5**	3.4**	4.4**	3.3**
Total VFA, μM/ml	70.4	66.3	66.3	64.8	54.9	60.2
Acetic acid, moles/100 moles	60.4	59.2	56.6	57.6	53.5*	54.4*
Proprionic acid, moles/100 moles	27.2	31.0	36.7**	37.0**	39.0**	39.8**
Burytic acid, moles/100 moles	12.4	9.6	6.7**	5.4**	7.3**	5.7**
A:P ratio[a]	2.2	1.9	1.5	1.6	1.4	1.4

*Indicates significantly different from control at $P<.05$ using Dunnett's t.
**Indicates significantly different from control at $P<.01$ using Dunnett's t.
[a] A:P ratio was calculated from the tabular values.

cating the optimum level was less than 30 g/t. Based simply on feed:gain ratios obtained in this study, 15 g/t of lysocellin-Mn is approximately equivalent to 30 g/t of lysocellin-Na.

In a study with growing cattle, there were linear decreases in feed intake and feed to gain ratio as lysocellin content of the diet increased from 0 to 30 g/t (3). These results suggest the optimum level of lysocellin for growing cattle fed a corn silage-based diet is greater than 30 g/t. However, since the authors did not report the form of lysocellin used it is difficult to make comparisons with the results obtained in the present study with sheep.

Literature Cited

1. Calhoun, M.C., L.H. Carroll, C.W. Livingston, Jr., and Maurice Shelton. 1979. Effect of dietary monensin on coccidial occyst numbers, feedlot performance and carcass characteristics of lambs. J. Anim. Sci. 49:10.
2. Dunn, A.M. 1978. Veterinary Helminthology. 2nd ed. William Heinemann Medical Books Ltd., London. pp. 296-298.
3. Harvey, R.W., J.W. Spears, and D.E. Darden. 1988. Effects of lysocellin on performance, ruminal and plasma characteristics of growing cattle. J. Anim. Sci. 66:1036.
4. NRC. 1975. Nutrient Requirements of Sheep. National Academy of Sciences, Wash. D.C.
5. Owens, F.N. 1980. Ionophore effect on utilization and metabolism of nutrients-ruminants. Proc. Georgia Nutrition Conf. pp. 17-25.
6. Schelling, G.T. 1984. Monensin mode of action in the rumen. J. Anim. Sci. 58:1518.
7. Steel, R.G.D., and J.H. Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill, New York.
8. Supelco Inc. 1976. GC Separation of VFA C_2-C_5. Supelco Bull. 749 B. Supelco Inc., Belfonte.

Acknowledgment

Financial support for this research was provided by International Minerals and Chemical Corporation.

PR-4583

Soybean Meal Vs. Cottonseed Meal as a Source of Protein for Early Weaned Lambs

J. M. Shelton, T. D. Willingham, and M.C. Calhoun

Early weaning is a relative term. Lambs may be removed from their mothers at birth if they are fed milk or milk substitutes, and they may be weaned to dry feeds (specially formulated rations) as early as two weeks. However, each of these alternatives presents a degree of intensification not generally acceptable to producers. Traditional weaning time on Texas ranges is about 5 months. Thus, any age markedly earlier than this may be referred to as early weaning. Weaning as early as 60 days and at 30-40 lb live weight is frequently practiced when range feed is poor as in extended droughts. It is generally accepted that these young lambs need a higher protein ration than more mature lambs. Recently some concern has been expressed that cottonseed meal may not be a satisfactory protein source for these early weaned lambs due to the gossypol content (1,2).

In the spring of 1988, lambs produced at the Texas A&M University Agricultural Research and Extension Center at San Angelo were weaned due to poor feed conditions on the range. One hundred and one of these lambs were used to com-

pare cottonseed meal with soybean meal as a source of protein. The lambs averaged 74 days of age and 43 lb in weight at weaning. The two rations utilized are show in Table 1.

The performance of the two groups of lambs are shown in Table 2. The lambs were on the experimental rations for 42 days.

Table 1. Rations Used in Protein Supplement Comparison.

Ingredients (%)	Cottonseed meal ration	Soybean meal ration
Sorghum grain	52.00	53.75
Dehy. alfalfa (17% crude protein)	15.00	15.00
Cotonseed meal (41% crude protein)	17.00	
Soybean meal (48% crude protein)		15.00
Peanut hulls	10.00	10.00
Cane molasses	3.50	3.50
Salt	0.50	0.50
Ground limestone	1.50	1.25
Ammonium chloride	0.50	0.50
Dicalcium phosphate		0.50
Total	100.00	100.00

Table 2. Feedlot Performance of Lambs Receiving Soybean Vs. Cottonseed Meal.

Treatment	No lambs	Avg initial weight (lb)	Avg final weight (lb)	Avg daily gain (lb/d)	Avg daily feed intake (lb/d)	Feed per lb gain	Feed cost per lb gain
Cottonseed meal	51	42.6	73.5	.74	3.5	4.8	21.8
Soybean meal	50	43.0	73.8	.73	3.3	4.6	25.6

There was no significant difference in average daily gain. Data on the other variables (daily feed intake, feed per lb gain, and feed cost per lb gain) were available only on a group basis and thus could not be tested statistically. These data appear to suggest that the animals gained more efficiently on the soybean meal ration, but this was not reflected in more economical gains. The difference in cost may be somewhat exaggerated since cottonseed meal purchases were made in quantity, whereas, soybean meal was purchased at retail prices. In any case, there is no evidence from this study that cottonseed meal adversely affected performance on lambs of this age and size, and in this case, its use was more economical than soybean meal.

Literature Cited

1. Holmberg, C.A., L.D. Weaver, W.M. Guterbock, J. Genes, and P. Montgomery. 1988. Pathological and toxicological studies of calves fed a high concentration cottonseed meal diet. Vet. Pathol. 25:147.
2. Morgan, S., E.L. Stair, T. Martin, W.C. Edwards, and G.L. Morgan. 1988. Clinical, clinicopathologic, pathologic and toxicological alterations associated with gossypol toxicosis in feeder lambs. Am. J. Vet. Res. 49:493.

PR-4584

Estimation of Waste in Feeding Large Round Hay Bales to Confined Sheep

J. E. Huston and K. W. Bales

Summary

A study was conducted in which the waste associated with feeding large round bales of hay to adult sheep was determined. Ten bales were fed at a single feeding station during a 40-day period to 100 adult ewes. The hay left in the residue heap was measured to be 24.7% of the hay offered. Thus, 75.3% was presumed eaten by the sheep. It is suggested that approximately 1,600 lb of similar quality sorghum hay would be required to support one ewe unit for 1 year. Hay requirements and costs associated with confinement during the various stages of production are presented.

Introduction

Confinement feeding of breeding flocks of sheep can provide needed flexibility in avoiding various hazards including seasonal predation, climatic adversity, and plant toxicosis. The nutrient requirements of breeding ewes are known (2) and practical approaches to meeting these requirements in confinement have been described previously (1). Yet, the logistics of providing adequate roughage economically continue to limit the adoption of this strategy. In a study comparing the productivity of ewes in drylot and ewes on range, large round bales of sorghum hay were used as a roughage source for the drylot ewes. During the study, an attempt was made to determine the degree of waste associated with feeding hay in this manner.

Experimental Procedure

The study involved maintaining 100 adult commercial fine wool ewes in drylot between December 1 and April 1. During that period, the ewes were given free access to large round bales as the only source of roughage. Various types and amounts of supplemental feeds were fed to subgroups of the flock. The ewes lambed mostly during February and early March. Details on the animal data are reported elsewhere (3).

During November and prior to confinement of the experimental flock, 90 large bales of local, current season, fine stemmed sorghum hay were purchased on contract delivery at $85 per ton. The hay was purchased on a weight basis and was delivered in 10 loads of 9 bales per load. A weigh ticket was obtained for each load. Average weight was 1,086 lb per bale. The bales were stored adjacent to the drylot and arranged orderly on pallets. They were covered with black polyethylene sheeting to protect the hay from the weather and were separated from the ewes by a movable electrified net fence. A round bale hay trailer, drawn by a pickup truck, was used to move bales into the drylot where they were placed on the ground, resting on the curved side with the flat sides vertical. Mainly, two feeding stations were used during the confinement period. Fresh bales were deposited on the residue heap when the previous bale had been eaten and(or) scattered to the point that it had lost all physical integrity (no longer identifiable and distinguishable as a bale).

At about midpoint of the confinement period, all residue left from previous bales of hay and debris (feces, sticks, rocks, etc.) from the feeding activities were cleared by raking and burning. Over a 40-day period, 10 bales were fed at the cleaned feeding station as described above. When the last of the 10 bales had been consumed (or otherwise lost identity), an estimate was made of the amount of hay that remained in the residue heap. The surface layer of residue (loose) was raked and weighed. The underlying, solidified layer was measured for determination of total solid volume, then a cross section slice of known volume was cut and subsequently dried and weighed (Figure 1). Samples of both layers were physically separated into hay and nonhay (feces, sticks, rocks, dirt, etc.) components.

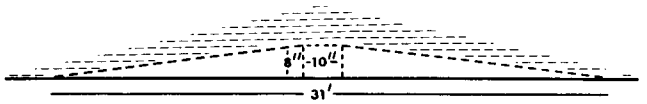


Figure 1. Dimensions and general shape of the residue heap remaining after feeding large, round bales of hay to sheep.

Results and Discussion

The residue heap that remains when large round bales are fed takes on a conical shape (Figure 1). After removal of the top layer, the solidified layer that remained was 31 feet across and 8 inches deep at the center. The cross section slice was 10 inches wide and was taken directly across the top of the conical shaped heap. Thus, the total volume of the residue cone and that of the cross section slice were calculated as follows:

$$\text{Total volume} = \frac{\pi r^2 h}{3} = \frac{(3.14)(240)(2/3)}{3} = 167.5 \text{ cu. ft.}$$

$$\text{Slice volume} = rhw = (15.5)(2/3)(5/6) = 8.6 \text{ cu. ft.}$$

Where: r = radius
h = height
w = width

Therefore,

$$\text{Residue wt} = \text{Slice wt} \times \frac{\text{Total volume}}{\text{Slice volume}}$$

Of the total hay offered, 24.7% was accounted for in the residue heap (Table 1). The balance, 75.3%, was presumed eaten. An unknown amount undoubtedly was carried from the site by wind, water, small animals, etc. On the other hand, it is likely that the method used to separate the residue into hay and non-hay fractions resulted in an overestimation of the hay fraction because of the dried urine, dirt, and feces that became attached to and inseparable from the hay. In the evaluation of the data, these two sources of error were considered offsetting.

For each 100 lb of hay offered at a cost of $4.25, only 75 lb were consumed. The actual cost was $5.67 per 100 lb of hay eaten. Estimates of forage requirements for ewes in the different production stages (2) are shown in Table 2.

These estimated hay requirements and costs can be used in determining the relative benefits of drylot feeding of sheep using large round bales. Certainly the quality of hay would influence both the amount of hay required and amount of waste. Also, concentrates can and should be fed with the hay during periods of high requirements (e.g., lactation). These data are presented for use by sheep producers in examining the option of partial or full confinement of breeding ewes.

Table 1. Estimate of Waste Associated with Feeding Large Round Bales of Hay to Adult Sheep.

