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RESEARCH REPORTS

Sheep and Goat, Wool and Mohair, 1990

The Texas Agricultural Experiment Station
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The Texas A&M University System

Foreword

The 1990 Sheep and Goat/Wool and Mohair Consolidated Progress Report has been prepared by Texas Agricultural Experiment Station scientists 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.

Sheet 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 sheet 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 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. Develop management schemes for optimal productivity under prevailing conditions.
2. Improve consumer acceptance of meat and fiber.
3. Decrease predation losses.
4. Develop objective processes to characterize meat, fiber and milk from sheep and goats.
5. Improve animal health by controlling parasites, infectious diseases and toxic and harmful plants.

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, 1990

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Reducing Lamb Mortality

T.D. Willingham and M. Shelton

Summary

Lamb mortality from birth to weaning has been reported (1) as the second greatest reason for reproductive inefficiency in the ewe. Research initiated in 1987 found that significant reductions can be made in lamb mortality by shifting to a fall or early spring lambing period, as compared to a winter lambing season. This course of action is especially important in prolific sheep because the increase in lamb survival can be attributed to greater survivability of multiple born lambs. While mortality rates among single-born lambs were relatively constant across seasons, losses from multiple births peaked in the winter. However, when shifting to a fall lambing season, caution should be taken to prevent breeding ewes in advance of June 15 as this may result in underweight, unthrifty, heat-stressed lambs. In addition, if prospects for unfavorable fall forage conditions exist, any gain in lamb survival may be offset by poor lamb performance. Care should also be taken to prevent breeding ewes for late spring lambs as growth and performance will be adversely effected.

Introduction

Improving reproductive efficiency has long been listed as a major concern among producers, researchers and industry groups. Research (1) indicates that there are three areas for improvement within the ewe's reproductive cycle. These areas include: 1) ovulation rate, 2) conception and embryo survival and 3) lamb survival.

Ovulation rate can be improved through several methods, three of which are selection within a flock or breed for increased lamb crop, inclusion of prolific breeds into a crossbreeding program or immunization against the ovarian androgen, androstenedione. While many opportunities exist for improving ovulation rate, such improvements in conception or implantation will prove difficult, because the reasons for fertilization or implantation failure are numerous and not readily understood.

Of the three identified areas of reproductive wastage, lamb survival is second only to losses from ovulation to conception (Figure 1), and it is conceivable that under certain conditions lamb mortality could be the greatest area of loss. Numerous articles have been written indicating that approximately 20 percent of all lambs born are lost between birth and weaning (2, 3, 4) with a range of 45 to 94 percent of these losses occurring in the first three days of life (5, 6). Several factors contributing to these losses are season of lambing or weather, birth type, birth weight, nutrition of the ewe, breed of the ewe or ram, and prior selection or culling practices. In addition, predation can cause catastrophic losses.

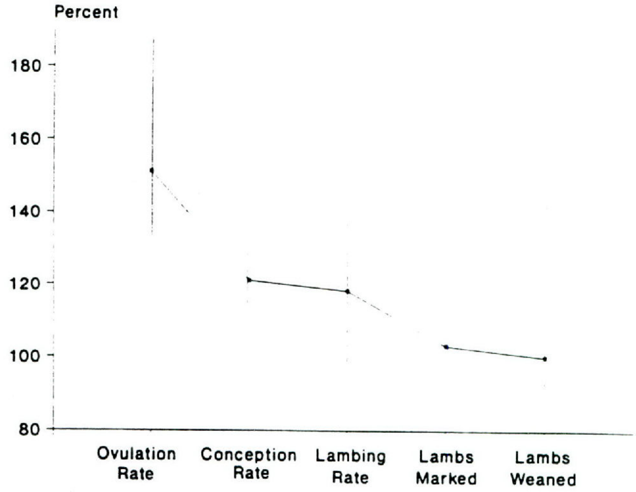


Figure 1. Areas of reproductive wastage.

While all of the factors listed may contribute to lamb mortality, the actual cause of death may result from starvation, hypothermia, dystocia, congenital defects or predation. Thus, it becomes important to manage the ewe so that contributing factors are controlled or limited in an effort to reduce losses to starvation, hypothermia or dystocia, to name a few.

Season of Lambing

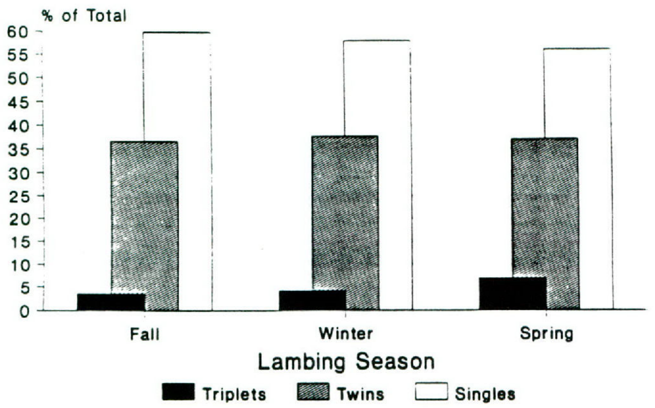
During the years of 1987 to 1989, evaluations of the influence of lambing season on lamb mortality have been made at San Angelo. Data was collected at the Winters Ranch near Brady, the Hill Ranch in Edwards County and at San Angelo. The lambing seasons evaluated were from mid-November to mid-December (fall), mid-January to mid-February (winter), and mid-March to mid-April (spring). Results of ewe reproductive performance are shown in Table 1.

Lambs born in the fall had the lowest mortality rate (13.1 percent) when compared to winter (21.7 percent) and spring (16.6 percent). Spring mortality was only marginally higher than fall, which was likely a result of the 7.8 percent increase in the number of lambs born per ewe lambing. This increase can be attributed largely to an increased incidence of multiple births among spring lambing ewes. Figure 2 exhibits the breakdown of birth type percentages by season. Notice the greater percentage (6.9) of triplet births during the spring as compared to only 3.6 percent for fall and 4.3

Table 1. Reproductive performance of ewes lambing at different seasons over a 2-year period (pooled across locations).

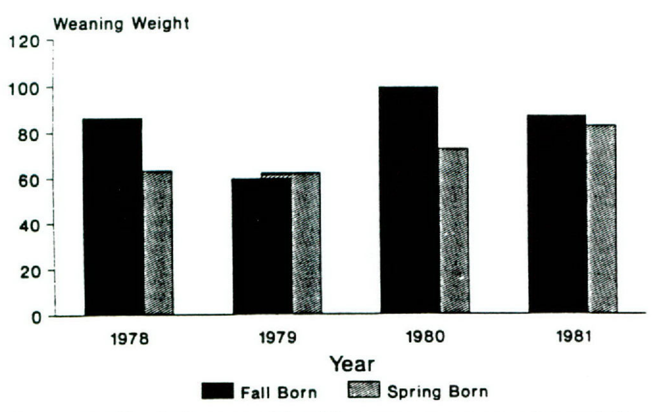
	Fall	Winter	Spring
Number of lambs born	397	415	464
Percent lambs born/ewe lambing	143.8	147.2	151.6
Number of lambs weaned	345	325	387
Percent lambs weaned/ ewe lambing	125.0	115.2	126.5
Percent mortality birth/weaning	13.1	21.7	16.6

percent for winter. The greater number of triplets in the spring skews the difference between fall and spring mortality rates (Table 1) because triplet births have a lower survival rate. The effect of birth type will be discussed more fully later.



Figrue 2. Birth type percentages by season.

Although lamb survival was better for fall- versus winter-born lambs, producers should not make a decision to breed for fall lambs for this reason alone. Generally, producers should breed for fall lambs only when the prospects for winter grazing from range or grain fields are reasonably good. Even under these conditions, the ewes should be exposed to the ram a second time for late winter or spring lambs. Shelton and Thompson (7) found a beneficial effect on lamb production at Brady (McCullough County) when ewes were bred for fall lambs with clean-up matings for spring lambs (Figure 3).



Figrue 3. The influence of lambing season on weaning weight.

Weaning weights and market prices favored fall-born lambs for 3 of the 4 years examined, although in periods of unfavorable forage conditions the fall lambs may perform less favorably than spring lambs, as in 1979. Also, the total number of lambs raised were approximately the same, suggesting a higher lambing rate in the spring. Most of the advantage in fall lamb production resulted from improved growth rate of lambs. These results are supported by an earlier study done by Shelton at McGregor (unpublished data), in which 120-day weaning weights (Figure 4) were evaluated for lambs born in four different seasons. The indicated differences may actually be greater under some conditions. These data indicate that winter-born lambs had the greatest weaning weight but only marginally so when compared to fall-born lambs. However the fall-born lambs would result in a greater advantage to the producer on a per ewe lambing basis because of the larger percentage of lambs weaned from a fall lambing season. However, it should be kept in mind that fewer lambs will be born on a total flock basis in a fall lambing because of the lower conception rate of ewes bred during the summer. Thus, it becomes essential to extend the breeding season or expose the ewes again at a later date to reduce the impact of lower conception rates. These data also suggest a lower growth rate for spring- and summer-born lambs, possibly making these time periods undesirable except in areas or periods of favorable feed conditions.

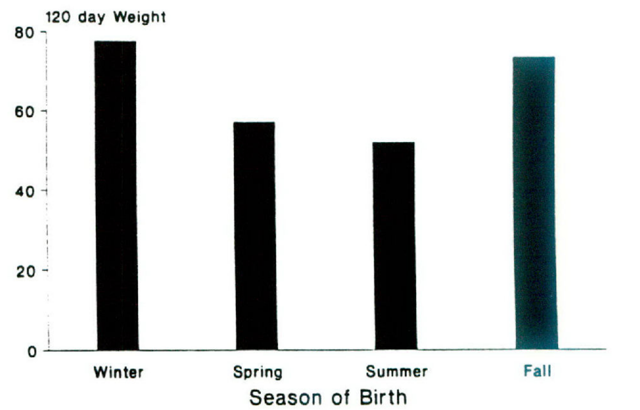


Figure 4. The effect of season of birth on weaning weight of lambs.

Figures 5 and 6, adapted from Rook (8), display the major time periods of lamb mortality with the greatest number of losses occurring in week one and the first 3 days of life, while Figure 7 displays the actual causes of death by season. Catastrophic losses such as predation were not a factor in these data. Focusing only on total losses, the primary observation is the low number of lambs lost to hypothermia. This may have been due to management intervention since the ewes were lambed with some supervision as proved necessary to collect lambing data. Second, the past 2 years have proven to be milder during the colder months, thereby aiding lamb survival. Third, and probably the most significant reason, is the possibility that lambs were erroneously classified into starvation and unknown groups. It is extremely possible that lambs may have starved as a result of chilling down and becoming too weak to nurse. Also, other lambs dying from hypothermia could have

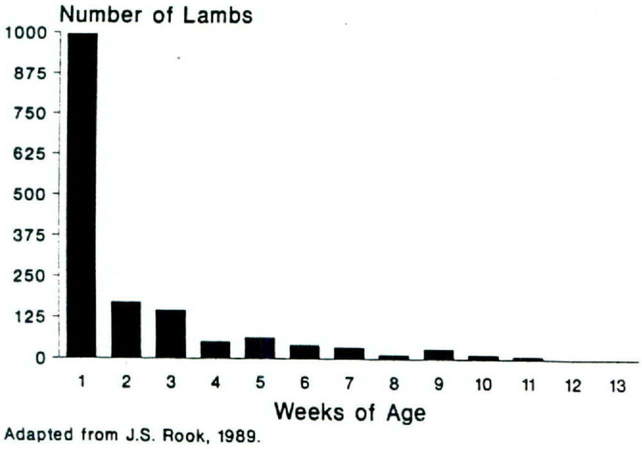


Figure 5. Age at time of death (post partum).

fallen into the unknown or undiagnosed classification. Whatever the explanation, the loss to hypothermia is less than expected and should vary greatly depending on the year. The combination of starvation and hypothermia accounts for 46.8 percent of the total losses, which is greater than the 30 percent Rook (9) reported. However, Rook reported that hypothermia and starvation may account for as much as 49 percent or as little as 2 percent of total lamb mortality. Rook also suggested that for lambs dying on day one in week one, 50 percent of these will be a result of hypothermia or starvation. Other major losses occur as a result of dystocia (16.8 percent) and autolyzed or stillbirths (8.4 percent).