	Avg per bale (air dry)	
	lb	%
Hay offered	1086	100
Refuse		
—Surface layer, loose		
Total	194	17.9
Non-hay	14	1.3
Hay	180	16.6
—Underlying layer, solid		
Total	90	8.2
Non-hay	2	.1
Hay	88	8.1
Net hay refuse	268	24.7
Hay presumed eaten	818	75.3

Table 2. Estimates of Forage Requirements for Ewes (Approximately 125 lb Body Weight) in the Different Production Stages.

Production stage	Approx. length of stage	Forage needs			Period Cost
		Per/day	Net	Offered	
	days	lb			$
Dry	100	2.5	250	333	14.15
Breeding	40	3.5	140	187	7.95
Early pregnant	100	2.8	280	373	15.85
Late pregnant	45	3.8	171	228	9.69
Early lactation	40	5.0	200	267	11.35
Late lactation	40	4.0	160	213	9.05
	365		1201	1601	68.04

Literature Cited

1. Huston, J. E., and Maurice Shelton. 1973. Potentials for confinement programs in sheep production. In: Management Practices to Evade Predator Losses. TAES Field Day Proc. San Angelo.
2. NRC. 1985. Nutrient requirements of sheep (6th Ed.). National Academy Press, Washington, D.C.
3. Ripley, L. H. 1988. Effect of protein supplementation on ewe performance, forage intake, lamb survival and growth. Ph.D. Dissertation. Texas A&M Univ., College Station.

PR-4585

Skirting of Texas Fine-Wools

F.A. Pfeiffer, C.J. Lupton, and N.E. Blakeman

Summary

Four Rambouillet ewe flocks maintained at three locations were identified for this study. Prior to shearing, two of the flocks (Brady I and San Angelo) were divided into two groups of equal numbers. Wool from one half of each flock was shorn and skirted, and the remainder was packaged in original bag (O.B.) form. A third flock (Barnhart) was divided into three groups of equal numbers in order that two skirting techniques could be compared with the original bag method. All the wool from the fourth flock (Brady II) was skirted.

Individual lots of wool were core sampled and the cores were tested for yield, vegetable matter content, fineness and colored fiber content. The wools were sold at three different warehouses to allow simple economic comparisons.

Objective measurements demonstrated that belly wool and tags were lower yielding than skirted and original bag wool. Vegetable matter content of skirts was invariably higher than the skirted staple. Belly wool tended to be finer than skirted staple. No definitive conclusion could be made regarding colored fiber contents.

In all four comparisons, the average prices received for skirted wools exceeded the comparable original bag price by amounts varying from $0.040-0.255/lb which translates to $0.40-2.56 per ewe. In addition to demonstrating some financial advantages of skirting wool, this set of experiments also indicated how rapidly such advantages can be diminished by excessive skirting.

Introduction

The technical demands and limitations of manufacturing worsted yarns, weaving and knitting require individual items in the broad spectrum of wool textile products to be composed of specific grades or classes of wool or blends thereof. Since between and within fleece variation of diameter, color, length, strength, and degree of cleanliness is often large, normal quality control requires fleeces to be graded and sorted prior to scouring. Traditionally, this function was performed at the textile mills or by companies that specialize in providing specific grades of raw materials to the textile industry. An opportunity has and still does exist for ranchers to sort, skirt, and/or grade wool either at the point of origin or pay a marketing organization to do the job for them. Theoretically, when it is no longer necessary for a textile mill to perform these tasks, labor savings can be passed back to the grower in return for prepared wools. Such efforts to increase the value of raw wool have been practiced for years by individual ranchers, warehouses and co-ops.

As applied to wool fleeces, the term skirting implies the practice of separating all inferior portions from the bulk of the fleece at shearing. This would normally involve but not be limited to removal of head, lower leg, and belly wool together with urine-stained and fecal- contaminated fibers. The products of skirting are termed skirted wool and skirts. All skirts are not of equal value and should be packaged separately for technical and economic reasons. Wool from the top of the head, jaw, and cheeks tends to be short and sometimes heavily contaminated with plant material. Belly wool is usually lower yielding and may be finer or coarser than the bulk of the fleece. It also tends to contain more vegetable and colored fiber contamination than the bulk of the fleece. Lower leg wool is short and tended to be composed predominantly of medullated hair fibers. The least valuable of the skirts, stained fibers and tags, typically contain full length fibers, scouring of which results in a relatively low yield of stained and colored fibers having limited utility. Since the term skirting generally implies removal of all wool that does not match the bulk of the fleece, short wool, matted pieces, paint, skin pieces, clumps of plant contamination, and colored wool (stained and pigmented) would all fall into the skirts category.

Separating fleeces into grades based upon diameter, length, strength, and color requires highly specialized training. Skirting, on the other hand, can be performed by anyone who is capable of recognizing the physical differences between belly, stained or soiled, and tender and short wool versus wool of staple length that is relatively clean and sound. Skirting appears to be a relatively easy method of adding value, particularly when the wool is produced by a breed having uniformly fine fleeces. Ideally, the skirted fleece would contain only a single diameter grade of wool in which case further grading would be unnecessary.

Various methods have been developed with the specific purpose of adding value to wool at shearing time. Such innovations include shearer or floor skirting in which the shearer makes an effort to drop the leg and belly wool onto the shearing floor in such a position that it can conveniently be picked up and placed in a designated bag while the remainder of the fleece is being sheared. "Shearer-assisted table skirting" involves the aforementioned floor skirting but in addition, the shorn fleece is placed flesh side down on a slatted table (approximate dimensions 10 × 5 ft.) at which time all remaining skirts are removed prior to rolling and packaging the fleece. The whole operation takes less than 1 minute for a trained operator. In "table skirting," all skirting of the fleece is performed on the table. To these basic skirting techniques may be added at least two innovations. In the former, sheep are run through the shearing shed twice. The sheep are crutched and belly, leg and sometimes wool from the head is removed on the first passage. The second time through, the balance of the fleece is shorn. In a similar operation, ewes being crutched prior to or just after lambing also have belly and leg wool removed. Subsequently, only the fleece wool is removed later in the year at shearing time. These methods were developed specifically for the purpose of minimizing contamination of fleece wool with inferior fibers and, in particular, optimizing isolation of colored fibers that are associated with belly, stained, and tag wools.

Experimental Procedure

Four Rambouillet ewe flocks containing 930 animals ranging from 2-8 years of age maintained at three locations were used for this study. The three locations included the Texas A&M Research Center in San Angelo, Winters Ranch at Brady, and the Texas Range Station at Barnhart. All land was controlled by the Texas A&M University System.

In two flocks at two locations (Brady I and San Angelo), the animals were divided into two groups of equal size. Wool from one group was skirted using the shearer-assisted table skirting technique while the other half was packaged in O.B. form. For the flock at Barnhart, two different forms of skirting (shearer-assisted table and twice through the shearing shed) were compared with original bagged wool. For the last flock (Brady II), all of the wool was skirted using the shearer-assisted table technique.

Following shearing, core samples were obtained from each lot of wool. Fiber diameter, yield, vegetable matter present and colored fiber content were determined for each group. Following the laboratory analyses, the different lots of wool from the three locations were sold at three separate warehouses, thus allowing simple economic comparisons.

Results and Discussion

Objective measurements determined in this study (Tables 1-4) demonstrate that belly wool and tags are consistently lower yielding than skirted and O.B. wool. Belly wools tended to be finer, but contained larger amounts of vegetable matter as compared to the skirted wools, while tags were variable in both fineness and vegetable matter content. No definitive conclusion was made concerning the colored fiber content. The bellies and O.B. wools in most cases contained more colored fibers than the skirted staple, indicating that

Table 1. Fleece Data on 257, Mixed Age, Untagged, Commercial Rambouillet Ewes, San Angelo.

Wool I.D.	Fiber diameter (μm)	Clean wool fiber present (%)	Vegetable matter present (%)	Colored fibers (#/1000)	Grease weight (lb)	Fraction of total (%)	Price ($/lb)
Skirted stable	20.9	53.7	2.3	2	1017	81.0	1.608
Belly wool	20.5	35.6	4.4	5	104	8.3	0.500
Tags and clippings	20.8	34.6	3.6	5	134	10.7	0.500
					1255		
Original bag	20.6	51.4	1.9	16	1348	100	1.360

Average price of skirted wools = $1.40/lb
Average weight of grease wool produced/sheep = 10.13/lb
Increased return from skirting = $1.40 − 1.36/lb
= $0.04/lb
= $0.40/sheep

Table 2. Fleece Data on 227, 3-Year-Old, Untagged, Rambouillet Ewes, Brady I.

Wool I.D.	Fiber diameter (μm)	Clean wool fiber present (%)	Vegetable matter present (%)	Colored fibers (#/1000)	Grease weight (lb)	Fraction of total (%)	Price ($/lb)
Skirted wool	20.9	55.8	1.5	2	907	73.9	1.665
Belly wool	20.5	36.9	3.8	6	161	13.1	0.890
Tags and clippings	21.4	36.4	4.1	2	159	13.0	0.475
					1227		
Original bag	20.7	51.7	2.6	5	1198	100	1.325

Average price of skirted wools = $1.41/lb
Average weight of grease wool produced/sheep = 10.86/lb
Average return from skirting = $1.41 − 1.325/lb
= $0.085/lb
= $0.92/sheep

Table 3. Fleece Data on 322, Mixed Age, Untagged, Rambouillet Ewes, Brady II.

Wool I.D.	Fiber diameter (μm)	Clean wool fiber present (%)	Vegetable matter present (%)	Colored fibers (#/1000)	Grease weight (lb)	Fraction of total (%)	Price ($/lb)
Skirted staple	22.7	49.4	2.3	1	2752	79.7	1.665
Belly wood	20.5	35.9	4.5	7	418	12.1	0.890
Tags and clippings	20.1	36.4	3.7	1	157	4.5	0.475
Tender	20.9	49.9	1.8	10	128	3.7	1.290
Original bag*	20.7	51.7	2.6	5	1198	100	1.325

Average price of skirted wools = $1.50/lb
Average weight of grease wool produced/sheep = 10.73/lb
Increased return from skirting = $1.50 − 1.325/lb
= $0.175/lb
= $1.88/sheep

*Brady Flock I—O.B. data

Table 4. Fleece Data on 124, Mixed Age, Tagged, Registered Rambouillet Ewes, Barnhart.

Wool I.D.	Fiber diameter (μm)	Clean wool fiber present (%)	Vegetable matter present (%)	Colored fibers (#/1000)	Grease weight (lb)	Fraction of total (%)	Price ($/lb)
I Skirted staple	21.0	55.3	0.2	6	293.0	77.4	2.07
Bellies and tags	20.4	51.8	0.5	7	85.6	22.6	0.62
					378.6		
II Skirted staple	22.1	51.3	0.4	6	366.0	89.0	1.97
Bellies and tags	20.9	47.3	0.7	18	45.4	11.0	0.62
					411.4		
III Original bag	22.3	54.7	0.6	27	414.0	100	1.565

Group I
Average price of skirted wool = $1.74/lb
Average weight grease wool produced/sheep = 9.71/lb
Increased return from skirting = $1.74 − 1.565/lb
= $0.175/lb
= $1.70/sheep

Group II
Average price of skirted wool = $1.82/lb
Average weight grease wool produced/sheep = 10.03/lb
Increased return from skirting = $1.82 − 1.565/lb
= $0.255/lb
= $2.56/sheep

skirting did have an advantage over non-skirting as far as colored fiber contamination is concerned.