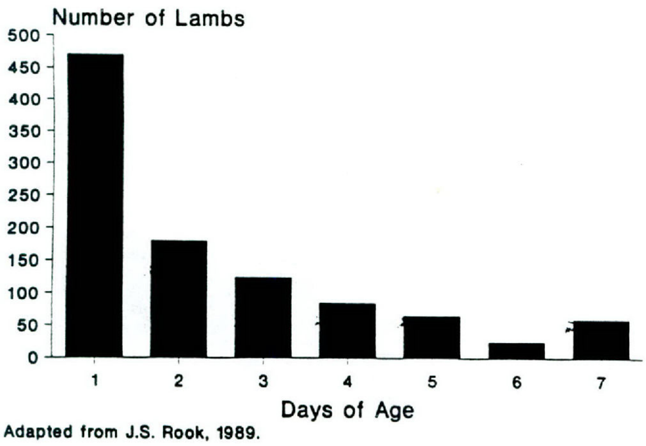


Figure 6. Age at time of death (post partum).

Results of these data indicate that lamb mortality can be reduced by shifting to a fall or spring lambing season. However, caution must be exercised when shifting to either of these lambing periods. If lambing is to occur in the fall, ewes should not be bred to lamb until at least 30 days after the expected termination of hot weather, as it has been shown (10, 11) that high ambient temperatures during gestation can reduce birth weights and lamb growth and survival, thus, making lambing before this time undesirable. Lambing late in the spring also should be avoided because of the potential reductions in lamb growth that result from increasing ambient temperatures, decreasing forage quality and the resurgence of parasites. Producers using small grain fields may also find spring lambing less

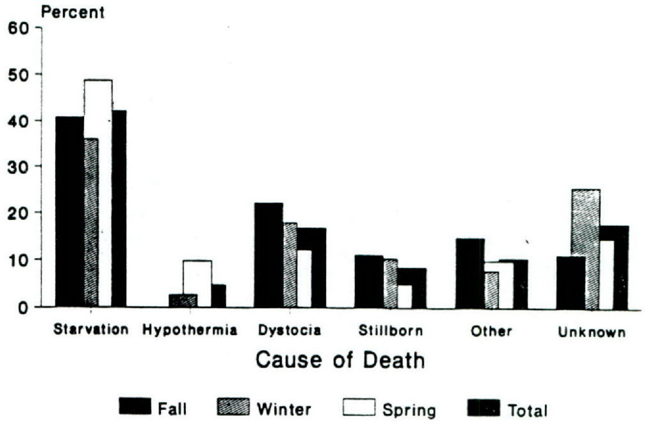


Figure 7. The influence of lambing season on lamb mortality by cause.

desirable because small grains are beginning to mature when lambs are reaching an age at which they are capable of utilizing the forage, thus, reducing the number of total grazing days.

Birth Type

It has long been recognized that with increases in multiple births, lamb survival decreases (4, 12). Reasons for this increased mortality can be attributed to reduced birth weights and increased competition for maternal nutrients, both pre-partum and post-partum. Research (12, 13) indicates a greater incidence of autolyzed or mummified lambs among multiple (triplet or greater) bearing ewes. This condition is believed to result from intrauterine competition, although disease also can be a factor. Dystocia also has been found to be related to birth type independent of birth weight. Researchers (12, 13) found increased proportions of malpresented lambs or prolonged births with increases in litter size. Dalton (5) reported similar results among multiple-born lambs even though birth weights were considered low. Seasonal effects also have a significant impact on lamb survival as reported by Shelton (10) and from the current study being conducted at San Angelo (Figure 8). Figure 8 gives a breakdown of lamb mortality by birth type and season. Triplet or greater birth types were deleted from the data because of their low incidence. Lamb

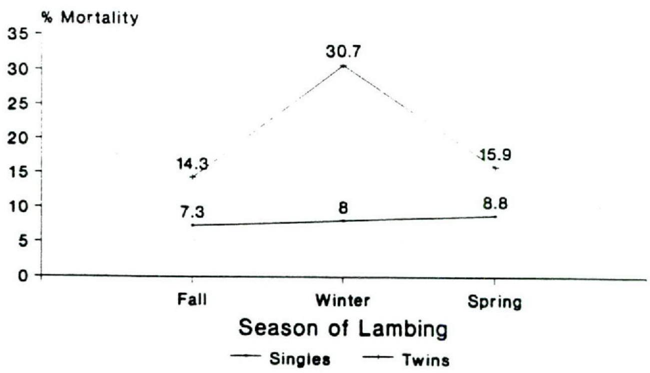


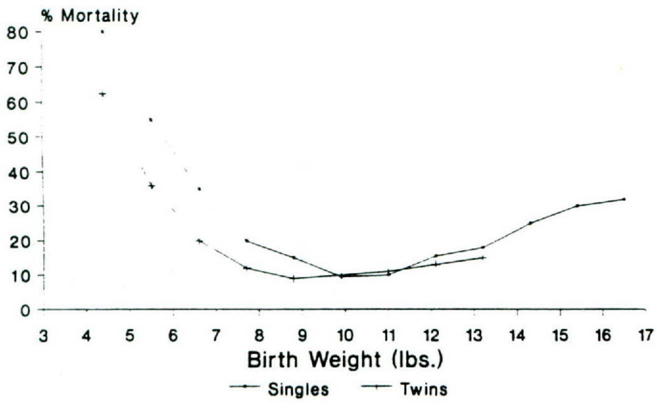
Figure 8. The influence of lambing season and birth type on lamb mortality.

mortality for singles tends to be constant across seasons, with a slight increase from fall to spring. This increase is likely due to chance, with season having little effect.

Mortality rates among twins were greater at each season when compared to singles and showed a marked increase during winter lambing. One would expect this increase during winter to result from increased hypothermia although the results of this study show hypothermia-related deaths to be only minor, but the authors believe that starvation and unknown causes are masking actual deaths due to hypothermia.

Birth Weight

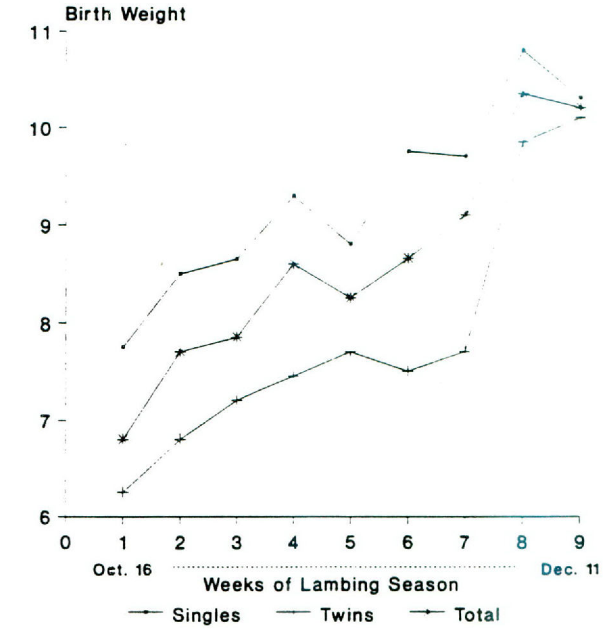
Numerous articles have been written discussing the relationship between large single lambs and dystocia as well as the greater mortality rate of multiple birth lambs (5, 6, 13, 14, 15). Figure 9, adapted from work done by Scales and associates (6), best illustrates this relationship. Mortality rates increased sharply for both single and twin lambs weighing below 8 pounds, while mortality rates increased only moderately for lambs weighing more than 12 pounds. While this weight range appears to be the consensus (6, 15, 16), it should not be considered absolute because other researchers (16) have shown the minimum to be approximately 6 pounds.



Adapted from G. H. Scales, et al. 1986.

Figure 9. The influence of birth weight on lamb mortality by birth type.

Achieving this weight range for all lambs will prove impossible but reducing the frequency of these extremes can be accomplished through supplementing the ewe's diet during gestation. Nutrition of the ewe is a major factor affecting birth weights; however, evidence has been reported (10, 11) that indicates that breeding during periods of high ambient temperatures can reduce birth weights. Work conducted by Shelton (10) best illustrates the effect of time of breeding and temperature on subsequent birth weights (Figure 10).



Adapted from Shelton, 1964.

Figure 10. The relation of birth weight of lambs to date of lambing in a fall lambing program

Breeding during this study began around May 20 and proceeded until late July. Birth weights were found to increase with the advance of the lambing season. Optimal birth weights of singles were not obtained until week four which approximates a June 15 breeding. Twin lamb birth weights did not reach an optimal level until late in the lambing period although acceptable weights occurred as early as week four. These data suggest that if fall lambing is chosen, breeding prior to June 15 may prove undesirable because of reduced birth weights and the production of weaker, heat-stressed lambs. Results from current work underway at San Angelo also indicate that ewes can be bred as early as June 18 or as late as November 15 without having a significant impact on birth weights (Table 2).

Ewe Nutrition

With the exclusion of lamb mortality related to disease or toxic plants, nutrition of the ewe during pregnancy likely has the greatest effect on lamb survival. Research has indicated that increased levels of prenatal feeding brought about a reduction in pregnancy toxemia and an increased birth weight and growth rate for both single and twin lambs

Table 2. Mean birth weights at three lambing seasons by birth type (pounds).

	Fall		Winter		Spring	
	Singles	**Twins**	**Singles**	**Twins**	**Singles**	**Twins**
Live	8.9	8.5	8.9	8.5	9.0	8.5
Died	10.0	7.6	9.8	8.7	10.4	8.1
Total	9.1	8.4	9.0	8.6	9.1	8.4

(17) in addition to improving milk production of ewes (18, 19). However, feeding at levels above those required to meet the ewe's needs or for time periods longer than necessary only reduce total profit to an operation. Therefore, it becomes important to identify nutrient requirements during gestation to optimize lamb production and survival. Determining prescribed levels of feeding and duration are confounded by yearly variation in pasture quality and number of fetuses the ewe is carrying. Research (20) conducted an San Angelo in 1985 indicate that increasing both protein level and length of feeding improves birth weights (Table 3).

Table 3. The influence of protein level and length of feeding on birth weights.

Treatment	Number	Birth weight, pounds Singles	Twins
Control/lactation	59	9.7	8.4
Late gestation	41	10.4	8.6
Mid-gestation	40	11.0	9.3
Control	59	9.7	8.4
Low protein	23	9.7	8.2
Medium protein	28	9.7	8.8
High protein	34	11.9	9.5

Adapted from L. H. Ripley, 1988.

However, all birth weights were within an acceptable range even for animals not supplemented before parturition or when supplemented at approximately 66 percent of NRC daily requirements. It should be pointed out, though, that these data were collected during a year when rainfall in September was twice the average amount. Because of this increase in rainfall, pasture quality likely was improved thereby reducing the impact of supplemental feeding. Other research (J.E. Huston, personal communication) conducted in 1988 further typifies the difficulty of developing static feeding regimes (Table 4). These data indicate a marked improvement in twin birth weights with increased levels of protein or energy.

Although evidence clearly defining a feeding regime for an individual producer may prove difficult because of forage differences due to year and location effects, supplemental feeding should be used to improve lamb production and survival. The authors believe that under average conditions, supplemental feeding and pasture forage allowing ewes to be near 100 percent of NRC daily requirements during the last 6 weeks of gestation will improve lamb survival. The amount of supplement and length of feeding will vary with pasture conditions. The use of fall lambing could eliminate much of the cost associated with supplemental feeding during gestation. However, under adverse conditions and in the absence of small grain fields, feed requirements could be greater because of the increased nutritional needs of the lactating ewe.

Table 4. The effect of level and length of supplemental feeding on lamb birth weights.

Treatment	Number	Birth weight, pounds Singles	Twins
Control	15	9.5	6.6
High protein/ low energy	30	10.1	8.8
Low protein/ high energy	22	11.5	9.5
High protein/ high energy	26	10.1	7.7

Adapted from J. E. Huston, unpublished data.