At present, wool buyers in Texas do not openly discriminate against wool suspected of have high colored fiber content. However, they do consistently pay higher prices for skirted wools which are expected to yield more clean wool and having relatively low colored fiber content.

The two flocks involved at Brady and San Angelo had not been crutched or tagged prior to lambing and 10.7%-13.0% of total fleece weights were removed as tags and clippings on the skirting table. The belly wool removed by shearers ranged from 8.3%-13.1%, resulting in total skirts removed of 19.0%-26.1%

In all four comparisons, the average combined prices received for skirts and skirted wools exceeded the comparable O.B. price by amounts varying from $0.04-$0.25/lb which translated to $0.40-$2.56/animal.

Inspection of the Brady data (Tables 2 and 3) reveals that identical prices were paid for similar wools from each flock. Thus relatively heavy skirting (26.1%) of the wool from flock I did not result in any financial reward compared to the light skirting (16.6%) of flock II fleeces. On the contrary, the excessive skirting actually resulted in lost income of $0.09 (i.e., $0.175 minus 0.085)/lb. A similar observation was made with the Barnhart wools. Running the sheep twice through the shearing shed resulted in a 22.6% skirt on sheep that had been previously tagged. Shearer-assisted table skirting, on the other hand, produced a relatively light (11%) skirt. The economic advantage of the lighter skirting process was $0.085 (i.e., $0.255 minus 0.175)/lb. Obviously, any economic advantages are rapidly diminished when an excessive amount of wool is removed in the skirting process.

Many Texas warehouses have personnel trained to assist producers in skirting and grading their wools. Typically, a producer pays $60/day for the services of a warehouse grader. Such a person could grade wool shorn by eight shearers. Assuming each shearer shears 100 head per day and each sheep yields 10 lb grease wool, the cost of using a grader is ¾ cent per pound. Based on data generated in this study, the extra income generated by skirting and grading is more than adequate to offset the cost of hiring a warehouse grader.

PR-4586

Effects of Short-Term Lice Infestation of Angora Goats on Objectively Measurable Mohair Characteristics

C.J. Lupton, T.W. Fuchs, and C.S. McCown

Summary

Large differences in biting lice populations between individual Angora goats in a flock were quantified prior to shearing. Subsequently, individual fleeces were characterized in terms of important mohair properties. Linear regression analysis revealed that the effect of heavy, short-term lice infestation on objectively measurable mohair characteristics was negligible.

Introduction

Biting lice, *Bovicola limbatus* (Gervais) and *B. crassipes* (Redow) are external parasites affecting Angora goats in Texas. The lice live on the surface of the skin causing irritation and discomfort to the host when populations are high. It has been claimed (4) that heavy infestations may result in loss of weight, lowered vitality, and reduction in mohair production. Further adverse effects include matting of fleeces due

to louse oviposition and excretion, loss of hair due to animals rubbing on objects and generally disarrayed fleeces due to biting and scratching to relieve irritation (3).

Several effective insecticides are available for control of biting lice on Angora goats (2). Since the residual control of most compounds lasts a relatively short period of time (about four weeks), low populations of lice can only be ensured through multiple applications of insecticide throughout the 6-month mohair growth period. Since one application immediately after or during an 8-week period after shearing is all many ranchers usually make, the question arises as to the effects of short-term (up to 5 months) lice infestation on objectively measurable mohair characteristics.

Experimental Procedure

This experiment utilized 37 two-year-old Angora does. The goats were maintained together on haygrazer and small grain fields throughout the 6-month study. The goats, averaging about 80 pounds each, were initially shorn on August 6, 1987. Most of the flock (30 animals) was treated for lice control on October 1, seven weeks after shearing. Lice counts were conducted prior to treatment and immediately prior to shearing on February 16, 1988. Estimates of lice populations were made on individual animals by counting the number of lice visible when parting the mohair approximately 1.5 inches in four sample areas (2). After shearing, individual fleeces were characterized in terms of grease and clean fleece

Table 1. Mohair Fleece, Fiber Characteristics, and Lice Counts for 37 Angora Goats.

Lice count[b] (2/16/88)	Grease fleece wt.(lb)	Fiber diameter (microns)	CMFP[a] (%)	Clean fleece wt.(lb)	Med fibers (%)	Kemp fibers (%)	Colored fiber (%)	Staple length (in)
0	8.71	36.48	65.21	5.68	1.2	.4	0	5.07
0	10.45	38.78	64.88	6.78	2.5	0	0	5.14
0	9.44	37.07	68.19	6.44	.4	.6	0	5.23
0	12.79	36.29	60.68	7.76	.4	.2	0	4.73
0	8.71	41.22	70.24	6.12	.7	1.0	0	5.19
0	8.84	35.50	70.26	6.21	.5	.3	0	4.86
0	10.12	37.80	70.50	7.14	5.0	.8	0	4.59
0	9.94	40.52	56.98	5.67	.6	.8	.1	4.31
0	6.88	36.13	73.44	5.05	.4	1.0	.5	5.32
0	9.11	36.63	68.83	6.27	1.1	.8	0	5.21
0	8.84	36.68	67.10	5.93	1.5	.8	0	5.11
1	10.89	36.23	74.91	8.16	.3	.3	.3	5.41
1	9.35	34.43	69.86	6.53	2.7	.4	0	4.48
1	8.05	36.62	75.39	6.07	.9	.3	0	4.47
1	7.92	38.19	75.98	6.01	1.9	.7	0	5.51
1	11.47	32.55	70.41	8.07	3.7	.2	.1	5.34
2	11.38	34.49	63.81	7.26	1.4	.5	.3	4.91
3	6.11	33.80	68.90	4.21	.8	1.1	0	4.96
4	7.03	37.20	78.71	5.54	4.6	1.2	0	5.32
4	11.11	39.96	66.05	7.34	.7	.5	0	4.80
5	8.86	39.93	68.40	6.06	1.1	1.2	0	4.30
6	6.64	38.53	76.30	5.06	.5	.2	0	5.16
8	9.50	35.50	67.34	6.43	1.1	.8	0	5.64
10	9.88	38.30	68.12	6.73	1.6	.2	0	4.69
13	8.58	37.93	74.74	6.41	1.2	.7	0	5.38
17	6.48	40.01	79.21	5.13	.3	1.1	0	5.10
19	7.45	34.72	71.20	5.31	1.7	.1	0	5.04
28	9.92	36.42	66.97	6.65	.8	.3	.1	4.59
60	9.02	36.63	70.51	6.36	.5	.1	.1	4.64
62	6.24	34.86	75.12	4.69	1.0	.5	0	5.44
75	8.53	37.28	73.59	6.28	3.4	.7	.1	5.17
87	11.40	40.14	65.07	7.42	1.7	.5	.1	5.06
102	8.82	35.60	65.53	5.78	1.6	.4	0	4.48
104	7.89	38.89	71.88	5.67	1.5	.2	0	5.32
105	7.52	37.72	74.44	5.60	1.7	.6	.1	5.06
105	9.68	40.06	70.17	6.79	.6	.4	0	5.48
144	10.05	37.98	71.54	7.19	1.3	.9	0	4.86
Mean 26.2	9.02	37.22	70.02	6.26	1.4	0.6	.1	5.01
S.D. 40.7	1.58	2.02	4.73	.89	1.1	.3	.1	.35

[a]Clean mohair fiber present

[b]Interpretation of lice counts (Lice were identified as *Bovicola limbatus*, the Angora goat biting louse).
0-20 lice per 4 hair-parts = light infestation
21-40 lice per 4 hair-parts = moderate infestation
41+ lice per 4 hair-parts = heavy infestation

weight, yield, staple length, fiber diameter, and medullated (kemp and med) and colored fiber content using standard ASTM methods. Simple linear regression analysis was used to establish the relationships between lice populations and mohair characteristics.

Results and Discussion

Initial lice counts conducted October 1, 1987, indicated lice infestation on all goats was either non-existent or very light. Lice counts conducted immediately prior to shearing in February 1988, revealed unusually large differences in lice populations between individual Angora goats (Table 1). Since insecticide treatments are known to control lice for at least 4 weeks, it is estimated that the time of high lice infestation ranged from 2 to 3 months on treated goats and 2 to 5 months on untreated animals.

Results of fleece and fiber analysis are also shown in Table 1. The correlation coefficients for the linear regression equations relating lice count and mohair characteristics are listed in Table 2. The magnitudes of these correlation coefficients indicate that under the conditions prevailing in this experiment, lice populations and mohair quality parameters are not significantly related.

Table 2. Correlation Coefficients for the Linear Relationships between Lice Counts and Mohair Characteristics.

	r value[a]
Grease fleece weight	−.056
Clean fleece weight	−.007
Clean mohair fiber present	.110
Fiber diameter	.177
Med content	.002
Kemp content	−.097
Colored fiber content	−.067
Staple length	.050

[a]None of the values are statistically significant at the 95% level of probability.

This experiment was not designed to establish the effects of the infestation on subjectively assessed mohair properties such as luster and character. Although these fleece properties are commonly reported to be affected by lice, no adverse effects were observed during the course of counting lice, shearing, or testing this mohair.

Literature Cited

1. American Society for Testing and Materials. 1987. Annual Book of ASTM Standards. Section 7, Vol. 07.02.
2. Fuchs, T.W., and M. Shelton. 1985. SW Entomol. 10(1):15.
3. Hopkins, D.E., and W.F. Chamberlain. 1969. In vitro colonization of the goat biting lice, *Bovicola crassipes* and *B. limbata*. Ann. Entomol. Soc. Amer. 62:826.
4. Peterson, H.A., and R.C. Bushland. 1956. Lice of sheep and goats. USDA Yearbook of Agriculture. 1956:411-414.

PR-4587

Spraying Oleic Acid on Angora Goats for Reduction of Vegetable Matter Contamination

F.A. Pfeiffer, C.J. Lupton, N.E. Blakeman, and R.F. Jenkins

Summary

Spraying with oleic acid was evaluated for reducing the amount of vegetable matter in mohair. Each of three flocks of Angora goats was divided into three groups. One group was sprayed with a formulation containing oleic acid (0.14% body weight) prior to mohair becoming contaminated with plant parts and seeds (late May-early June). A second group was sprayed with the same formulation approximately one month prior to shearing (late July-early August). The third group was not treated. All animals were shorn in late August. Spraying with oleic acid had little effect on clean mohair fiber present (CMFP). Small significant reductions in vegetable matter (VMP) resulted from three of the six sprayed applications.

Introduction

Vegetable matter (or "defect") in mohair poses serious problems in the manufacture of textiles containing mohair. Vegetable matter refers to burrs, seeds, twigs, and other plant parts which become entrapped in the Angora goat fleeces. In Texas, the contamination usually occurs during late spring and summer when animals are grazing or bedding in pastures or pens where the problem plants occur.

Some vegetable matter in the fleeces of range animals is inevitable but excess amounts increase waste in the carding and combing processes. Some types of vegetable matter cannot be physically removed by carding and combing and may require carbonization, a method using acids to completely remove cellulosic contaminants. This process which follows scouring is expensive (3) and results in decreased luster and strength of the treated hair. Consequently, mohair buyers are prepared to pay more for mohair free of defect. Thus, a cost-effective method for reducing the amount of contamination before shearing might offer an economic advantage to mohair producers.