Breed

In addition to the previous factors discussed, breed of sheep has a significant impact on lamb survival (21). Large differences in lamb mortality (Table 5) were observed between breeds, within and across season of lambing. Prolific breed crosses exhibited greater mortality rates than Rambouillet ewes with the exception of Booroola Coopworth cross ewes. The lower mortality rate of the Booroola Coopworth is believed to be due to a lower number of observed ewes lambing and would likely be higher as a result of increased multiple births (Figure 11), as would be the case with all the prolific crosses. Fall lambing exhibited the lowest mortality rate for all breeds except the Booroola Merino in which only four ewes lambed. Observed mortality rates reflect badly on several of the prolific breeds. However, selection of a breed should not be based solely on the basis of reducing lamb mortality, as this would exclude many of the prolific breeds that may well prove more profitable even with increased levels of lamb mortality. Rather, breed selection should include adaptability to the environment and management system, wool quality and the pounds of lamb sold.

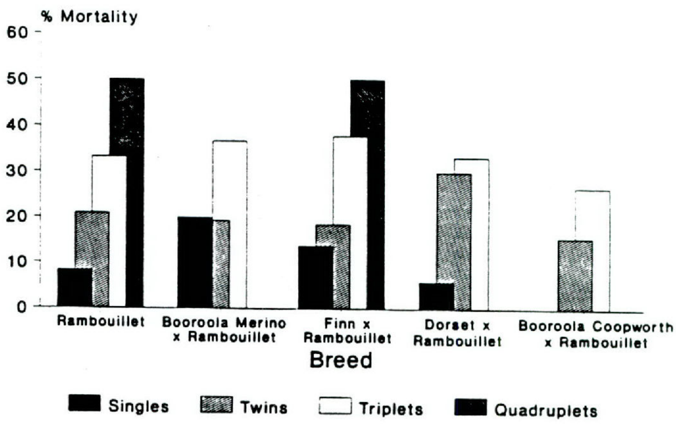


Figure 11. The influence of breed and birth type of lamb mortality.

Table 5. Ewe reproductive performance by breed and season of lambing.

First lambing season	Rambouillet	Booroola Merino x Rambo.*	Finnish Landrace x Rambo.	Dorset x Rambo.	Booroola Coopworth x Rambo.
Ewes lambing	161	4	46	25	21
Number of lambs born	214	8	81	34	39
Percent lambs born/ ewe lambing	132.9	200.0	176.1	136.0	185.7
Number of lambs weaned	184	6	69	31	34
Percent lambs weaned/ ewe lambing	114.3	150.0	150.0	124.0	161.9
Percent lamb mortality to weaning	14.0	25.0	14.8	8.8	12.8
Second lambing season					
Ewes lambing	228	13	22	8	7
Number of lambs born	319	26	39	15	11
Percent lambs born/ewe lambing	139.9	200.0	177.3	187.5	157.1
Number of lambs weaned	256	20	28	6	9
Percent lambs weaned/ewe lambing	112.3	153.8	127.3	75.0	128.6
Percent lamb mortality to weaning	19.7	23.1	28.2	60.0	18.2
Third lambing season					
Ewes lambing	224	11	31	6	9
Number of lambs born	333	27	66	14	16
Percent lambs born/ewe lambing	136.5	245.5	212.9	233.3	177.8
Number of lambs weaned	292	17	46	11	13
Percent lambs weaned/ewe lambing	119.7	154.5	148.4	183.3	144.4
Percent lamb mortality to weaning	12.3	37.0	30.4	21.4	18.7

* Data are available on a larger number of Booroola x Rambouillet ewes, but many of these were bred back to Booroola rams. Data on these have been excluded from the above tabulation. Data for this group are reported only for Booroola cross ewes which are bred back to the same rams used on the other ewes.

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PR 4772

Angora Kid Survival in Grass versus Fourwing Saltbush-grass Pastures

D.N. Ueckert, J.L. Petersen, B.K. Lawrence and J.E. Huston

Summary

Death loss of kids is the single greatest loss in reproductive efficiency of Angora goats. Death loss of kids can be largely reduced by management, such as kidding in areas which afford natural protection during inclement weather, kidding in small pastures to minimize abandonment of kids, and providing adequate supplemental nutrients to does during late gestation and lactation. A study was initiated during 1990 to evaluate fourwing saltbush-grass mixture pastures for "small-camp" kidding. The dense, evergreen shrub canopies provided protection during inclement weather and the saltbush foliage provided supplemental nutrients. Kid crops were significantly greater in saltbush-grass pastures (1.28 kids/doe) than in bluestem pastures with temporary shelters (1.06 kids/doe) ($P \leq 0.10$). The percentage of does that lost a kid or kids in saltbush-grass pastures was 13 percent compared to 19 percent in bluestem pastures, but the difference was not statistically significant. The data suggest that fourwing saltbush-grass plantings may be useful for increasing the reproductive efficiency of Angora goats. The experiment will be repeated in 1991 and 1992.

Introduction

Achieving a high reproductive rate is economically advantageous to Angora goat producers because of increased income from kids sold, increased ability to improve flocks by selection, and improved quantity and quality of mohair produced. The average Angora kid crop weaned in Texas has been estimated at only 50 to 60 percent. Death loss of kids is the single greatest loss in reproductive efficiency of Angora does (3). In a 1973 study, 22 percent of the does lost their kid or kids (4).

Loss of kids is attributed to abandonment, predation, chill or cold stress, low birth weights and low vigor of kids, and damaged udders. Death losses of kids can be minimized through management, such as extensive predator control prior to the kidding season, kidding in pastures which provide natural protection during inclement weather, minimizing disturbance such as gathering flocks during the kidding season, minimizing travel necessary for the doe to search for forage, "small-camp" kidding or confinement kidding (1, 3). Kid crops averaged 87, 71 and 64 percent for confinement kidding, small trap kidding and pasture kidding, respectively, during a 3-year study in the Edwards Plateau. An economic analysis suggested that both confinement kidding and small-trap kidding were more profitable than pasture kidding (1).

Small pastures supporting dense stands of fourwing saltbush (*Atriplex canescens*) and an understory of herbaceous vegetation appear to be ideal for "small-camp" or small-trap kidding because of the natural protection afforded by the dense, evergreen shrub canopies. Although the nutritive value of fourwing saltbush forage to pregnant or lactating Angora does has not been quantified, the laboratory-determined nutritional value of its winter foliage (17 to 18 percent crude protein, 0.13 to 0.14 percent phosphorus, and 58 to 59 percent in vitro digestible organic matter) (2) and data from our 1989-90 grazing trial with yearling Angoras (5) suggest that the shrubs would provide some of the supplemental nutrients needed by Angora does during late gestation and lactation. A study was initiated during February 1990 to evaluate the use of fourwing saltbush pastures for kidding of Angora does.

Experimental Procedures

Sixty Angora does diagnosed as being pregnant based on udder examination (bred during October 2 - November 29, 1989) were selected from a flock at the Texas Agricultural Experiment Station at San Angelo after they were slick sheared (no capes) on February 7, 1990. The does were divided into eight uniform groups (average weight 99 pounds). The groups were randomly assigned to small pastures at the Research Center supporting monocultures of WW-Spar old world bluestem (*Bothriochloa ischaemum* var. *ischaemum*) or mixtures of fourwing saltbush and various grasses [sand dropseed (*Sporobolus cryptandrus*), slim tridens (*Tridens muticus*), kleingrass (*Panicum coloratum*), and silver bluestem (*Bothriochloa saccharoides*)] on February 8, 1990. Annual forbs, including redseed plaintain (*Plantago rhodosperma*), huisache daisy (*Amblyolepis setigera*), and plains dosedaisy (*Aphanostephus ramossissimus*) established in the saltbush-grass mixture plots subsequent to significant precipitation in late February and mid-March 1990. Forbs did not establish in the bluestem pastures. Grasses initiated spring growth in both treatments in early March.

Four replications of each treatment were stocked at one doe/0.63 acres. Eight does were placed in each of four 5-acre saltbush-grass mixture pastures, and four does were placed in each of four 2.5-acre bluestem pastures. Initial weights of the does were recorded following a 14-hour fast.

Whole cottonseed was fed twice weekly until April 26 to does in both treatments to provide 0.5 pound/head/day. Water, salt and a mineral supplement containing 10 percent phosphorus and 7 percent calcium were provided *ad libitum*. Temporary, plastic shelters were provided in the bluestem pastures for protection from northerly winds and rain. An observer quietly walked through each pasture weekly to count live kids and remove dead kids. The goats were removed from the pastures on May 6, 1990, and final weights were recorded after a 14-hour fast. The number of does in each group that were lactating on May 7 was recorded to facilitate calculation of percentages of does that had apparently lost a kid (or kids).

Results and Discussion

Temperatures were relatively mild during most of the study period, but there were two precipitation events during February, three during March, five during April, and two during May that created conditions conducive to chill or cold stress of does and kids. Kidding began on about March 1. Kids were frequently observed bedded down beneath saltbush canopies. There was no mortality of does during the study and only three dead kids were found (one in a saltbush-grass mixture pasture and two in a bluestem pasture). However, examination of udders at the end of the experiment revealed that about 19 percent of the does grazing bluestem pastures had lost their kid or kids compared to about 13 percent of the does grazing saltbush-grass pastures (Table 1). The kid crop from saltbush-grass pastures (1.28 kids/doe) was significantly greater ($P \leq 0.10$) than that from bluestem pastures (1.06 kids/doe). The weight loss of Angora does in saltbush-grass pastures was -22 pounds/head during the 87-day trial, which was significantly less ($P \leq 0.10$) than the -26 pounds/head weight loss for does grazing bluestem pastures. Average weights of Angora kids raised in saltbush-grass pastures and bluestem pastures were similar (27 versus 28 pounds) (Table 1).

Kid crops for both treatments were about twice the estimated average of 50 to 60 percent for the state, however, this increase cannot be attributed totally to management, since only does that were obviously pregnant were utilized in the experiment. Differences in kid crops among the two treatments may have been greater if the plastic shelters had not been used in the bluestem pastures. The data on kid crops and percentages of does that lost their kid (or kids) suggest that small saltbush-grass pastures may be excellent sites for "small-camp" kidding of Angoras. Differences in weight changes of Angora does cannot be attributed to the nutrients provided by fourwing saltbush in this study, even though the does appeared to readily consume saltbush, because forbs were also present and utilized by goats in the saltbush-grass pastures. This experiment will be repeated in 1991 and 1992.

Table 1. Effects of kidding Angora does in fourwing saltbush-grass versus grass pastures on reproductive efficiency and on doe and kid weights

	Pasture type	
Performance criteria	**Fourwing saltbush - grass**	**Grass only**
Kids raised (number/doe)	1.28 a[a]	1.06 b
Does losing kid (or kids) (percent)	12.5	18.8
Doe weight loss February 8 - May 7, 1990 (pounds/head)	-22 a	-26 b
Kid weights May 7, 1990 (pounds/head)	27	28

[a]Means in a row followed by different lower case letters are significantly different at the 10 percent probability level.

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PR 4773

The Efficacy of Immunization Against Androstendione in Improving Various Reproductive Traits

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

Summary

Two experiments of 3 years duration each were conducted to study the effect of immunization against the hormone androstenedione on lamb production of range Rambouillet ewes. In the 1 year in which it was recorded, the ovulation rate was increased by 0.47 per ewe. However, this increase in ovulation rate resulted in an additional wastage of 18 ova or embryos per 100 ewes exposed. In addition to improving ovulation rate, an overall increase of 0.24 and 0.39 in the number of lambs born per ewe lambing was obtained in experiments 1 and 2, respectively. Significant increases were realized in the number of lambs born per ewe exposed and lambing for each year in each experiment, with the exception of the ewes lambing as 7-year-olds, in experiment 1. Treated ewes raised more lambs than controls, but this difference was statistically significant only in 1987 for the second experiment or for the 3 years combined. These data suggest that, if the increase in both ovulation rate and lambing rate is to be exploited, additional measures must be taken to improve lamb survival.

In each experiment, reproductive data were obtained for 1 additional year, in which the ewes did not receive booster shots. In this comparison there was no beneficial carry-over effect, as the ewes which had been treated (immunized) in previous years were slightly below the controls in reproductive efficiency.