In 1985, Texas produced 13,300,000 lb mohair averaging $3.45/lb which totaled $45,885,000 (9). Mohair is traditionally discounted on a 10%, 20%, and 30% basis for light, medium and heavy defect, respectively. According to a survey of Texas warehousemen (6) the 1987 fall clip was estimated to contain light (20% to 40% of the total clip), medium (10% to 15%) and heavy (3% to 10%) defect varying slightly with age classification and geographic location. This translates into a loss of ranch income ranging from $2.1 million to $4.6 million. Typically, objective methods are not used to quantify vegetable matter in mohair prior to sale. Buyers and warehousemen agree on a level of contamination based on the amount and type of defect in a particular sample.

For several years, ranchers have tried to remedy this problem of defect in mohair by spraying Angora goats with emulsions of oleic acid ($C_{18}H_{34}O_2$) commonly referred to as "red

oil". Oleic acid is a colorless (commercial grades are pale yellow) unsaturated fatty acid with a lard-like odor that is soluble in organic solvents but insoluble in water. It is a major component of olive oil and is used in soaps, ointments, and cosmetics (3).

There are several theories of how oleic acid actually works in the reduction of vegetable matter content in mohair (6). Spraying with red oil is said to modify the structure of a fleece to create a tighter lock which prevents the introduction of contaminants into the fleece. Another theory claims that spraying 3-4 weeks prior to shearing allows the plant particles to "slip out" of the fleece while adding luster and softness. A third theory also applies to spraying goats with red oil several weeks prior to shearing. The oil is said to coat the fleece and vegetable matter, thus restricting water loss from the animals' natural sweating process. The net effect of restricting water loss in the presence of microorganisms is to cause a relatively rapid breakdown (composting) of plant materials, thus permitting burrs and other plant parts to disintegrate and shed from the fleece prior to shearing.

The purpose of this study was to determine if spraying with oleic acid at different times affected the vegetable matter content in Angora goat fleeces.

Experimental Procedure

Three flocks of Angora does averaging 2.5 years of age were used for this study. The animals were maintained on ranges located close to San Angelo, Brady, and Sonora, Texas, on ranches managed by the Texas Agricultural Experiment Station. Does in each of the three flocks were randomly assigned to groups of equal size for three different treatments as shown in Table 1. Treatment 1 involved spraying the goats at the beginning of the study (late May) when contaminating plants were starting to become a problem. The animals were sprayed with an aqueous emulsion (0.7-1.0 gallon/animal) containing oleic acid, (2%), 57% Malathion[1] (1%) and 10% Triton N101[2] (2%). The goats exposed to treatment 2 were sprayed with the same formulation 1 month prior to shearing (early August). The control group was not sprayed.

All animals were shorn in late August and the fleeces from each treatment were sacked separately. Following shearing, combined fleeces from the treatments were sampled, using a 2-inch coring tool, for subsequent analysis. Clean mohair fiber present (CMFP) and vegetable matter present (VMP) of subsamples were determined for each treatment in accordance with ASTM Standard Test Methods D 584 (1) and D 1113 (2), respectively. Fiber diameter measurements were also determined on subsamples of mohair using the Peyer Texlab FDA200 Fiber Fineness Measuring System[3]. Determination of wool fineness characteristics using this laser-computerized instrument has been described by Lynch and Michie (8) and Lunney and Irvine (7).

Table 1. Experimental Design, Spraying, and Shearing Dates.

Location	Flock size: Early-sprayed	Late-sprayed	Control	Date of early-spray	Date of late-spray	Shearing date
Brady	40	39	39	6/5/87	7/30/87	8/20/87
San Angelo	24	22	23	6/2/87	8/4/87	8/25/87
Sonora	32	30	30	5/28/87	8/5/87	8/27/87

Table 2. Percentage Clean Mohair Fiber Present by Treatment and Location.

Treatment	Location: Brady	San Angelo	Sonora
Oleic acid early-spray	74.37[a]	62.36	77.68
Oleic acid late-spray	67.88[b]	63.80	77.06
Control	72.27[a]	63.06	75.02

[a,b]Means in the same column with different superscript letters differ ($P<.05$).

Analysis of variance (5) was used to test for differences between groups within a flock at all locations.

Results and Discussion

The results of CMFP analyses are presented in Table 2 for the treated and control groups. Spraying with this formulation either before or after the contamination period had no significant effect on CMFP at two of the three locations. However, mohair from Sonora was higher yielding than Brady mohair and San Angelo mohair had the lowest CMFP. Mohair produced in the San Angelo area was very heavily contaminated (15%) primarily with horehound, *Marrubium vulgare*. Mohair produced in Brady was heavily contaminated (8%) with burclover, *Medicago minima* and horehound. The Sonora mohair was only lightly contaminated (1.5%) with horehound and threeawns, *Aristida wrightii* and *A. purpurea*.

Table 3 provides information on the VMP in fleeces from the three flocks. The precontamination spraying at Brady resulted in a small but significant reduction in VMP whereas the late-spraying apparently produced an increase as compared to the control group. Early-spraying had no significant effect on the VMP of the San Angelo mohair. However, the late-sprayed mohair contained slightly less vegetable matter than the control. Pre-spraying resulted in small reductions in VMP in the lightly contaminated mohair from Sonora. The magnitudes of VMP reductions would probably not affect prices paid to producers.

Table 3. Percentage vegetable matter present by treatment and location.

Treatment	Location: Brady	San Angelo	Sonora
Oleic acid early-spray	5.83[a]	16.36[a]	0.85[a]
Oleic acid late-spray	10.29[b]	13.54[b]	1.25[ab]
Control	8.25[c]	15.45[a]	1.54[b]

[a,b,c]Means in the same column with different superscript letters differ ($P<.05$).

It is likely that the inconsistencies in effect of oleic acid sprays on the VMP among locations are related to uncontrolled variables, particularly specific type and quantity of vegetable matter at the three locations. In addition, substantial differences existed between the average fiber diameters of the three goat populations (Brady, 33.5 μm; San Angelo, 31.7

[1]Ortho Malathion 50, Chevron Co. For control of external parasites.
[2]Nonionic ethoxylated alcohol, Rohm and Haas Co. The detergent was used as an emulsifier for oleic acid.
[3]Peyer FDA200, a product of Peyer Electronics, Wollerau, Switzerland.

μm and Sonora 37.0 μm). Reduction of vegetable matter in mohair by spraying Angora goats with oleic acid emulsions has been rationalized in terms of three theories. Data generated in this experiment have not indicated which, if any, of the three theories is operative.

In conclusion, more data are required before definite recommendations can be made concerning the spraying of Angora goats for reduction of vegetable matter. However, these data appear to indicate that spraying with oleic acid can be beneficial, particularly at lower levels of contamination, but this needs to be validated or clarified by subsequent experiments.

Literature Cited

1. American Society for Testing and Materials. 1987. Wool content of raw wool-laboratory scale. Annual Book of ASTM Standards. Section 7, Vol. 07.02, D 584.
2. American Society for Testing and Materials. 1987. Vegetable matter and other alkali-insoluble impurities in scoured wool. Annual Book of ASTM Standards. Section 7, Vol. 07.02, D 1113.
3. Anonymous, 1984. McGraw-Hill Dictionary of Scientific and Technical Terms (3rd Ed.). McGraw-Hill Book Co. New York.
4. Bassett, J.W., G.R. Engdahl, and J.M. Shelton. 1970. Vegetable matter defect in mohair. Tex. Agric. Exp. Sta. PR-2754.
5. Freese, F. 1967. Elementary Statistical Methods for Foresters, United States Dept. of Agriculture, Agriculture Handbook 317.
6. Jenkins, R.F. 1987. Effects of various chemical applications on plant contamination in mohair. M.S. Thesis. Angelo State University, San Angelo, Texas p. 1-68.
7. Lunney, H.M., and P.A. Irvine. 1982. Measurement with the CSIRO fiber fineness distribution analyzer. Text. Res. J. 52:217.
8. Lynch, L.J., and N.A. Michie. 1976. An instrument for the rapid automatic measurement of fiber fineness distribution. Text. Res. J. 46:653.
9. Tex. Dept. Agri. and USDA. 1986. 1985 Texas Livestock, Dairy and Poultry statistics. Bull. 235.

PR-4588

Comparison of Three Methods of Measuring Wool Fiber Diameter

C.J. Lupton, N.E. Blakeman, R.F. Jenkins, and F.A. Pfeiffer

Summary

A microcomputer-based sonic digitilization technique and an electro- optical laser instrument were compared to the ASTM standard projection microscope and wedge card method for measuring wool fineness. The means and standard deviations of six wool samples were measured using each technique. Despite improved ease, speed of measurement, and excellent single-operator precision, the digitizer method resulted in four of six means being significantly different ($P<.05$) than the standard measurements. In contrast, the diameter means of four of the six samples measured by the laser instrument were not significantly different ($P>.05$) than those obtained using the standard method.

Introduction

The textile end-uses in which wool may be utilized are determined to a large extent by fiber diameter. Consequently, a major emphasis has historically been placed on the accurate determination of this characteristic. The standard method (2) for determining fiber fineness and distribution involves the use of a projection microscope (PM) in conjunction with a wedge card scale (WC) for measuring individual fibers. When the requisite number of fibers is measured, this method is (arguably) the "absolute" method. Unfortunately, it is also time-consuming, tedious, and expensive. Air-flow techniques (1) were developed to obtain estimates of fiber diameter in a relatively short time. These instruments have formed the cornerstone to international wool marketing. However, the inability of air-flow instruments to provide a measure of variability of fineness has proven a serious limitation, particularly in wool research applications. Other technologies (e.g., automated image analysis and electro-optical fiber fineness distribution analysis [FFDA, 12]) have been developed to obtain rapid, accurate measurements of fiber fineness and distribution. These instruments are very expensive ($45,000+) and consequently, have not been purchased by a significant number of textile processors or research groups in the U.S. Thus, a need has existed for a relatively rapid, equally accurate, but inexpensive alternative to the standard PM,WC method.

To this end, Bassett (4) used a pressure-sensitive, electronic digitizing pad to replace the wedge card and measure the average diameter of wool and mohair fibers. Campbell and Bassett (6) reported there was no significant difference in mean diameter between samples measured with the standard wedge card and the digitizing pad. It was further noted that the digitizing pad used in conjunction with a programmable calculator was faster (5×) than the standard wedge card method. Hutchings and Ryder (7) described the use of a digitizer in conjunction with a computer for the measurement of fiber diameter and medullation. The authors noted that the digitizing method was faster and potentially more accurate than current standard methods, although the ultimate precision of measurement is determined by the limitations of the optical system and the ability of the operator to position the stylus. More recently, Stobart and Russell (15) described microcomputer-based digitization of wool fibers for measurement of diameter mean and standard deviation using two different systems. The authors reported there were no significant differences in mean diameter between samples (60) measured with the standard PM,WC and the projection microscope/digitizer (PM,D) combinations. In contrast, the coefficients of variation (CV) of diameter as measured by the PM,D methods were significantly greater ($P<.05$) than the CV measured by the PM,WC technique. This was attributed to the fact that means and standard deviations (SD) are calculated using intervals (2.5 μm) when using the standard method

whereas the digitizing systems compute actual micron values of diameter and utilize these values to calculate SD and CV. If plausible, this would serve to explain the relatively high values of SD obtained when 2 or 1 μm intervals are used (e.g. in the IWTO projection microscope method (8) and the FFDA, respectively) instead of 2.5 μm intervals (as in the ASTM PM,WC standard). Also, it would be a relatively simple task to write a program in which digitizer values were assigned to 2.5 μm intervals prior to calculation of mean and SD. However, if the example shown in the appendix of IWTO-8-61 is recalculated using 4 μm intervals (instead of 2 μm) an identical SD value (5.2) is obtained. Thus, the higher CV values noted by Stobart and Russell (15) are more likely a result of the particular measuring systems rather than mathematical differences in the methods used to calculate CV.