Introduction

Improving reproductive efficiency in sheep has been listed as a top priority for the sheep industry by researchers and producers. The use of selection within a flock for increased prolificacy or the inclusion of prolific breeds into a crossbreeding program are potential methods for improving reproductive potential. However, both of these options, although desirable, may present problems. Within-flock selection for increased prolificacy offers the greatest long-term improvement but requires extensive record keeping and genetic progress will be slow. Thomas (1) reported an average annual increase of 2 percent in flocks selecting for prolificacy. The use of prolific breeds or crosses offers a great potential in many parts of the U.S. With the prolific breeds, problems such as fleece quality, reduced lamb survival or growth may be encountered. In any case, breeders may desire a more immediate response than that to be realized through genetic approaches. In recent years research has been initiated (2, 3, 4) proposing that the immunization of sheep to androstenedione, using androstenedione protein conjugates, leads to the formation of antibodies which results in increased ovulation rate. Scaramuzzi (2) suggested that these antibodies disrupt the normal feedback relationship between the hypothalamo-pituitary axis and the ovary, resulting in increased ovarian stimulation and increased ovulation rate. It was the purpose of this study to determine if this increase in ovulation rate would result in an increased lamb crop weaned under Texas range conditions.

Experimental Procedure

An experiment was initiated in September 1984 to evaluate the usefulness of immunizing against the ovarian steroid androstenedione to increase reproductive performance in Rambouillet ewes. Ninety-eight 4-year-old Rambouillet ewes were randomly sorted into two groups. Forty-eight ewes were assigned to the control group, in which no treatment was implemented. The additional 50 ewes were assigned to a immunized group. Immunization consisted of treating the ewes with a 2 ml subcutaneous injection of androstenedione-7 HSA in a DEAE dextran adjuvant (Fecundin)[1] 7 weeks prior to mating. An additional 2 ml booster was given 2 weeks prior to mating. In subsequent years, only a single 2 ml injection of Fecundin was given to the immunized ewes 2 weeks prior to the start of the breeding season. This procedure was followed through the breeding season of 1986. In the breeding season of 1987, the immunized ewes were not given a booster injection but reproductive performance was monitored for an additional year in an attempt to evaluate any residual effects of prior treatment.

The ewes were maintained on native grass pastures at the Winters-Wall Ranch in McCulloch County, Texas. Ewes were given protein supplementation prior to and after lambing based on range condition. Individual ewe records were maintained each year and included dam weight at beginning of breeding season, number of lambs born, number of lambs weaned and weaning weights. At lambing all ewes were placed in small pens with shelter or in adjacent traps so that lambing records could be obtained. No measures were taken to artificially rear any lambs. This experiment was terminated at weaning in 1988.

In 1986, a second experiment was initiated using 100 2-year-old ewes. These animals were randomly assigned to two groups: control and immunized. Each group was treated the same as the older ewes in the first experiment, and the appropriate records were maintained. In addition to lambing data, ovulation rates were collected in 1986 only by laparoscopy. The immunized animals were not given booster injections prior to the 1989 breeding season in an attempt to gain additional data on residual effects of Fecundin. The second experiment was terminated in 1990.

Data were analyzed by the use of the General Linear Model (5), testing for the main effects of treatment and year. A full factorial model also was used to test for any year and treatment interactions, for which none was found to be significant. The variables of lambs born and weaned were transformed prior to significance testing, by taking the square root of the number of lambs born or weaned per ewe observed after adding one. Means were tested using Tukey's Least Significance Difference Test. Chi square was used in determining the significance of treatment on the number of ewes lambing per ewe exposed. Overall means were calculated by taking the sum of all observations across years and dividing by the total number of ewes observed. Analysis of variance was then used to test for a significant treatment effect.

Results and Discussion

Results from the first experiment involving immunization of 4-year-old ewes are shown in Table 1. These data indicate a significant increase in the number of lambs born per ewe exposed (27.8 percent and 31.6 percent in 1984 and 1985, respectively). The increase was only 25.0 percent and 24.0 percent when expressed as the number of lambs born per ewe lambing. However in 1987, when the ewes were lambing as 7-year-olds, no significant improvement was found. This may suggest that while the use of immunization against androstenedione will increase the number of lambs born, the impact of this increase likely follows the natural reproductive stage of the ewe, with the ages of 4, 5 and 6 being the most productive years under normal conditions. Ages outside of this range would be expected to reproduce at lower levels. Although the effects of age and year are confounded, Figure 1 suggests that immunization did not enhance reproductive performance in ewes lambing as 7-year-olds. In addition, the data suggest that actual reproductive performance may fall below that of control animals if annual booster injections are not given. However, these differences in the number of lambs born per ewe exposed and lambing were not significant.

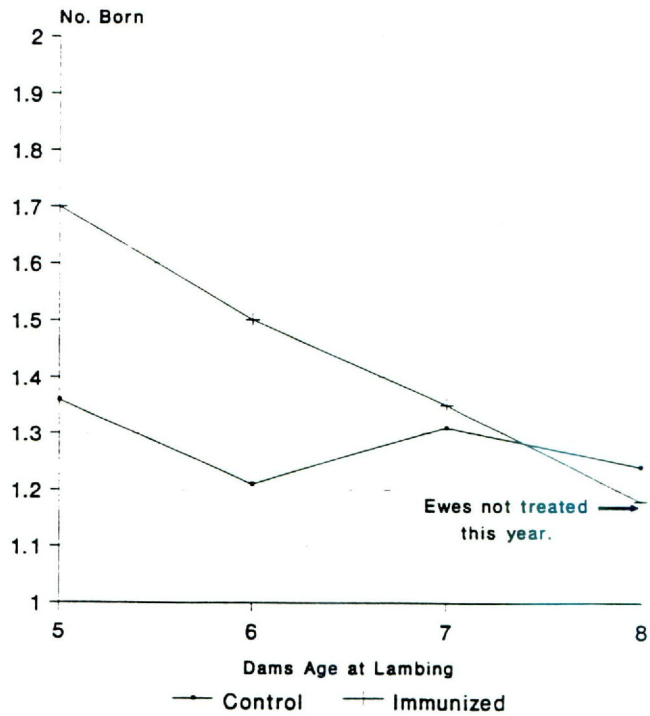

Figure 1. Mean number of lambs born per ewe lambing (Experiment 1).

Table 1 and Figure 2 also indicate an area of major economic importance, the number of lambs weaned per ewe exposed and lambing. In all years examined during the first experiment, immunized ewes weaned more lambs than control ewes, but this difference was not statistically significant. This may largely be explained by the greater number of immunized ewes having multiple births, as shown in Table 2. Previous studies (6, 7) have documented increased lamb mortality among multiple-born lambs. Therefore, management practices for aiding the survival of multiple births should be implemented to more completely realize the potential gains from the increased number of lambs born to immunized ewes. During this study, no effort was given to artificially rear any lambs.

[1]Fecundin - Polyandroalbumin is a product of Glaxo, (Australia) Pty. Ltd., Boronia, Victoria. It is an experimental compound and is not approved for use in U.S. sheep.

Table 1. Reproductive performance of ewes treated initially at 4 years of age and subsequent years. (Experiment 1).

Year treated	Treatment group	Age at lambing	No.	Body[1] weight at treatment	Percent ewes[1] lambing of ewes exposed	Lambs[1] born/ewe exposed	Lambs[1] born/ewe lambing	Lambs[1] weaned/ewe exposed	Lambs[1] weaned/ewe lambing
1984	Control	5	48	103.2[b]	97.9	1.33[a]	1.36[a]	1.21	1.23
1984	Immunized	5	50	110.7[a]	100.0	1.70[b]	1.70[b]	1.34	1.34
1985	Control	6	36	113.0[a]	94.4	1.14[a]	1.21[a]	1.03	1.09
1985	Immunized	6	44	113.6[a]	100.0	1.50[b]	1.50[b]	1.18	1.18
1986	Control	7	38	112.2[a]	92.1	1.21[a]	1.31[a]	0.89	0.97
1986	Immunized	7	39	116.6[a]	87.2	1.18[a]	1.35[a]	0.90	1.03
Overall Mean	Control	-	122	108.9[a]	95.1	1.24[a]	1.30[a]	1.06	1.11
	Immunized	-	133	113.4[b]	96.2	1.48[b]	1.54[b]	1.16	1.20
1987	Control	8	35	125.2[a]	94.3	1.17[a]	1.24[a]	1.06	1.12
1987	History of immunization	8	35	130.1[a]	94.3	1.11[a]	1.18[a]	0.86	0.91

[1] Means within columns by year or overall, having a common superscript are not significantly different

In the second experiment, starting with 2-year-old ewes prior to breeding for their second lambing at 3 years of age, ovulation rates were obtained in the first year of observation. Data shown in Table 3 support the observation by Scaramuzzi (2) that immunization against androstenedione increases ovulation rate. In this one instance, immunized ewes had a mean increase of 0.47 ovulations per ewe, or 47 additional ovulations per 100 ewes. However, this increase in ovulation rate did not in this case, and will not in most cases, result in an equivalent increase in lambs born because of reproductive wastage (8). As a result of this wastage, a greater percentage of ova will be lost in the immunized ewes than the controls. These data indicate that the immunized ewes lost on the average 0.18 more ova or embryos per ewe exposed in the 1 year examined. Therefore, if any gain is to be realized in the number of lambs

Table 2. The number of ewes having various birth types by year.

Experiment 1

Year	Age at lambing	Treatment	Open	Birth Type: Single	Twin	Triplet
1984	5	Control	1	30	17	0
1984	5	Immunized	0	19	27	4
1985	6	Control	2	27	7	0
1985	6	Immunized	0	25	16	3
1986	7	Control	3	25	9	1
1986	7	Immunized	5	22	12	0
1987	8	Control	2	25	8	0
1987	8	Immunized*	2	27	6	0

*Ewes were not given a booster injection this year.

Experiment 2

Year	Age at lambing	Treatment	Open	Birth Type: Single	Twin	Triplet
1986	3	Control	1	30	17	0
1986	3	Immunized	0	22	22	4
1987	4	Control	6	34	6	1
1987	4	Immunized	6	13	21	5
1988	5	Control	4	25	16	1
1988	5	Immunized	1	15	26	4
1989	6	Control	3	20	17	2
1989	6	Immunized*	8	22	10	2

*Ewes were not given a booster injection this year.

Figure 2. Mean number of lambs weaned per ewe lambing (Experiment 1).

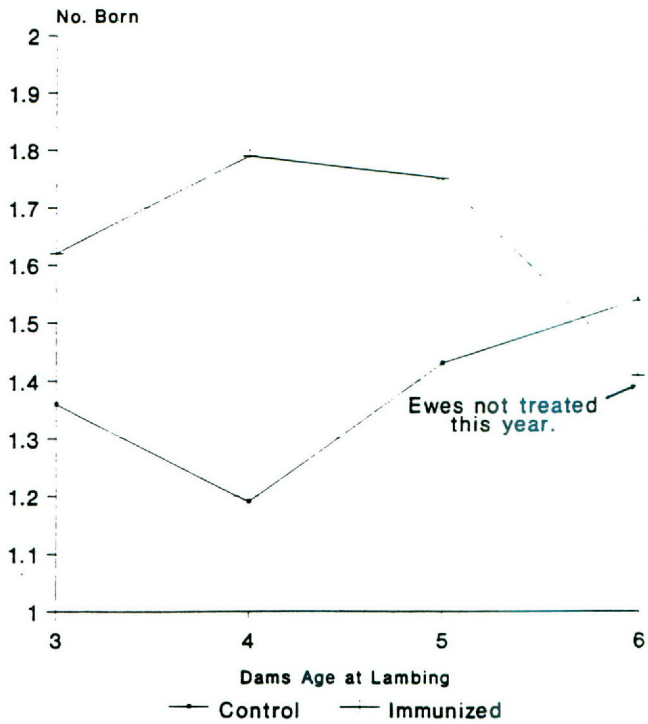

Figure 3. Mean number of lambs born per ewe lambing (Experiment 2).

born, the increase in ovulation must be of a magnitude sufficient to offset the greater level of ova wastage. Immunized ewes had significantly more lambs per ewe exposed and lambing from 1986 to 1988, and the overall average increase in lambs born per ewe exposed and lambing were 0.40 and 0.39 respectively. Figure 3 indicates the effect of immunization on the number of lambs born per ewe lambing.

In this experiment, as with the first, the immunized ewes raised more lambs than the controls (Figure 4), but this increase was statistically significant in only 1 year (1987), or when the 3 years data are combined. This can be explained by the higher mortality among the increased number of multiple births in the immunized ewes.

In 1989 (Table 3), ewes that were immunized in previous years, but not given a booster injection prior to mating in 1988, produced fewer lambs than in 1986 to 1988 and fewer lambs than controls for the same year. Although, the decreases in the number of lambs born and weaned were not significantly less than the controls, they were below the levels of the controls.

Table 3. Reproductive performance of ewes treated initially at 2 years of age and subsequent years (Experiment 2).

Year treated	Treatment group	Age at lambing	Number of animal	Body weight at treatment	Ovulation rate	Percent ewes lambing of ewes exposed	Lambs[1] born/ewe exposed	Lambs[1] born/ewe lambing	Lambs[1] weaned/ewe exposed	Lambs[1] weaned/ewe lambing
1986	Control	3	48	106.2	1.63[a]	97.9	1.33[a]	1.36[a]	1.19[a]	1.21[a]
1986	Immunized	3	48	105.0	2.10[b]	100.0	1.62[b]	1.62[b]	1.44[a]	1.44[a]
1987	Control	4	47	117.5	—	87.2	1.04[a]	1.19[a]	0.91[a]	1.05[a]
1987	Immunized	4	45	116.9	—	86.7	1.56[b]	1.79[b]	1.38[b]	1.59[b]
1988	Control	5	46	110.6	—	91.3	1.30[a]	1.43[a]	1.15[a]	1.26[a]
1988	Immunized	5	46	110.9	—	97.8	1.72[b]	1.75[b]	1.24[a]	1.27[a]
Overall Mean	Control	-	141	111.4	—	92.2	1.23[a]	1.33[a]	1.08[a]	1.18[a]
Overall Mean	Immunized	-	139	110.8	—	95.0	1.63[b]	1.72[b]	1.35[b]	1.42[b]
1989	Control	6	42	125.1	—	92.9	1.43[a]	1.54[a]	1.00[a]	1.08[a]
1989	Immunized in prior years	6	42	119.2	—	80.1	1.14[a]	1.41[a]	0.79[a]	0.97[a]

[1] Means within columns by year and overall, having a common superscript are not significantly different ($P \leq .05$).

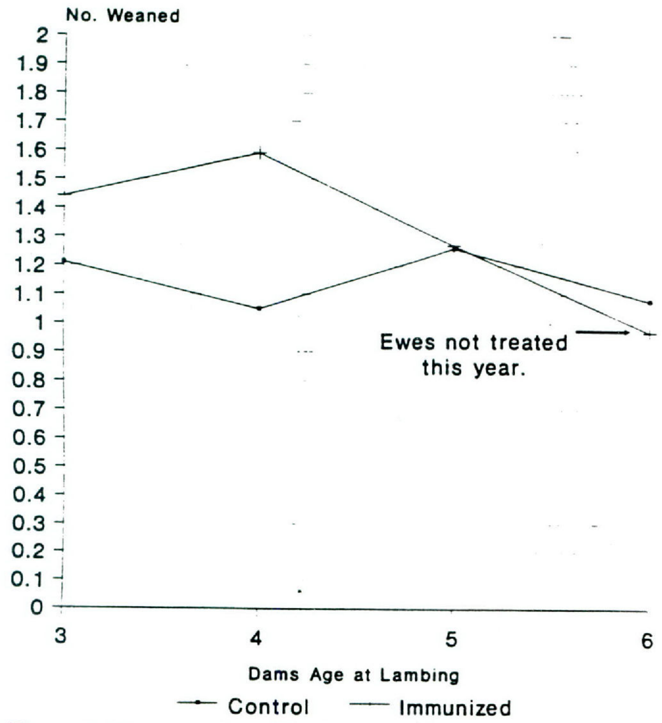

Figure 4. Mean number of lambs weaned per ewe lambing (Experiment 2).

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PR 4774

Influence of Management Level on Productivity of Spanish Goats

P. Thompson and M. Shelton

Summary

Three different management treatments were imposed upon three groups of Spanish goats to study the effects on reproductive performance. Does that were continually exposed to billies over a 3-year study period produced significantly more offspring than does under high- and low-maintenance regimes bred for a single annual kidding. Does maintained at a level above minimal maintenance produced a greater number of kids (23.2 percent) than those does managed on pasture only.

Introduction

Most Spanish or meat-type goats are run on native range with heavy concentrations of browse species. In earlier years, they were managed for their contribution to brush management and as a home meat supply. These goats were provided with low levels of supplemental care and management. In recent years more attention has been given to meat goats as income producers. Thus, it has become increasingly important to raise as many offspring as possible to maximize the net income.

Experimental Procedures

In September 1985, 198 meat-type Spanish does were assigned to three treatment groups to study the effects of differing management systems on their reproductive performance. These flocks were maintained under range conditions on the Winters Ranch lease in McCulloch County. The goats were rotated randomly through pastures that contained shin oak and live oak browse. The three management systems were high-maintenance (high), low-maintenance (low) and a group continually exposed to billies (continual). The continual group was selected from a flock of does which had previously been mated in the same manner. The other two treatment groups were randomly derived by subdividing a flock which had been bred only annually.

For 3 years, the high and low groups were mated during the fall for production of a spring kid crop. The continual group was managed under a more typical producer system of having fertile billies continuously in the flock. These males were periodically rotated to ensure maximum performance, especially when single sires were in use. The high and low groups were randomly sorted into single-sire groups within treatments and then exposed to multiple-sire (clean-up) matings at the end of the breeding season. All experimental animals were weighed annually prior to the fall matings.

Thirty days prior to breeding, the high-maintenance group was flushed by hand feeding 1/4 pound of shelled corn per head per day. During the winter months and prior to kidding, does in the high group had access to a 20 percent crude protein, salt-limited range supplement. This supplementation did not exceed 1/2 pound per head per day. At the same time, the continual animals were fed only sparingly, usually in conjunction with finewool ewes that were within the same pasture. The low group received no supplemental feeding.

Other management practices were also imposed. One of these included all groups having access to free choice salt. The high group was given a commercially prepared mineral in addition to the salt. These high does were drenched annually and sprayed for external parasites (one time only). The continual group was drenched but never sprayed. The low-maintenance group was neither drenched nor sprayed for parasites. All billy kids were weaned at approximately 120 days of age. All doe kids were weaned at least 30 days prior to the next breeding season.

Results and Discussion

The reproductive performance results are shown in Table 1. After the initial year of treatment began to take effect, the high-maintenance group of does produced a significantly larger kid crop than the low-maintenance group. In the first year, improved management showed no improvement in the percent kid crop born, but in the 2 succeeding years the percent kid crops for the high and low groups were 150.0 and 117.9, and 115.3 and 82.5, respectively. Over the 3-year study, the high group had an average kid crop of 123.0 percent as compared to 105.4 percent for the low group. The continually-mated group dropped and raised a higher kid crop (approximately 15 percent) than the high group. The average kid crop born for the continual group was 139.5 percent as compared to the 123.0 percent for the high group. The continual does had the distinct advantage of being able to produce more than a single kid crop per year. In the first year after breeding, the continual does had kids in the spring and winter season, leading to the 170.8 percent kidding. The next year their percent kid crop dropped to 98.9 percent. This was due to the high number of dry does, 22.7 percent. These does tended to be the ones that produced two kid crops the previous year. These three experimental groups were maintained on brush and native grass pastures which varied in size from 300 to 800 acres. Abandonment, weak kids and natural predation were contributing factors in the death losses that seem to drastically affect the weaning rates for each group. Only in the case of the high-maintenance group (spring, 1986) was a specific predator responsible for losses in one pasture.

The percent kid crop weaned had a direct relationship to the kidding rate of each group, as would be expected. The does from the continually-mated group weaned an average 121.9 percent kid crop, as compared to 107.1

Table 1. Reproductive performance of Spanish does on three management systems.

	Years											
	1985-86			1 986-87			1987-88			Average		
Treatment groups[d]	C	H	L	C	H	L	C	H	L	C	H	L
Number of does	96	102	100	88	96	95	86	85[a]	80[b]	90.0	94.3	92.7
Average breeding weight (lb)	107.2	84.1	87.4	87.3	91.6	83.8	102.0	78.6	78.2	99.1	85.0	83.6
Open does (%)	0	9.8	10.0	22.7	0	0.9	0.9	25.9	33.7	7.4	11.3	13.4
Kid crop born (%)	170.8	103.9	112.0	98.9	150.0	117.9	146.5	115.3	82.5	139.7	123.0	105.4
Kid crop weaned (%)	130.2	71.6[c]	80.0	98.9	150.0	114.7	136.0	101.2	62.5	121.9	107.1	86.9
Average weaning weight (lb)	39.9	35.5[c]	40.5	48.0	44.5	42.8	39.0	47.3	47.9	41.7	43.3	43.3
Average doe weight (lb) (at weaning)	81.6	89.6	84.6	84.3	85.4	82.4	76.7	83.3	84.9	81.3	86.2	86.8

[a]Twenty-four replacement doe kids were added.
[b]Ten replacement doe kids were added.
[c]This group suffered unusually heavy predation.
[d]Designations:
C-Continually-mated group
H-High-maintenance group
L-Low-maintenance group

percent for the high group and 86.9 percent for the low group. Average weaning weight of kids (43.3 pounds) was the same for high and low groups, and was slightly less (41.7 pounds) for the continually-mated group. This difference would be minor in light of the greater number of kids produced in the latter group.

In this study, the estimated annual cost per head of the higher level of management was approximately $5.90. For this, approximately 20 additional kids were marketed per 100 does. At current prices this would approximate a break-even situation. In this particular study, the accelerated or continual kidding provided a greater return. This suggests that the practice employed by most producers is a reasonable one. The implementation of a higher level of management in connection with some version of accelerated kidding would appear to hold interest. However, at this time data are not available comparing contrasting levels of management and accelerated kidding.

Because of the unmanageable feeding habits of the continual goat flock, it is not a fair comparison to make between it as a mating system and the other two treatment groups. It also should be noted that the supplemental feeding was not the only contributing factor in enhancing the reproductive performance of the high-maintenance group. With these data, it is impossible to factor out the individual benefits received from spraying, drenching or providing supplemental mineral. The comparison between the high- and low-treatment groups is one of no particular management versus the use of a few simple and well-recognized management tools.

The productivity of all three of the groups in this study was below expectations. Some young replacement doe kids were added to all the flocks and these young does were included in the number of does considered in the analysis. Also, it should be noted that these does were largely managed to utilize shin oak.

The data indicate some large differences in average doe weights at breeding and at weaning. The average weight for does in the continually-mated treatment group was significantly greater than those weights in the high- or low-maintenance groups in the fall of 1985 and 1987. This is simply due to the number of does which were already bred and would eventually kid within the following 2 to 3 months. Doe weights taken at weaning for these same 2 years show that the continually-mated does had significantly larger weight losses. The major contributing factor to this is that all the does in the continual system gave birth to and weaned kids during these 2 years. The average data for the 3 years show a direct relationship between breeding weight, percentage of dry does, percent kid crop born and weaned and weight of does at weaning. Those does at the highest level of reproductive performance have the greatest nutritional needs and also the greatest depletion of body reserves.

PR 4775

Effects of Fat and Monensin on Reproductive Success in Mature Angora Nannies

N.E. Garza, Jr., C.A. Taylor, Jr., R.A. Moen, J.E. Huston, L.J. Hunt and K.W. Bales

Summary

Results of a study conducted during the 1988-89 breeding season on mature Angora nannies suggest that adding fat and/or monensin to complete feed rations has little effect on the number of kids born. The goats fed the high-fat diet had elevated blood cholesterol but neither glucose nor triglycerides in the blood was affected. No effect of elevated cholesterol on reproductive measures was observed. Monensin in the diet did not influence blood metabolites. However, nannies fed the monensin ration at 20 and 40 grams/ton had significantly higher ovulation rates. Weight gains were similar between treatments and overall health of the nannies was not influenced by treatment.

Introduction

Overstocking Edwards Plateau rangelands has a greater long-term impact on range condition than any other management practice. Range deterioration caused by overgrazing is accelerated by droughty conditions, making proper stocking so important.

Long-term stocking at a moderate rate means that the proper number of animals are grazed under droughty conditions and that under favorable growing conditions an excess of forage can usually be grown. To obtain the optimum level of production under these conditions, without damaging the range resource, it is best to improve reproductive efficiency rather than add breeding stock to the herd or flock. This effectively increases productivity without increasing stocking rate.