When comparing new methods of measurement versus established or standardized, at least two general approaches are feasible. First, a relatively large number (e.g., 100) of individual samples can be characterized by measuring a relatively small number (e.g., 50-200) of fibers (3,4). Alternatively, a relatively small number of samples (e.g., 6) can be characterized by measuring a large number of fibers (e.g., 10,000). The former method results in relatively broad limits of the individual sample means and small differences (.5 μm) in measurements made by the methods being compared tend to be insignificant. In contrast, the latter method, although characterizing the sample more precisely, is just as likely to illuminate minute heterogeneities in the sample being measured as small differences in the methods being compared. Ideally, comparisons would consist of the measurement of large numbers of fibers and samples. Time restraints did not allow this approach in the current experiment and a relatively small number of wool samples were compared.

Experimental Procedure

Three samples of wool top and carded, half-inch wool cores were obtained (14). These samples had been previously standardized in terms of fiber diameter in accordance with ASTM test method D 2130 (2). A GP- 7 Grafbar Two-Dimension Sonic Digitizer[1] was utilized (5,13) by two operators in conjunction with an IBM Personal Computer AT[2] and a Wool Fiber Digitizing Program[3] (Geographix, Denver, Colorado) to measure the mean diameter of fiber images produced by a projection microscope, also in accordance with ASTM test method D2130.

After preparation the six sub-samples were also measured using a Peyer Texlab FDA 200 System[4] that had been calibrated (10) using standardized IWTO tops.

Results and Discussion

Diameter means, standard deviation, and limits for the individual means (at the 95% probability level) were calculated for each sample and method of measurement. Table 1 summarizes the measurements and calculations. For five of the six test samples, the project microscope/sonic digitizer (PM,D) method resulted in smaller diameter means than the PM,WC method. In contrast, SD values were very similar. As Hutchings and Ryder point out, the ultimate precision of both of these methods is dependent upon the optical system and the ability of operators to focus and correctly position the wedge card scale and/or the stylus. In the case of the PM,D measurements, one of the two operators differed from the other (on average) by 0.3 μm. It should be recognized that PM,WC and PM,D measurements were conducted by different operators at different times in different labs. Thus, the observed small differences in means incorporate operator and laboratory biases in addition to any contribution caused by sampling errors and the different measuring methods.

Despite this isolated result, digitization is being seriously considered as a replacement for the wedge scale card in ASTM Test Method D2130. ASTM Subcommittee D13.13 members are currently conducting a round test utilizing the GP-7 Grafbar Sonic Digitizer. In fact, these particular results are this lab's contribution to the round test.

Overall, diameter means measured using the Texlab FDA 200 System were very similar to those obtained using the PM,WC. Four of the six means are not significantly different ($P>.05$). However, values of SD are higher than those obtained using the standard method. This problem has been recognized previously (11,16) and has led to the introduction of a new form of measuring cell (9) that was designed to correct this and other problems. This method is expected to receive IWTO approval within the next 2 years.

In conclusion, the accuracy (though certainly not the single-operator precision) of the relatively fast SAC GP-7 Grafbar Sonic Digitizer for measuring wool diameters remains to

[1]A product of Science Accessories Corporation, Southport, Connecticut.
[2]A product of IBM Corporation, Boca Raton, Florida.
[3]A product of Geographix, Denver, Colorado.
[4]A product of S. Peyer AG, Wollerau, Switzerland.

Table 1. Results of Three Methods of Measuring Wool Fiber Diameter.

	Projection microscope wedge card			Projection microscope/sonic digitizer			Peyer Texlab FDA 200 System		
	Average diameter (μm)	S.D. of diameter (μm)	No. fibers measured	Average diameter (μm)	S.D. of diameter (μm)	No. fibers measured	Average diameter (μm)	S.D. of diameter (μm)	No. fibers measured
Top	$20.71 \pm .25^{ab}$	4.50	1200	$20.52 \pm .16^{a}$	4.95	3720	$20.95 \pm .10^{b}$	5.10	10,000
Samples	$27.30 \pm .29^{a}$	6.95	2200	$27.74 \pm .14^{b}$	7.38	9960	$27.46 \pm .16^{ab}$	8.31	10,000
	$37.40 \pm .30^{b}$	9.60	4000	$36.38 \pm .14^{a}$	10.15	18824	$37.48 \pm .24^{b}$	12.12	10,000
Carded	$19.72 \pm .30^{a}$	4.33	800	$19.34 \pm .13^{a}$	4.04	3752	$20.19 \pm .11^{b}$	5.78	10,000
Core	$26.58 \pm .47^{c}$	8.26	1200	$24.86 \pm .16^{a}$	7.70	8632	$25.78 \pm .16^{b}$	8.44	10,000
Samples	$32.27 \pm .48^{b}$	8.45	1200	$31.28 \pm .14^{a}$	8.62	15216	$31.89 \pm .18^{b}$	9.36	10,000
Means	27.33	7.01		26.29	7.14		27.28	8.18	

^{abc}Means in the same row without a common superscript differ ($P<.05$).

be demonstrated in this lab. Although the Peyer Texlab FDA 200 System appears to be more accurate, reported values of SD are significantly higher than those obtained using the standard method of measurement. A new design of measuring cell may cure this problem.

Literature Cited

1. American Society for Testing and Materials. 1987. Resistance to airflow as an indication of average fiber diameter of wool top, card sliver and scoured wool. Annual Book of ASTM Standards. Sec. 7, Vol. 07.02, D1282.
2. American Society for Testing and Materials. 1987. Diameter of wool and other animal fibers by microprojection. Annual Book of ASTM Standards. Sec. 7, Vol. 07.02, D2130.
3. Andrews, R.N., Hawkes, H., and S.F. Crosbie. 1987. Evaluation of five methods for measuring mean fiber diameter of fleece samples from New Zealand sheep. N.Z. J. Exp. Agr. 15:23.
4. Bassett, J.W. 1988. Personal communication. Dept. Animal Science, Texas A&M Univ., College Station, Texas.
5. Blakeman, N.E., C.J. Lupton, and F.A. Pfeiffer. 1988. A sonic digitizer technique for measuring medullation in mohair. Text. Res. J. In Press.
6. Campbell, J., and J.W. Bassett. 1983. A comparison of two methods of measuring wool fiber diameter. Texas Agr. Exp. Sta. CPR 4171:154.
7. Hutchings, N.J., and M. L. Ryder. 1985. The automation of the projection-microscope method of fibre-diameter measurement. J. Text. Inst. 4:295.
8. International Wool Textile Organization. 1966. Method of determining wool fiber diameter by the projection microscope. IWTO Specifications of Test Methods. IWTO-8-61.
9. Irvine, P.A. 1986. A new cell for the CSIRO Fibre Fineness Distribution Analyzer. IWTO, Ostend. Rep. 7:1.
10. Irvine, P.A., and H.W.M. Lunney. 1979. Calibration of the CSIRO Fiber-Fineness Distribution Analyzer. Text. Res. J. 49(2):97.
11. Lunney, H.W.M., and P.A. Irvine. 1982. Measurement with the CSIRO Fiber-Fineness Distribution Analyzer. Text. Res. J. 52(3):217.
12. Lynch, L.J., and N.A. Michie. 1976. An instrument for the rapid automatic measurement of fiber fineness distribution. Text. Res. J. 46(9):653.
13. Science Accessories Corporation, GP-7 Grafbar Model Operator's Manual, Southport, Connecticut, June 1982.
14. Stobart, R.H. 1986. Personal Communication. Dept. Animal Science, Univ. of Wyoming, Laramie, Wyoming.
15. Stobart, R.H., and W.C. Russell. 1987. Use of microcomputer-based image digitization for the measurement of wool fiber diameter. Comput. Electron. Agri. 1:339.
16. Thompson, B., and D.C. Teasdale. 1985. Measuring wool fiber diameter with the FFDA. Proceedings, 7th Int. Wool Text. Res. Conf. Vol. II:127.

PR-4589

Dietary Energy Intake Effects on Mohair Growth

M.C. Calhoun, C.J. Lupton, S.W. Kuhlmann, and B.C. Baldwin, Jr.

Summary

Thirty-six, two-year-old, castrated male Angora goats were used in a 168-day feeding study to examine the effects of digestible energy intake on mohair growth and quality. Dietary energy intakes were .061, .077, .094 and .110 Mcal digestible energy/lb metabolic body size (live $wt^{.75}$) per day. Protein content of the diets was adjusted so that all sheep received the same protein intake regardless of energy intake. Grease fleece production was positively correlated with average shorn body weight ($r = .33$; $P<.10$) and actual digestible energy intakes ($r = .36$; $P<.05$). However, there was considerable variation among individual goats in fleece production and in both cases the correlations were low. Fiber diameter was also positively correlated with body weight ($r = .56$; $P<.01$) and actual digestible energy intake ($r = .34$; $P<.05$). Dietary energy was without effect on the percentages of med and kemp fibers present in mohair samples.

Introduction

Angora goats are efficient fiber producers. They produce more fiber in relation to their size than Rambouillet sheep and produce it more efficiently (9). Although specific information is available on the effects of nutrition on wool production (5) similar information is generally unavailable for mohair production by Angora goats. Mohair growth responds dramatically to additional dietary protein or supplementation with a rumen-protected form of the amino acid methionine (1,8). The relative contribution of energy and protein to the quantity and quality of mohair produced is unknown. The purpose of this research was to assess the effects of dietary energy intake on mohair growth when protein intake was held constant.

Experimental Procedure

Thirty-six, two-year-old, castrated male Angora goats were used in this study. They were individually housed and fed one of four dietary energy intakes for a 168-day period. The energy intakes were .061, .077, .094 and .110 Mcal digestible energy (DE)/lb live $wt^{.75}$ per day. Regardless of energy intake all diets were formulated to provide 3.6 g crude protein/lb live $wt^{.75}$ per day (Table 1).

Table 1. Percentage Ingredient and Calculated Nutritional Composition of the Experimental Diets.

Ingredient	Experimental diets 1	2	3	4
Corn ground	28.50	40.50	48.35	54.25
Dehydrated alfalfa	10.00	10.00	10.00	10.00
Cottonseed hulls	20.00	20.00	20.00	20.00
Cottonseed meal	34.25	22.75	15.20	9.50
Molasses, sugarcane	4.00	4.00	4.00	4.00
Limestone, ground	1.75	1.25	.95	.75
Ammonium chloride	.50	.50	.50	.50
Vitamin-mineral premix	1.00	1.00	1.00	1.00
Calculated Nutritional Values[a]				
Dry matter, %	90.9	90.4	90.0	89.8
Digestible energy, Mcal/lb	1.36	1.40	1.43	1.45
Crude protein, %	22.7	18.6	16.0	13.9
Calcium	1.17	.97	.85	.77
Phosphorus	.61	.50	.42	.37

[a]All values except dry matter are expressed on a dry matter basis.