A study was conducted during the 1988-89 breeding season to determine if animal fat or monensin added to an otherwise complete ration could be used to stimulate ovulation and improve kidding success in mature Angora nannies. Reproductive efficiency has been increased in cattle by feeding high levels of lipid (4) and monensin (1). It is not presently known whether similar effects occur in Angora goats.

Experimental Procedure

Beginning in September 1988, 80 mature Angora nannies were divided into 16 groups of five nannies/group and fed in confinement for approximately 75 days. They were randomly divided into four treatments of 20 goats each. Each experimental ration (Table 1) was fed to four individual groups at a rate of 2.5 percent of their body weight per day for 30 days prior to breeding.

During this pre-breeding period the nannies were in proximity to rutting billies (no physical contact) to initiate estrus. At the end of the pre-breeding period nannies were exposed to the billies for 45 days. On day 10 of the breeding period, ovulation rate was estimated by counting corpora lutea via a laparoscopic technique (2).

Blood samples were taken before the nannies were put on feed and at the end of the pre-breeding period. Blood samples were tested for glucose, cholesterol and triglycerides and means were tested using Duncan's multiple range test. Differences among treatments in ovulation rate and kid production were determined using orthogonal contrasts.

Results and Discussion

Weights taken periodically during the study (Figure 1) indicated that the nannies received above adequate nutrition from all treatments. The goats gained approximately 40 pounds regardless of diet. The high-fat diet resulted in a 30.4 percent elevation in blood cholesterol ($P < 0.05$) but

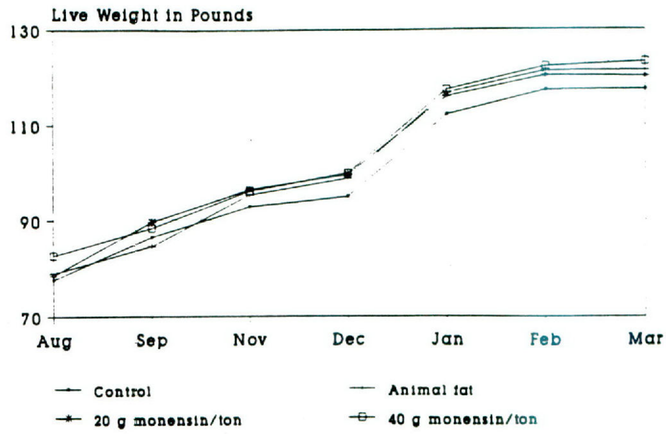

Figure 1. Live weights of Angora goats under different treatments taken periodically during the study.

did not significantly increase either glucose or triglycerides in the blood (Table 2) or ovulation or kidding rates (Table 3). Monensin fed at either the 20 or 40 grams/ton level did not influence blood metabolites (Table 2). The increased number of corpora lutea in the goats fed either level of monensin (Table 3) indicated increased ovulation rates ($P < .05$). However, kidding rates were not higher for goats consuming monensin.

Results with cattle fed high-lipid diets (4) and diets containing monensin (1) suggest positive effects on reproductive efficiency. In this study with Angora females, fat in the diet increased blood cholesterol but failed to affect either ovulation or kidding rate. Monensin appeared to increase ovulation rate but did not increase kidding rate. However, the observed trends toward increased reproductive efficiency justify additional studies. These results seem to substantiate a previous study which suggested that goats are more responsive to the timing of feeding than to the kind and amount of feed received (3).

Table 1. Experimental rations fed to adult angora females for 30 days before a 45-day breeding season.

Ingredients	Rations: Control	Fat Rumensin®	Low Rumensin®	High Rumensin®
	Percent			
Cottonseed hulls	20	20	20	20
Peanut hulls	14	15	14	14
Milo	50	46	50	50
Cottonseed meal	10	10	10	10
Molasses	5	3	5	5
Calcium carbonate	0.8	0.8	0.8	0.8
Salt	0.2	0.2	0.2	0.2
Beef tallow		5		
Rumensin[a]			+	++

[a]Rumensin® added at a level to provide 20 (+) and 40 (++) grams of monensin sodium per ton of feed. Rumensin, a product of Eli Lilly & Co. contains 60 g of monensin sodium per pound of premix.

Table 2. Metabolites in the blood of adult Angora females before and 30 days after various dietary treatments were imposed.

Treatment	Glucose		Cholesterol		Triglycerides	
	Before	After	Before	After	Before	After
	mg/100 ml					
Control	70.6[a]	63.9[a]	51.2[ab]	55.7[b]	10.9[a]	12.6[a]
Fat	67.6[a]	64.7[a]	53.2[a]	83.6[a]	7.0[a]	14.1[a]
Rumensin[c]						
20 g/ton	69.9[a]	62.5[a]	46.3[b]	52.6[b]	8.5[a]	15.9[a]
40 g/ton	69.0[a]	62.8[a]	48.5[ab]	53.0[b]	8.6[a]	13.2[a]

[ab]Means in the same column without a common superscript are different ($P < .05$).
[c] See footnote (Table 1).

Table 3. Effects of various diets on ovulation and kidding rates in adult Angora females.

Treatment	Total corpora lutea	Kidding rate
	(Number/female)	(Live kids/female)
Control	0.95[a]	1.10[a]
Animal fat	1.15[a]	1.25[a]
Rumensinc		
20 g/ton	1.26[b]	1.15[a]
40 g/ton	1.32[b]	1.15[a]

[ab]Values in the same column with different letters are different (P).
[c] See footnote (Table 1).

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Influence of Feeding Fat at Mating to Angora Does on Reproduction and Fleece Weights

M. Shelton, T. Willingham, P. Thompson and S. Kuhlmann

Summary

Three studies were conducted to determine the effects of feeding diets containing animal fat or whole cottonseed on weight change, ovulation or kidding rates and circulating triglyceride and cholesterol levels in mature Angora nannies. These results indicate that feeding diets containing animal fat under confined conditions had no favorable influence on ovulation rates or body weight changes. This is likely due to the reluctance of nannies to consume sufficient quantities of feed and the limited number of days the nannies were on feed prior to ovulation. Under range conditions, a favorable response was indicated for weight change, ovulation rate and the number of kids born per nannie exposed, when animals received whole cottonseed or rations containing 10 percent animal fat. Use of animal fat or cottonseed increased circulating cholesterol levels in each of the two experiments in which these values were determined, while triglyceride levels tended to be increased, but the differences were not statistically significant.

Introduction

It can be shown that improved body condition or increased weight at the start of a breeding season improves reproductive efficiency. This is particularly true with Angora goats. However, improved weight or condition may require improved feeding for an extended period of time before breeding. It is understood by most producers that improved condition improves reproductive performance, but there still must be a physiological key or signal that fat on the body or in the system stimulates reproduction. The energy requirement for ovulation is infinitesimally small; thus, the presence of fat is a cue to the animal system and should not be a requirement. The short-term feeding of fat would appear to hold some interest as a possible means of increasing the number of does cycling and the ovulation rate.

Experimental Procedure

Three different experiments have been conducted utilizing matured or aged Angora does in the fall of the year. The first experiment was conducted at San Angelo in the fall of 1988. Forty-three Angora nannies were weighed, condition scored and placed on the following treatments in dry lot and group fed:

- Complete feed (peanut hulls, sorghum grain and cottonseed meal)
- Complete feed plus 1 pound of whole cottonseed
- Five percent animal fat added to the above complete feed

The complete feeds were fed *ad libitum* and the cottonseed was weighed out and offered daily. Intact males were placed with the does at the start of the experiment and mating records taken daily. The does were laparoscoped approximately 7 days after mating to determine ovulation rates. Does were weighed and blood samples were taken for the determination of cholesterol and triglycerides 1 day prior to laparoscopy. After laparoscopy, the does were removed from the experiment.

The second experiment was conducted in the fall of 1988 on pasture at the leased Winters-Wall Ranch at Brady. Forty-five Angora nannies were weighed, condition scored and group fed. The treatments imposed were as follows:

- One pound daily of salt limited supplement (approximately 20 percent protein)
- One pound whole cottonseed daily (offered)
- Ad libitum access to a complete feed containing 10 percent fat

Does were placed with intact males at the start of the treatments, with daily estrus checks. Laparoscopy was performed 7 days post estrus. Cholesterol and triglycerides were not determined. After laparoscopy, all does were placed in one group and were carried to kidding.

The third experiment was conducted at Brady in the fall of 1989. The treatments consisted of 25 control animals (pasture only) and 26 animals placed on pasture with one pound of whole cottonseed offered daily. However, these treatments were initiated 12 days before the males were turned in and were continued for an additional 23 days after exposure to the males, for a total of 35 days on treatment. After 35 days, the does were maintained together until kidding. Ovulation rates were not recorded, but cholesterol and triglycerides were determined on blood samples taken at the end of the feeding period.

Results and Discussion

Results of the experiments are shown in Tables 1, 2 and 3, respectively. The only significant differences in the first experiment were in final condition score and in blood cholesterol. It appears that any direct fat intake will elevate blood cholesterol. There appears to be a similar influence

Table 1. The influence of feeding whole cottonseed or animal fat in dry lot on mean weight change, ovulation rate and blood cholesterol and triglycerides.

Treatment	Number of animals	Initial[1] weight 11-3-88 (lb)	Feed/day (lb)	Weight change (lb)	Initial[1,2] condition score	Final[1,2] condition score	Ovulation[1] rate	Cholesterol[1] (mg/dl)	Triglyceride[1] (mg/dl)
Complete feed	15	77.80[a]	4.39	-1.07	3.0[a]	3.1[a]	1.27[a]	57.31[a]	29.07[a]
Complete feed plus 1 lb cottonseed	14	79.00[a]	4.29/0.44	2.36	2.8[a]	3.7[b]	1.21[a]	80.66[b]	37.24[a]
Complete feed plus 5% fat	14	79.14[a]	2.83	-0.07	2.8[a]	3.2[a,b]	1.07[a]	90.75[b]	42.58[a]

[1]Column means without a common superscript are significantly different ($P < 0.05$).
[2]Condition scores range from 1 to 5 with 1 representing an extremely poor, unthrifty animal and a score of 5 indicating a high degree of body fat, with a score of 3 being a moderate condition.

Table 2. Mean effect of feeding whole cottonseed and animal fat to angora does on the range.

Treatment	Number of animals	Initial[1] weight 11-2-88 (lb)	Average daily consumption per head (lb)	Weigh[t] change (lb)	Initial[1,2] condition score	Final[1,2] condition score	Ovulation[1] rate	Kids[1] born
Pasture plus 1 lb salt limited supplement	15	71.20[a]	0.877	4.87	3.2[a]	3.2[a]	1.07[a]	0.87[a]
Pasture plus 1 lb cottonseed	15	68.80[a]	0.483	4.04	3.1[a]	3.0[a]	1.20[a]	1.00[a]
Pasture plus ad-lib complete feed with 10% fat	15	68.33[a]	0.866	8.40	3.1[a]	3.3[a]	1.40[a]	1.20[a]

[1]Column means without a common superscript are significantly different ($P < 0.05$).
[2]Condition scores range from 1 to 5 with 1 representing an extremely poor, unthrifty animal and a score of 5 indicating a high degree of body fat, with a score of 3 being a moderate condition.

Table 3. The influence of supplementing does on a dry range with whole cottonseed.

Treatment	Number of animals	Initial[1] weight 10-16-89 (lb)	Final weight 12-19-89 (lb)	Average daily feed intake (lb)	Weight change (lb)	Fleece[1] weight 3-7-90 (lb)	Cholesterol[1] (mg/dl)	Triglyceride[1] (mg/dl)	Kids[1] born
Control	25	74.00[a]	69.94[a]	–	-4.36	4.08[a]	42.71[a]	8.58[a]	.72[a]
1 lb cottonseed	26	74.65[a]	75.50[b]	0.514	0.85	5.02[b]	74.63[b]	9.04[a]	1.12[b]

[1]Column means without a common superscript are significantly different ($P < 0.05$).

on triglycerides, but in this case, the differences were not significant. There was no evidence of a favorable influence on ovulation. However, it should be noted that the does were on the experiment only a few days before estrus and the blood analysis was conducted on a sample taken approximately 6 days post estrus. In this experiment, it proved difficult to get the does to consume the feed containing fat and, although the observed differences were not significant, their low feed intake appeared to reduce ovulation. This tends to confirm the general thesis that breeding while they are losing weight should be avoided. The does in this experiment also were reluctant to consume whole cottonseed initially and, thus, had an average intake of only 0.44 pound daily.