Goats were sheared initially and weighed. They were reweighed at 28-day intervals and sheared again upon completion of the 168-day study. Feed was offered and feed refusals were picked up daily. The amount of feed offered was based on live weight and recalculated at each 28-day weigh period.

Live weight gains, grease and clean fleece production, fiber diameter, and the numbers of medullated fibers (med and kemp) were the criteria used to assess the effects of energy intakes.

The General Linear Model Procedure and regression analysis were used in the statistical analysis of the data (7).

Results and Discussion

In general, the health of the goats was excellent during this experiment. No problem was encountered with coccidiosis which can be a serious problem with goats fed in confinement. One goat died on the 123rd day from urinary calculi.

Actual energy intakes (Mcal DE/lb live weight$^{.75}$ per day) closely approximated the amounts offered daily indicating the goats consumed what was fed. The only exceptions were one goat fed the .094 level of energy intake and three fed the .110 level. Feed intakes (lb/day) and energy intakes (Mcal DE/day) are presented in Table 2 and reflect the energy levels fed. Daily crude protein intake (lb/day) was relatively constant across energy intakes. This was expected since the diets were formulated so that crude protein content was proportionately decreased in those diets used to increase digestible energy intake.

Increasing digestible energy intake had a positive effect on live weight change ($P<.01$). However, the mean values presented in Table 2 for live weight are misleading since, as mentioned previously, one goat on the .094 and three goats on the .110 level of digestible energy intake had considerable feed refusals. A better indication of the relationship between digestible energy intake and live weight change is given in Figure 1. The equation for this relationship is $Y = -45.2 + 503.7X$ ($r = .85$, $P<.01$); where Y = live weight change in lb for the 168 day period and X = actual digestible energy intake in Mcal/lb live weight$^{.75}$ per day. Based on this equa-

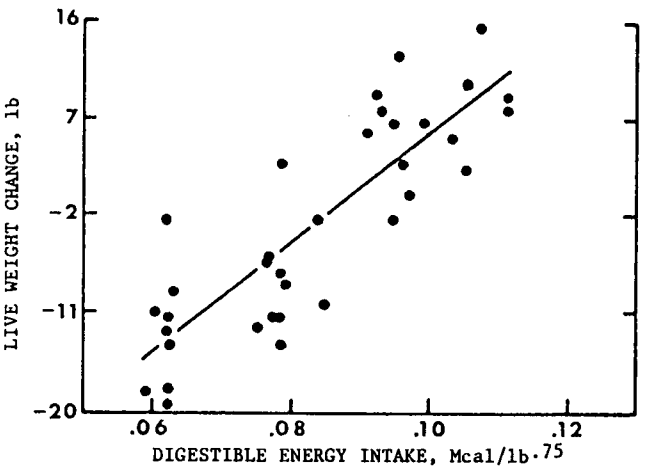


Figure 1. Relationship between digestible energy intake (Mcal/lb live weight$^{.75}$, X) and live weight change (lb, Y) during a 168-day feeding period. $Y = -45.2 + 503.7X$ ($r = .85$; $P<.01$).

Table 2. Effects of Dietary Digestible Energy Intake on Live Weight Gains and the Quantity and Quality of Mohair Produced by Castrated, Male Angora Goats.

Statistical Criterion	Daily digestible energy intakes, Mcal/lb$^{.75}$ .061	.077	0.94	.110	SEM[a]	Comments
Number goats	9	9	8	9		
Initial live weight, lb	95.3	96.6	91.2	98.2	5.1	N.S.[c]
Feed intake, lb/d	1.31	1.65	1.91	2.23		
Energy intake, Mcal DE/day	1.78	2.30	2.73	3.24		
Energy intake, Mcal DE/lb	.062	.078	.093	.103		
Protein intake, lb/day	.30	.31	.30	.31		
Live weight change, lb[b]	−13.1	−8.4	5.0	4.6	2.0	L, $P<.01$[d]
Grease fleece weight, lb	5.86	6.74	7.56	6.65	.40	Q, $P<.05$[e]
Clean fleece yield, %	77.0	75.9	73.1	77.2	1.3	
Fiber diameter, m	35.1	35.2	37.7	38.5	1.2	L, $P<.05$[d]
Med fibers, %	1.3	1.3	1.3	1.4	.26	N.S.
Kemp fibers, %	.39	.19	.52	.42	.12	N.S.

[a]Standard error of the mean.
[b]Based on shorn weights (gain does not include fleece weight).
[c]No significant treatment effect.
[d]L = significant linear response.
[e]Q = significant quadratic response.

tion the maintenance energy requirements of a 95 lb mature, castrated male Angora goat at minimal activity approximates .090 Mcal DE/lb live weight$^{.75}$ per day or 2.74 Mcal DE per day. This value is about 17% higher than that reported in the National Research Council's publication on the nutrient requirements of goats (6).

Grease fleece production increased with increasing digestible energy intake. Once again the value in Table 2 for the grease fleece production of goats receiving the highest energy intake is misleading. Regression analysis revealed that variation in grease fleece production was positively associated with average shorn weight ($r = .33$, $P<.10$) (Figure 2) and actual digestible energy intake ($r = .36$, $P<.05$) (Figure 3). However, there was considerable variation in fleece production, and in both cases the correlations were low. A slightly better fit was obtained when both average shorn live weight and actual digestible energy intake were included in the regression model. The equation was $Y = 2.51 + .0234X_1 + 23.8X_2$ ($r = .44$, $P<.05$); where Y = grease fleece production in lb/168 days, X_1 = average shorn live weight in lb and X_2 = actual digestible energy intake in Mcal DE/lb live wt$^{.75}$ per day.

The analysis of variance on the grease fleece data in Table 2 indicated a significant quadratic effect. Although a significant quadratic component was not found in the regression analysis, examination of the data points in Figure 3 shows no evidence that grease fleece continued to increase when the highest energy level was fed. If this is the case, these results would support the possibility there is an optimum protein to energy ratio for fiber production in Angora goats. Since protein intake was held constant in this study, the lack of response at the highest energy level suggests protein may have been a limiting factor. The protein to energy ratio in the diet fed to goats receiving the highest energy intake was 43.5 g CP/Mcal DE. This value slightly exceeds the protein to energy ratio (41.3 g TP/Mcal DE) recommended by NRC for a 95 lb goat producing 16 lb of mohair per year (6).

In studies with sheep, the supply of both protein and energy to the small intestine of adult animals affects the rate of wool growth and there appears to be an optimum ratio of protein to energy absorption required for maximum wool growth (5). When protein is limiting, an increase in protein absorption stimulates wool growth, but an increase in energy absorption reduces it. Goats may be similar to sheep in this regard. This possibility is supported by the work of Huston (4). When supplemental energy and protein were fed at varying rates to weaned Angora female kid goats, mohair production reached a maximum when .33 lb of TDN and .11 lb of crude protein were fed per day. However, growth rates were increased by higher levels of either or both supplemental nutrients.

Clean fleece yield was unaffected by digestible energy intake. Fiber diameter was positively correlated with both size of goats ($r = .56$, $P<.01$) (Figure 4) and digestible energy intake ($r = .34$, $P<.05$) (Figure 5). However, the best fit was obtained by including both average shorn live weight and actual digestible energy intake as independent variables in the regression model. The equation for this relationship was $Y = 19.5 + .133X_1 + 55.5X_2$ ($r = .61$, $P<.01$); where Y = fiber diameter in m, X_1 = average shorn live weight in lb and X_2 = daily digestible energy intake in Mcal DE/lb live weight$^{.75}$.

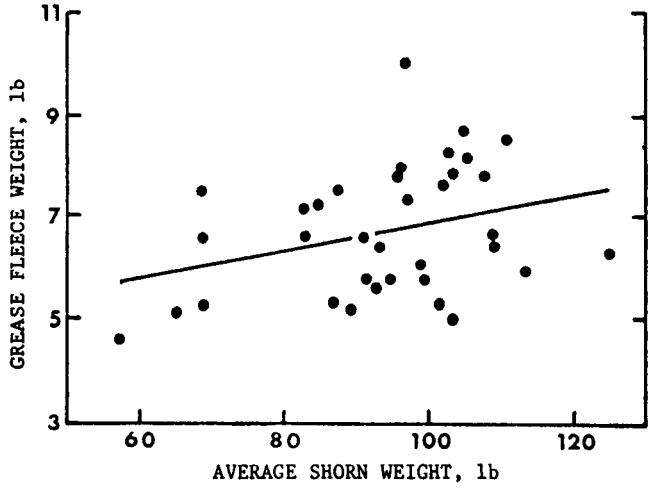


Figure 2. Relationship between average shorn weight (lb, X) and grease fleece produced (lb, Y) during a 168-day feeding period. Y = 4.01 + .0282X ($r = .33$; $P<.10$).

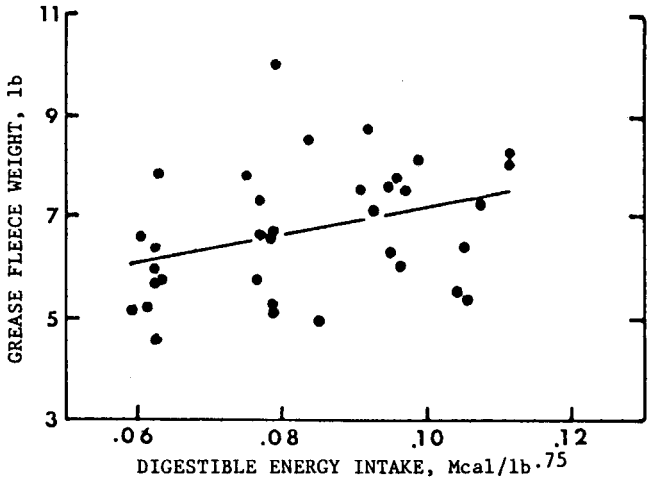


Figure 3. Relationship between digestible energy intake (Mcal/lb live weight$^{.75}$, X) and grease fleece produced (lb, Y) during a 168-day feeding period. Y = 4.36 + 27.8X ($r = .36$; $P<.05$).

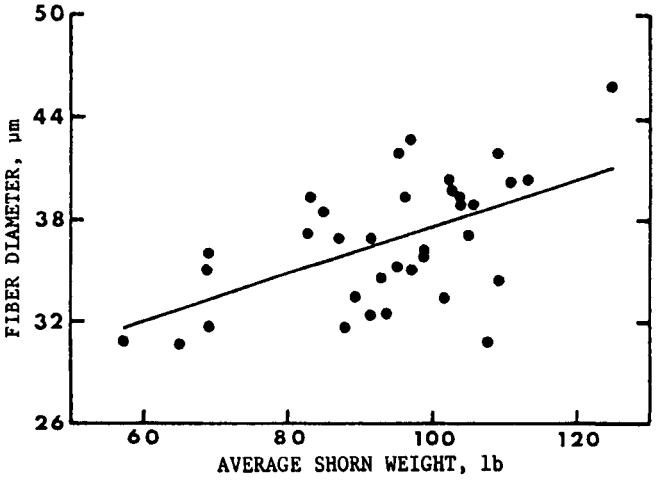


Figure 4. Relationship between average shorn weight (lb, X) and fiber diameter (µmY). Y = 23.0 + .144X ($r = .56$; $P<.01$).