In experiment 2 at Brady, the does again were reluctant to consume whole cottonseed, with an average consumption of 0.483 pound daily instead of the one pound provided. In this experiment, there appeared to be a response to treatment in respect to ovulation and kidding rate, but these were not statistically significant. It might be noted that the salt-limited protein supplement group had the lowest ovulation rate. This supports previous observations with sheep, suggesting that this is a poor choice of a feeding system for flushing. The complete feed with fat added showed some evidence of an increase in body weight and ovulation rate.

The third experiment was also conducted at Brady, on a very dry range. This study was initiated 12 days before the males were put out. In this case, significant increases were realized in body weights, cholesterol levels, number of kids born and fleece weights the following year. Since a body weight response was realized, it is not possible to attribute the increased kidding rate to the specific presence of fat in the cottonseed. The response obtained in this trial would certainly more than recover the cost of the small amount of cottonseed used. However, it should be noted that this study was conducted on a very dry range and that the controls received no feed at breeding. The triglyceride values reported in this study were markedly lower than those reported in Table 1. The blood samples were stored for a period of time before the analyses were run, and these lower values are thought to be due to deterioration of the samples or the reagents used in the analyses. Hopefully, the values are valid for treatment comparisons, which were not significant in any case.

Conclusions

Collectively, these studies point out that a period of adjustment may be required in feeding animal fat or whole cottonseed to goats. A meaningful response was obtained from feeding goats at breeding time on a dry range, but these studies do not confirm a unique contribution for inclusion of fat in the diet. Additional studies would be required to conclusively answer this question.

PR 4777

Interaction between Nutrition and Haemonchosis in Weaned Goats

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Summary

Weaned wether goats approximately 6 months of age were placed in a 2 X 3 factorial design experiment, to test the main effects and interaction of two levels of nutrition (growth + maintenance, NUT1; and twice growth + maintenance, NUT2) and three levels of Haemonchus burden (0, 500 and 2000 larvae drench every 2 weeks; W0, W500 and W2000, respectively) on weight, intake, infestation and packed cell volume. The rationale for the experimental design was based on the lack of information concerning the interaction between nutrition and worm burden. Results indicate significant effects of nutrition and worm burden levels on packed cell volume (PCV) and eggs per gram (EPG). Nutrition by worm burden effects were also significant for these two measurements. However, the differences detected for PCV and EPG did not translate into large and consistent differences in body weight. Goats on NUT2 after an initial period showed little difference in body weight irrespective of worm burden. Within the NUT1 treatment, W0 kids weighed more than W500 or W2000 throughout the study. There were no body weight differences between the W500 and W2000 for NUT1 until the last time period. This pattern was also observed in the NUT2 treatment. These results indicate the impact of parasitic burden was cumulative over time. The results also indicate that if the challenge was not as consistent as in this experiment growing kids could withstand a considerable difference in worm load.

Introduction

Important economic losses occur when small ruminants are infested with internal parasites. Mechanisms of how internal parasites impact sheep and goats have been extensively studied. However, a review of the literature shows that very little work has been performed on the interaction between nutrition and parasite burden (4, 5). Understanding this interaction is important in determining how the host is able to withstand the challenge presented by varying levels of parasites. Some work has shown that if nutrition level is sufficiently high, the impact of worms may be reduced. To test and quantify this assumption the present experiment was designed to evaluate the performance of young growing goats with different infestation and nutrition levels.

Materials and Methods

One hundred forty-four indigenous Brazilian goats approximately 6 months of age were randomly allocated to six treatments in a 2 X 3 factor factorial design. Two nutritional levels were provided to the kids, these were maintenance + growth (NUT1), and twice maintenance + growth (NUT2). Three worm burden levels were imposed by drenching the kids every 2 weeks with no larvae (W0), 500 larvae (W500) and 2000 larvae (W2000). Prior to the experiment, kids were drenched three times to ensure that no parasites previously acquired were resident in the animal. Kids were drenched with Haemoncus contortus infective third stage larvae. Fecal egg counts (EPG), packed cell volume (PCV), body weights and feed intake were monitored every week. The goats were serially slaughtered at monthly intervals so that worm establishment rates could be determined.

Statistical analysis included a wide range of techniques including: logarithmic transformation, residual and outlier analysis, multiple regression and generalized linear models (2). The basic model was comprised of nutrition level, parasite burden treatment, time, pens nested within treatments and appropriate interactions.

Results and Discussion

Body weights are reported in Table 1. Differences between NUT1 and NUT2 were pronounced and significant during the last 80 days of the experiment. Parasite load had significant impact on kid growth during the first 2 weeks of infestation. After that time worm burden ceased to be significant until it approached significance in the last 3 weeks of the experiment. Within NUT1 the differences in weight between kids with and without worm burden were large. Differences in weight between goats receiving W500 and W2000 were small, indicating kids were able to withstand a four-fold difference in infestation. During the last 3 weeks of the experiment, growth of the W2000 kids slowed, perhaps indicating a cumulative parasitic effect. By doubling the level of nutrients, as in NUT2, the impact of Haemonchus was negated after the first 3 weeks of the experiment. Differences occurred only at day 155 where W2000 goats were approximately 6.6 pounds lighter than W0 and W500.

Table 1. Body weight (pounds) least square means for kid goats fed at two nutrition levels and with three worm burden levels.

	NUT1			NUT2		
DAYS	WO	W500	W2000	WO	W500	W2000
0	29.9	27.7	27.7	29.9	27.9	27.7
49	32.8	27.7	29.3	31.7	27.5	30.1
77	33.7	29.0	30.6	37.0	31.7	33.2
105	38.3	31.7	30.8	38.1	38.5	37.8
133	41.1	34.8	36.1	45.3	45.5	45.5
155	43.6	36.3	33.4	50.8	52.1	45.3

Evaluation of feed intake relative to the W0 (e.g. intake W500/intake W0) within each nutritional treatment indicated that when kids were challenged with Haemonchus their feed intake increased above controls after an initial period of depression (Table 2). The average relative intakes for W500 and W2000 within NUT1 was 1.24 and 1.10, respectively. Within NUT2 average relative feed intakes for W500 and W2000 were 1.05 and 1.02, respectively. These results imply that on lower levels of nutrition the kids were attempting to compensate for the effects of the worm burden by increasing feed intake. When a higher quality ration was given to the kids, as in NUT2, the increase in relative intake was not as great as for NUT1. Within both nutritional treatments the relative intakes of W500 were

TABLE 2. Relative feed intake[a] of goats fed at two nutritional levels and given three worm burden levels.

	NUT1			NUT2		
DAYS	WO	W500	W2000	WO	W500	W2000
49	1.0	1.001	0.935	1.0	0.782	0.867
77	1.0	1.069	0.877	1.0	0.969	0.928
105	1.0	1.439	1.282	1.0	1.070	1.312
133	1.0	1.380	1.140	1.0	1.288	1.075
155	1.0	1.324	1.249	1.0	1.155	0.933

[a]Relative intake is expressed as the ratio of a worm burden level to the control within a nutritional treatment for the different time periods.

greater than W2000. Perhaps the W2000 treatment has some negative effects on appetite.

Eggs per gram (EPG) of fecal material were found to be highly significant for worm burden and the interaction of worm burden by nutrition (Table 3). In all treatments EPG fluctuated across time in relation to the life cycle of Haemonchus. There were logical differences between infection levels, with the W2000 goats having larger counts than the W500 goats. The interaction between nutrition and worm burden occurred when the differences were wider within the NUT2 than within NUT1. It is possible that with low levels of infection and high levels of nutrition, the egg-laying ability of the parasite was inhibited (1,3). Actual worm counts were significantly different and are presented in Table 4. At the W500 level there was no significant difference between NUT1 and NUT2 for worm numbers. However, number of worms present at the W2000 level was different between nutrition treatments. Therefore, it appears that with higher levels of nutrition, the kids were able to affect worm establishment.

Table 3. Egg counts in feces of kid goats fed at two nutrition levels and with three worm burden levels.

	NUT1		NUT2	
DAYS	W500	W2000	W500	W2000
28	907	1176	665	1164
42	1658	3702	1551	4133
69	2883	3041	1525	5541
96	4273	1988	1367	1930
123	2540	4024	706	5271

[a]Least square means in number of eggs per gram of feces.

Packed cell volume (PCV) for worm burden and nutrition level is presented in Figure 1. Differences between treatments were significant for PCV; as worm infestation increased under NUT1, PCV decreased. A significant interaction between infection levels and nutrition was present. This interaction consisted of a change in magnitude not an alteration in ranking. An animal with a PCV level of less than 20 percent is usually considered to have health problems. Our PCV results show that kids fed NUT1, drenched with W2000, did fall below this level during the later stages of the experiment, perhaps indicating that the parasitic effect had a cumulative impact on the kids which was reflected in body weight.

Table 4. Worms in the gastrointestinal tract of kid goats fed at two nutrition levels and with three worm burden levels.

	WO		W500		W2000	
DAYS	NUT1	NUT2	NUT1	NUT2	NUT1	NUT2
40	-	-	405	634	1367	1326
68	-	-	612	476	1976	1373
96	-	-	1171	846	1891	1894
123	9	4	695	865	2422	2161

Conclusions

The infection levels tested were different enough to show clear separation with respect to blood parameters and feed intake. The effects on body weight were too similar to be consistently different by statistical test. This indicates that biological thresholds may not have been exceeded in the treatments. Although the body weights were not consistently different, a clear trend of nutrition by worm burden interaction was observed. Therefore, it appears that nutrition does affect the ability of an organism to resist parasitic infections. These results also show that there is a wide range of infestation levels which young goats can withstand before showing depressed performance. Preferably, a follow-up study using larger differences between worm burdens can be performed to further quantify where critical levels of infestation are and the magnitude of their impact on kid growth.

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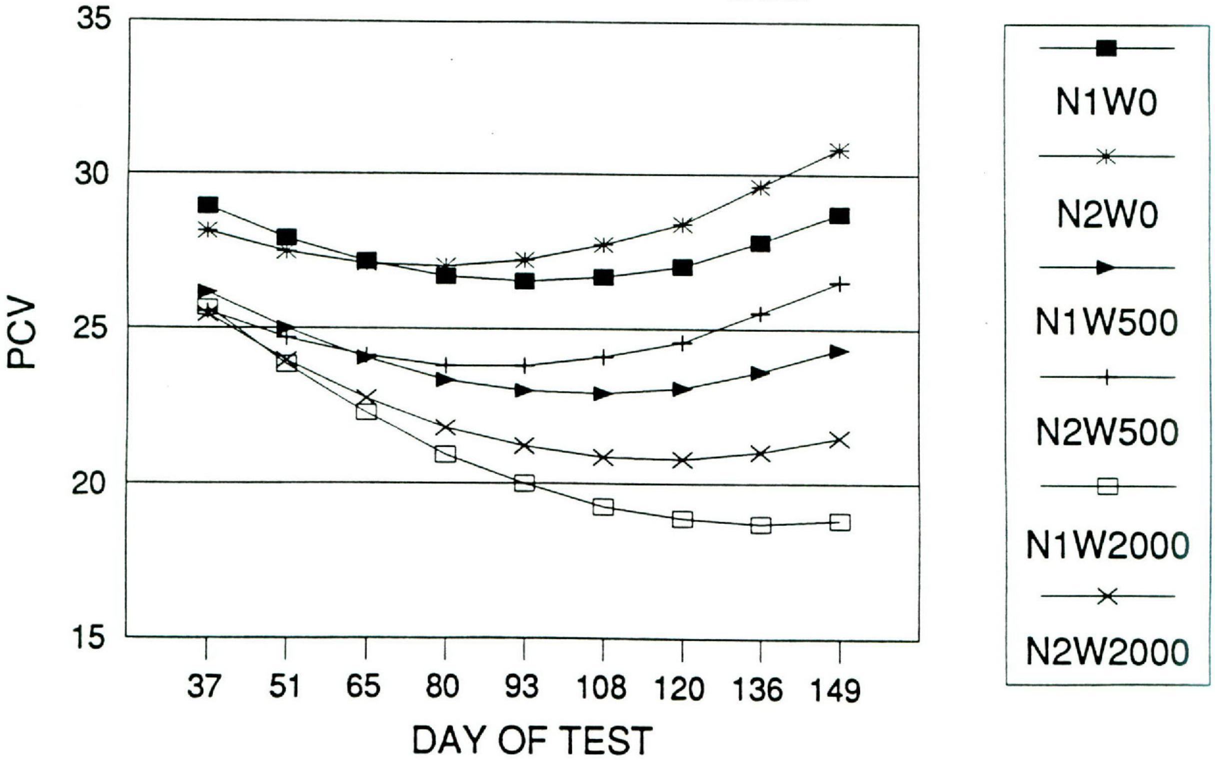

Figure 1. Progression of packed cell volumes for goats with different levels of nutrition and worm burden.