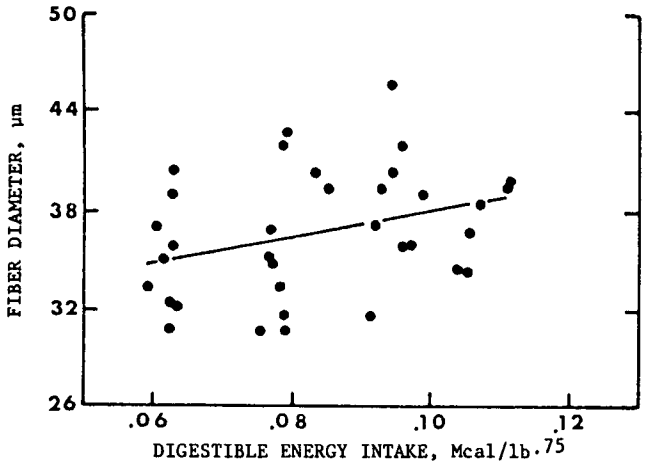


Figure 5. Relationship between digestible energy intake (Mcal/lb live weight$^{.75}$, X) and fiber diameter (µmY). Y = 30.1 + 77.7X (r = .34; P <.05).

Dietary energy was without effect on the numbers of medullated (med and kemp) fibers present in mohair. Medullated fibers differ from true mohair fibers in that they possess a hollow center or medulla of large air-filled cells. Med fibers are those in which the area of medullation is less than 60% and kemp fibers are those in which the area of medullation is greater than 60%. In studies to date there is no indication that nutritional factors affect the numbers of medullated fibers (2, 3); however, a seasonal increase in med fibers has been observed. The number of med fibers produced during fall and winter is much higher than during spring and summer (2).

Literature Cited

1. Bassett, J.W., B.C. Baldwin, Jr., M.C. Calhoun, and R.H. Stobart. 1981. Plasma methionine and mohair response to dietary rumen- protected methionine in Angora goats. Tex. Agr. Exp. Sta. Prog. Rpt. 3904.
2. Calhoun, M.C. Unpublished data.
3. Calhoun, M.C., J. Maurice Shelton, C.J. Lupton, B.C. Baldwin, Jr., and S.W. Kuhlmann. 1988. Effect of frequency of feeding a protein supplement on mohair production by Angora goats. Tex. Agr. Exp. Sta. Prog. Rpt.
4. Huston, J.E. 1980. Supplemental energy and protein effects on growth rate and mohair production in weaned Angora female kids. Tex. Agr. Exp. Sta. Prog. Rpt. 3706.
5. Kempton, T.J. 1979. Protein to energy ratio of absorbed nutrients in relation to wool growth. *In:* Physiological and Environmental Limitations to Wool Growth. ed by J.L. Black and P.J. Reis. Univ. of New England Publ. Unit. Armedale, pp. 209-222.
6. NRC. 1981. Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries. National Academy Press, Washington, D.C.
7. SAS Institute, Inc. 1985. SAS/STAT™ Guide for Personal Computers. Version 6 Edition. SAS Institute, Inc., Cary, North Carolina.
8. Shelton, J.M., and J.E. Huston. 1966. Influence of level of protein and other factors on the performance of yearling billies maintained in drylot. Tex. Agr. Exp. Sta. Prog. Rpt. 2399.
9. Shelton, M., J.E. Huston, J.R. Gallagher, and M.C. Calhoun. 1973. Efficiency of fiber production of various types of sheep and goats. Tex. Agr. Exp. Sta. Prog. Rpt. 3189.

Acknowledgment

This research was supported by a grant from the Natural Fibers and Food Protein Commission of Texas.

PR-4590

Effect of Frequency of Feeding a Protein Supplement on Mohair Production by Angora Goats

M.C. Calhoun, J. Maurice Shelton, C.J. Lupton, B.C. Baldwin, Jr., and S.W. Kuhlmann

Summary

Thirty, yearling, male Angora goats were used in a 120-day study to examine the effects of frequency of feeding a protein supplement on mohair production and fleece characteristics. The protein supplement (based on cottonseed meal) provided 48.2% of the crude protein in the diet. Feeding a protein supplement as infrequently as once every 5 days did not affect live weight gains, voluntary hay intake, fleece production, fiber diameter, and numbers of medullated (med and kemp) fibers compared to feeding at intervals of 1, 2, 3, or 4 days. Although frequency of protein feeding did not affect any of the performance criteria measured, an increase in the amount of hay consumed resulted in linear increases in live weight gain, fleece production, and fiber diameter, indicating the goats were responsive to nutrition. In view of the known responsiveness of mohair growth to dietary protein levels, the lack of effect of frequency of protein feeding was unexpected. A possible explanation would be increased by-pass (decreased breakdown in the rumen of dietary protein) as the amount of protein offered at each feeding increased.

Introduction

It is often necessary to provide supplemental feed during periods when quantity and quality of forage available to grazing animals is limited, i.e., late fall, winter, and early spring or during drought. Feeding less frequently than daily during these periods reduces labor requirements and encourages animals to spend more time grazing and to range farther from feeding areas. An additional advantage of less frequent feeding is that timid or slow-eating animals have a greater oppor-

tunity to get their proportion of feed. Numerous studies with cattle and sheep have demonstrated that feeding a protein supplement as infrequently as twice a week does not adversely affect performance (1, 2, 3, 4, 5). In reviewing the available literature, similar studies were not found for Angora goats; therefore, this research was conducted to determine the effects of frequency of protein supplementation on live weight changes and mohair production of Angora goats.

Experimental Procedure

Thirty yearling, male Angora goats (59.1 + 1.4 lb) were placed in individual pens and fed *ad libitum* a diet based on ground sorghum-sudangrass hay, cottonseed meal, and corn (Table 1) for a 28-day uniformity period. Subsequently, during a 120-day comparison period the complete diet was separated into three components; ground sorghum-sudangrass hay, ground corn, and a protein supplement. The percentage composition of the protein supplement is given in Table 1. The sorghum-sudangrass hay was provided *ad libitum* and fed separately from the corn and protein supplement.

Voluntary feed intake (VFI) during the uniformity period was used to calculate the amount of corn and protein supplement to be fed during the comparison period. Since corn comprised 20% of the complete diet during the uniformity period, ground corn was fed daily at a rate of .2 times VFI. The protein supplement was fed at a daily rate of .165 times VFI, but at intervals of 1, 2, 3, 4, and 5 days. On days a goat was scheduled to receive protein, the amount fed was determined by multiplying frequency of feeding by the daily rate. The actual amounts of corn and protein supplement offered were recalculated at 28-day intervals corresponding to the times goats were weighed.

All goats were weighed and sheared initially, and were reweighed at 28-day intervals. Goats were sheared again upon completion of the study. Fleeces were weighed and scoured. Grease and clean fleece yields were calculated and fiber diameter and numbers of medullated (med and kemp) fibers determined.

The design of this experiment was a randomized block (goats were blocked based on initial shorn weight) with five treatments (frequency of protein supplementation) and six replicates. The General Linear Model Procedure and regression analysis were used in the statistical treatment of the data (6).

Table 1. Percentage Ingredient Composition and Calculated Nutritional Values for a Complete Diet and Protein Supplement.

Item	Complete diet[a]	Protein supplement
Sorghum-sudangrass hay, ground	58.0	—
Corn grain, ground	20.0	—
Cottonseed meal	14.0	84.8
Calcium carbonate	1.0	6.1
Molasses, sugarcane	6.0	6.1
Salt, vitamin and trace mineral premix	1.0	3.0
Nutritional values[a]		
Dry matter, %	89.7	89.5
Total digestible nutrients, %	62.1	69.8
Crude protein, %	15.0	39.7
Calcium, %	.73	2.6
Phosphorus, %	.33	1.2

[a]With the exception of dry matter, nutritional values are expressed on a dry matter basis.

Results and Discussion

Because of the larger amounts offered on the days they were fed protein supplement, goats fed less frequently required more time to consume the supplement. However, the corn and protein supplements were consumed within several hours regardless of feeding frequency. Live weight gains presented in Table 2 were calculated from the difference between initial and final shorn weights. With the exception of those fed the protein supplement at 4-day intervals, all goats were gaining slightly during the study. However, differences in gains were slight and were unaffected by feeding frequency. Frequency of feeding the protein supplement did not affect hay intake, fleece production, fiber diameter, and the numbers of medullated fibers (med and kemp) present (Table 2).

Although feeding frequency was without effect on the criteria examined, there was considerable variation among animals in these measurements. For example live weight gains varied from -.066 to .108 lb/day. Grease fleece produc-

Table 2. Effect of Frequency of Feeding a Protein Supplement on Live Weight Gains, Voluntary Hay Intake, and Mohair Production of Male Angora Kid Goats.

	Frequency of feeding a protein supplement					
Item	1d	2d	3d	4d	5d	SEM[a]
Goats, no	6	6	6	6	6	
Initial shorn weight, lb	62.2	61.8	62.3	64.5	63.8	.7
Live weight gain, lb/d	.029	.028	.027	−.015	.016	.015
Feed consumption						
Hay, lb/d	1.21	1.18	1.21	.99	1.13	.10
Corn, lb/d	.60	.61	.60	.60	.61	.010
Protein supplement, lb/d	.36	.36	.36	.37	.37	.005
Grease fleece, lb	4.84	4.94	4.84	4.65	4.6	.22
Clean fleece, lb	3.95	4.06	3.95	3.83	3.95	.17
Fiber diameter, μm	32.6	34.3	34.1	32.9	34.5	.94
Med fibers, no/1000	9	12	16	10	6	4.9
Kemp fibers, no/1000	2	2	2	2	1	.6

[a]Standard error of the mean.

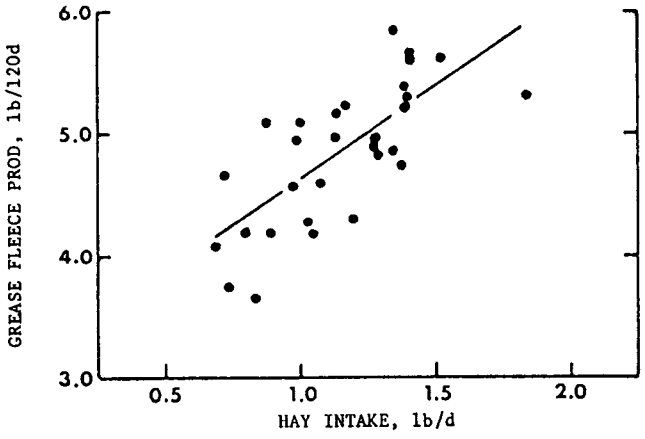


Figure 1. Relationship between voluntary hay intake (lb/day, X) and grease fleece production (lb, Y) during a 120-day feeding period. Y = 3.10 + 1.51X (r = .75; P<.01).

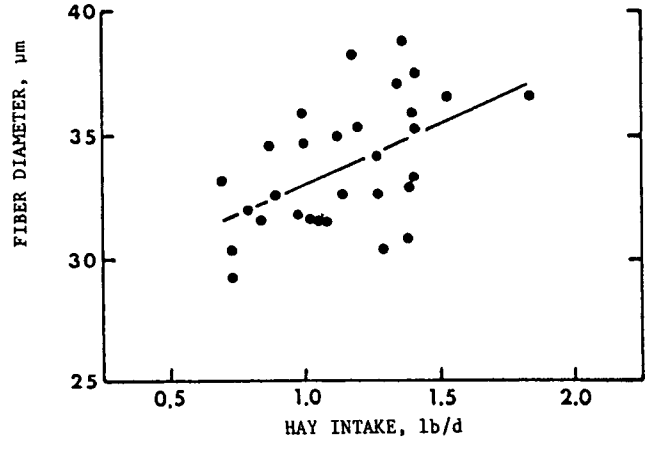


Figure 2. Relationship between voluntary hay intake (lb/day, X) and fiber diameter (µm,Y). Y = 28.0 + 4.97X (r = .54; P<.01).

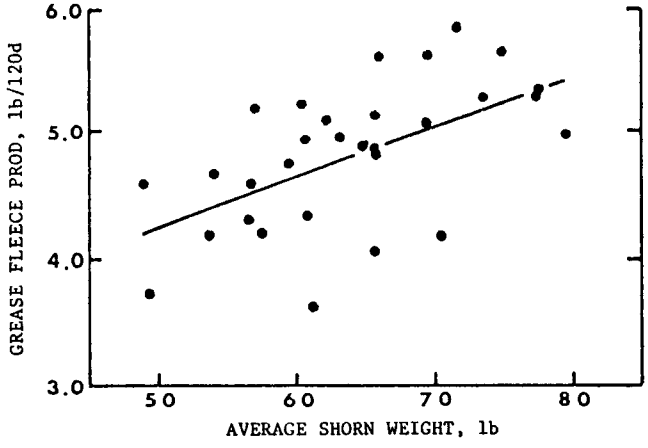


Figure 3. Relationship between average shorn weight (lb, X) and grease fleece production (lb, Y) during a 120-day feeding period. Y = 2.23 + .040X (r = .58; P<.01).

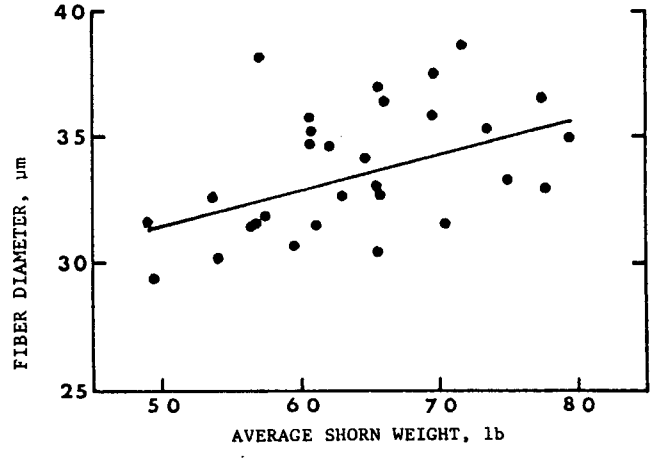


Figure 4. Relationship between average shorn weight (lb, X) and fiber diameter (µm,Y). Y = 24.4 + .14X (r = .47; P<.01).

tion varied from 3.64 to 5.82 lb/120 days and fiber diameter ranged from 29.4 to 38.7 µm. Part of this variability was associated with variation in the size of goats used. Average shorn live weights varied from 49.0 to 79.8 lb. Since all goats consumed the corn and protein supplement within a few hours on the day offered, the only nutritional variable remaining which might contribute to differences in performance was the amount of hay voluntarily consumed by individual goats. This varied from .69 to 1.83 lb/day and appeared unrelated to the size of the goats.

Live weight gain was negatively related to average shorn weight and positively related to voluntary hay intake. The equation for this relationship was $Y_1 = .094 - .0033X_1 + .117X_2$ (r = .67; P<.01), where Y_1 = live weight gain (lb/day), X_1 = average shorn weight (lb) and X_2 = hay intake (lb/day).

Grease fleece production (Figure 1) and fiber diameter (Figure 2) were also positively related to voluntary hay intake. The equations for these relationships were $Y_2 = 3.10 + 1.51X_2$ (r = .72; P<.01) and $Y_3 = 28.0 + 4.97X_2$ (r = .54; P<.01), where Y_2 = grease fleece production in lb/120 days, Y_3 = fiber diameter in µm, and X_2 = hay intake in lb/day. Grease fleece production (r = .58; P<.01) (Figure 3) and fiber diameter (r = .47; P<.01) (Figure 4) were correlated with average shorn weight, but the inclusion of average shorn weight in the regression model along with hay intake did not appreciably increase the correlations over those obtained when hay intake alone was used.

Averaged across all treatments, hay intake was 1.14 lb per day. This amount provided 54.3% of the daily dry matter intake and 35% of the crude protein. In comparison, corn provided 28.6% of daily dry matter and 16.8% of crude protein and the protein supplement 17.1% of dry matter and 48.2% of crude protein. Fleece production of yearling, male Angora goats has been shown to increase dramatically as dietary protein levels increased from 9.7% to 21.3% (7). The lack of an effect of frequency of protein feeding on performance criteria examined in this study was unexpected. The reason for this lack of response is unclear, but may be related to the extent of protein escaping ruminal degradation as the amount of protein available at each feeding increases. If the amount of dietary protein escaping from the rumen increased with less frequent feeding this would tend to compensate for less frequent feeding. Other compensating mechanisms may also be involved when protein is made available on an infrequent basis.

Additional studies specifically designed to examine nitrogen metabolism and rumen by-pass as influence by frequency of protein feeding are needed to provide an explanation.

Literature Cited

1. Coleman, S.W., and R.D. Wyatt. 1982. Cottonseed meal or small grains forages as protein supplements fed at different intervals. J. Anim. Sci. 55:11.
2. Kromann, R.P., E.E. Ray, and A.B. Nelson. 1966. Influence of frequency and source of protein supplementation on energy metabolism in feeder lambs. J. Anim. Sci. 25:1040.
3. McIlvain, E.H., and M.C. Shoop. 1962. Daily versus every-third-day versus weekly feeding of cottonseed cake to beef steers on winter range. J. Range Manage. 15:143.
4. Melton, A.A., and J.K. Riggs. 1964. Frequency of feeding protein supplement to range cattle. Tex. Agr. Exp. Sta. Bull. 1025. 8 p.
5. Nelson, A.B., R.P. Kromann, and W.E. Watkins. 1965. Interval of feeding cottonseed meal and ration utilization. J. Anim. Sci. 24:594. (Abstr.).
6. SAS Institute Inc. 1985. SAS/SAT™ Guide for Personal Computers, Version 6 Edition. SAS Institute Inc., Cary, North Carolina.
7. Shelton, J.M., and J.E. Huston. 1966. Influence of level of protein and other factors on the performance of yearling billies maintained in dry lot. Tex. Agr. Exp. Sta. Prog. Rpt. 2399.

Acknowledgment

This research was supported by a grant from the Natural Fibers and Food Protein Commission of Texas.

Table 1. Medullated Fiber and Fineness Values of Scoured Mohair and Top Samples.

Scoured hair				Top			
Diameter (μm)	S.D. of diameter (μm)	Kemp (%)	Med (%)	Diameter (μm)	S.D. of diameter (μm)	Kemp (%)	Med (%)
36.9	11.5	.6	1.3	34.2	10.4	.1	1.4
31.9	9.5	1.4	2.1	31.5	9.3	.7	.9
36.5	12.3	.8	1.2	37.6	11.6	.2	1.7
28.0	8.3	0	1.0	28.4	8.9	.3	1.2
35.0	11.0	.3	.4	35.6	10.9	.3	.6
25.3	7.0	.7	1.8	25.6	7.7	.2	1.4
31.7	10.8	.4	2.7	30.7	9.2	0	1.8
36.8	12.1	.3	3.0	35.8	11.6	.7	3.0
37.1	13.2	.9	1.8	38.8	12.2	.2	2.1
32.3	9.0	.1	.6	32.1	9.3	.1	1.1
30.0	9.7	.3	1.7	32.2	9.6	.1	1.4
32.0	10.3	.3	1.7	35.1	10.5	.5	2.4
36.1	11.5	.3	2.9	35.0	10.8	.3	1.3
25.8	8.0	.8	1.4	25.3	7.6	.7	2.4
25.8	8.2	.2	1.8	25.9	7.9	.4	1.9
29.6	8.8	.7	.1	30.2	9.3	.7	.4
40.8	11.7	.6	2.7	37.4	11.8	.4	1.6
38.0	11.7	1.2	.7	38.6	12.1	0	1.5
30.9	10.0	.5	1.5	32.6	10.3	.1	1.1
42.0	12.6	.6	3.2	37.7	11.7	.4	.9
25.3	8.0	.8	1.6	25.5	8.0	.5	1.0
27.2	9.0	.6	1.4	26.9	8.2	.7	1.1
27.8	8.8	.3	2.1	27.2	8.6	.1	.9
38.2	12.1	.8	2.2	38.0	11.9	.2	1.2
32.3	9.8	.6	.6	34.9	11.1	.4	.7
32.3	10.4	.6	1.6	36.2	11.6	.8	2.1
36.9	11.5	.1	.4	33.8	10.7	.5	1.0
34.7	11.0	.8	.4	34.4	10.8	.3	.5
31.9	9.8	.3	.8	32.6	10.0	.3	.8
Means							
32.72	10.26	.54	1.53	32.75	10.11	.35	1.35
Minimum							
25.3	7.0	0	.1	25.3	7.6	0	.4
Maximum							
42.0	13.2	1.4	3.2	38.8	12.2	.8	3.0

PR-4591

Determination of Acceptable Levels of Kemp in Mohair

C.J. Lupton, D. Lawford, N.E. Blakeman, and F.A. Pfeiffer*

The undesirability of kemp in mohair is well documented (1). Numerous genetic and environmental questions concerning kemp remain to be answered. In addition, at least one practical question has not been fully answered. How much kemp may be present in grease mohair that will result in tolerable amounts (e.g., less than 45 kemps per ounce) in top? Restated, this question becomes: What is the effect of standard scouring and worsted processing procedures on the kemp content of mohair? Although elimination of kemp in mohair is the ultimate goal, establishment of practical tolerance levels for grease mohair would be helpful in the interim.

A cooperative experiment between the Texas Agricultural Experiment Station and Texas International Mohair, Inc. (TIM), of Brady, Texas, was initiated in 1987. TIM is supplying .5 lb of scoured mohair and top from each production lot being processed at the mill. To date, the Wool and Mohair Research Laboratory has characterized 29 of these sets of samples in terms of diameter and medullated fibers. The results are summarized in Table 1.

The coefficients of determination (r^2) of simple, linear regression equations relating med and kemp in scoured versus top form are 0.015 and 0.221, respectively. Using the infor-

*Texas International Mohair, Inc., Brady, TX 76825.

mation obtained to date, only a poor prediction of medullation in top form may be obtained from a knowledge of med and kemp percentages in scoured form. Even the incorporation of diameter into the regression equations has failed to significantly increases the r^2 values.

This experiment will continue until a definitive conclusion is determined.

Literature Cited

1. Tiffany-Castiglioni, E. 1986. Review: genetics and management of kemp in mohair. Tex. Agri. Exp. Sta. PR-4403.