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Experimentally Induced Congenital Malformations in Lambs Infected with Cache Valley Virus in Utero

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Summary

Ewes were infected in utero with Cache Valley Virus (CVV) during three periods in early gestation; 27-35 days, 36-45 days and after 46 days of gestation. Ewes were killed and fetuses were examined 28 days after inoculation. CVV caused mummification and early embyronic resorption, arthrogryposis (limbs twisted and joints fixed in a flexed position) and brain malformations in lambs infected before 45 days of gestation. Additionally, there was a 46.1 percent incidence of arthrogryposis and oligohydroamnion (insufficient fluid in the uterus so that the fetus is constricted in a tight sac of placental membranes) in fetuses infected between 36-45 days of gestation. Surviving fetuses were able to develop CVV antibodies and eliminate the virus. Fetuses infected after 45 days of gestation supported viral growth and seroconverted with no visible adverse affects. The teratogenic potential of CVV for sheep fetuses was confirmed and it appears CVV only causes fetal damage during a brief period of gestation. Vector control, careful timing of the breeding season to avoid periods of peak viral activity in areas and vaccination of new breeding ewes will minimize lamb losses due to CVV infection.

Introduction

Cache Valley Virus (CVV) was diagnosed as the cause of an outbreak of congenital malformations in lambs in 1986 (1, 3, 4). Affected lambs were born with arthrogryposis or arthrogryposis with hydrancephaly (severe necrosis of the brain so that only a fluid-filled sac of brain membranes remains in the skull) or hydrocephaly (AGH). Of 360 lambs born, 19.2 percent had arthrogryposis or other musculoskeletal problems often associated with central nervous system defects. There was a high incidence of weak lambs, so that the total loss in the lamb crop in the affected herd was 25.6 percent. Several ewes died in dystocia (difficult birth process due to improper positioning of the lamb in the birth canal) and many ewes needed to be assisted at birth due to malpositioning of malformed lambs. More than 10 percent of bred ewes failed to lamb and many ewes lambed late. This was hypothesized to be due to early, virus-induced fetal death and resorption and later rebreeding of ewes when they began recycling after early loss of embryos. Vectors known to be able to transmit CVV were plentiful in the area and the prevalence of CVV-specific antibody in sheep in the area increased from 5 to 63.4 percent during the period of the outbreak. Susceptible sentinal sheep were put into the pastures and CVV was isolated from the sheep that seroconverted in the fall of 1987 on pastures where the outbreak had occurred. Because the disease observed mimicked the disease produced by Akabane virus (5), a related bunyavirus exotic to the U.S., experimental reproduction of CVV-induced AGH was attempted using a system modelled after that used to study Akabane disease.

Experimental Procedure

The CVV isolate obtained from sentinal sheep was propagated in cell culture and used for experimental infection of pregnant ewes. Twenty-eight pregnant ewes were infected in utero. Fifteen were infected between 27 and 35 days of pregnancy (Group A); eight were infected between 36 and 45 days of pregnancy (Group B); two were infected at 50 and 54 days of pregnancy (Group C); and three control ewes were sham infected, one per each of the above intervals (Group D). In cases of multiple fetuses, each fetus was inoculated individually. A total of 38 fetuses were inoculated. The ewes were killed 28 days after inoculation and the fetuses were examined for defects and sampled for virus content and presence of CVV antibody.

Results and Discussion

The effect of in utero infection with CVV in pregnant ewes is shown in Table 1 (2). Only fetuses exposed to CVV prior to 45 days of gestation were adversely affected by the infection. Mummification and resorption of fetuses were seen more commonly in earlier stages of gestation, and there was a higher incidence of lesions as well as more severe malformations in fetuses infected at earlier dates. The virus did not kill all infected fetuses and virus was recovered from those fetuses that were collected prior to 70 days of gestation. The fetuses infected late (after 45 days) in gestation were not malformed. These fetuses had antibodies to CVV and no virus was recovered from these fetuses presumably because they were immunocompetent at the time of collection. Control fetuses were normal and remained seronegative to CVV. Only two of 25 infected ewes failed to become seropositive for CVV following infection. An additional observation was a high incidence of oligohydroamnion and arthrogryposis without the brain malformations seen in fetuses infected between 36 and 45 days of gestation. In these cases, the fetus was constricted within fetal membranes containing a minimal amount of gelatinous fluid.

The experiment confirmed the potential of CVV to induce malformations identical to those seen in spontaneous outbreaks in lamb fetuses. The virus is also capable of causing a significant embryonic mortality. Previous experiments in which ewes were infected intravenously with an attenuated (less virulent due to being maintained by cell culture in the laboratory), CVV isolate failed to induce lesions. In light of the present results, the lack of success was likely attributable to the failure of the isolate to cross the placenta (i.e., route of administration).

Intravenous infection of ewes with a virulent isolate using infected vectors should be performed to truly reproduce the disease as seen in the field. No ewes were allowed to go to term so that early embryonic loss would be documented and virus recovery from infected and malformed fetuses would be possible. It was shown that fetuses infected later in gestation are susceptible to infection but can develop antibodies to CVV and clear the virus. This explains the inability to isolate virus even from malformed lambs. Once the lamb becomes immunocompetent the virus is cleared from the host's tissues and fetal membranes. The fetuses infected after 35 days demonstrated arthrogryposis without brain malformations and were found constricted in the fetal membranes. Thus, we can hypothesize that the natural cases seen with only arthrogryposis are the result of compression of the fetus early in gestation and that fetal brains are no longer susceptible to CVV infection after 35 days of gestation. Future studies will be directed toward establishing the infection pattern of the host cells in early infection to better understand development of lesions. A nucleic acid probe for CVV will be developed to increase the sensitivity and specificity of CVV detection in tissues and diagnostic samples.

The experiment demonstrates that fetal malformations only occur in ewes infected with CVV during a brief period early in gestation. Infections may be controlled or prevented by vector control alone or in combination with shifting breeding seasons to prevent exposure of susceptible ewes during peak periods of vector activity. The dramatic decrease in CVV-induced disease in West Texas can be attributed to both the dryer conditions of the subsequent seasons and the high prevalence of antibody to CVV in flocks in the area. Thus, in areas at risk, there is the justification for development of a vaccine to CVV to protect yearling ewes before they enter into breeding flocks.

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Table 1. *Malformations induced in infected lambs.

Groups	A (N=21)	B (N=13)	C (N=2)	D (N=4)
	Percent			
Mummification or resorption	33.3	23	0	0
Arthrogryposis (AG)	23.8	15.3	0	0
Oligohydroamnion (OH)	4.7	0	0	0
AG with OH	9.5	46.1	0	0
Hydranencephaly	4	0	0	0
Normal	28.5	15.3	100	100
Total Affected	71.4	85.6	0	0

*Data derived from Chung et al [2]
Lesions seen expressed as a percentage of fetuses (N=38) infected

Comparative Toxicity of Gossypol Acetic Acid and Free Gossypol in Cottonseed Meal and Pima Cottonseed to Lambs

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Summary

Fifty-two Rambouillet lambs (58.6 $\pm$ 2.7 days old and 29.3 $\pm$ 1.3 pound live weight, LW) were individually fed for 28 days to assess the toxicity of free gossypol from three sources (gossypol acetic acid, GAA; direct solvent cottonseed meal, DSM; and Pima cottonseed, PCS). Each source of gossypol provided free gossypol at levels of 2.3, 4.5, 9.1 and 13.6 mg/pound LW/d. Four lambs received each source and level of free gossypol. Gossypol acetic acid was given daily in gelatin capsules. Isocaloric (1.45 Mcal DE/pound), isonitrogenous (19.4 percent CP) diets based on sorghum grain and dehydrated alfalfa meal were formulated using glandless cottonseed meal to adjust CP and DSM and PCS to give the desired free gossypol levels. Diet intake was restricted to 3.5 percent of LW. All lambs receiving GAA and four additional lambs (negative controls) were fed a diet without gossypol. All lambs given 9.1 and 13.6 mg GAA/pound LW/d died. Time of death was 15.8 $\pm$ 0.8 and 13.2 $\pm$ 0.2 days for the 9.1 and 13.6 mg levels of GAA, respectively. One lamb given GAA at 4.5 mg/pound LW/d died on the 26th day. Clinical signs prior to death were anorexia and chronic depression. Sudden death occurred in several lambs. Macroscopic lesions were consistent with gossypol poisoning and included excessive, often red-tinged, pericardial, thoracic and intraperitoneal fluid volumes; generalized icterus; enlarged, flabby hearts, enlarged livers and edematous lungs. None of the lambs fed DSM or PCS exhibited clinical signs of gossypol poisoning and none died. Performance (ADG and FI) of lambs fed the diets containing DSM or PCS, regardless of gossypol level, was not different from lambs fed the negative control diet ($P > .05$). Increases in osmotic fragility of erythrocytes were observed for lambs given all levels of GAA ($P < .05$) and the 9.1 and 13.6 mg levels of free gossypol from PCS ($P < .05$). These results indicate the oral administration of GAA is much more toxic to young lambs than feeding equivalent amounts of free gossypol in cottonseed or cottonseed meal.

Introduction

Cotton plants produce a toxic yellow compound called gossypol (1). Gossypol occurs throughout the plant but is concentrated in pigment glands contained in cottonseed (1). Gossypol content of cottonseed samples collected in the San Angelo area during 1988-1990 contained 0.56 $\pm$ 0.03 and 0.77 $\pm$ 0.03 percent gossypol for upland (fuzzy) and Pima cottonseed, respectively. All the gossypol in cottonseed is considered to be free gossypol (1). During the production of cottonseed meal a portion of the free gossypol is bound. The extent of binding depends on the processing method used. Cottonseed meals produced by any of the pressing methods (hydraulic, screw and prepress solvent) contain less than 0.1 percent free gossypol; whereas, meals produced by direct solvent extraction of the oil are much higher in free gossypol (0.1 to 0.5 percent) (1).

Free gossypol is toxic to non-ruminants (e.g. poultry and swine) and to ruminants prior to the development of normal rumen function (e.g. young lambs and calves); however, it has been known for many years that ruminating animals can detoxify free gossypol by binding with soluble proteins in the rumen (8). Because of this there has been little concern with gossypol poisoning in ruminants. Recently, however, there have been several reports of gossypol poisoning in calves, lambs and mature ruminants (2, 3, 4, 5, 10). These reports, coinciding with an increased use of whole cottonseed, sometimes in conjunction with high levels of direct solvent cottonseed meal, have caused producers to be concerned about the safety of feeding cottonseed products to their animals. This research was conducted to provide information on the comparative toxicity of free gossypol from three sources (gossypol acetic acid, direct solvent cottonseed meal and Pima cottonseed) and to provide information on the safe level(s) of cottonseed products to feed to young lambs.

Experimental Procedure

Animals and Feeding. Fifty-two early-weaned Rambouillet lambs of mixed sex (ewe and ram) were obtained from the Texas Agricultural Experiment Station ewe flock at San Angelo. They were weaned, ear-tagged, drenched (Tramisol®)[1], vaccinated with *Clostridium perfringens* (Types C and D) toxoid[2], placed in four pens with 13 lambs/pen and fed the control diet (Table 1) *ad libitum* for 3 days. Subsequently all lambs were placed randomly in individual raised pens with expanded metal floors and fed

[1]Levamisole hydrochloride, American Cyanamid Co., Tramisol®, 0.25 g of levamisole hydrochloride was given to each lamb in 20 ml of water, using an automatic drench gun.

[2]**Clostridium perfringens** Types C and D toxoid, Anchor Laboratories, Inc. Lamb-Vax, 1 ml per lamb was injected subcutaneously in the neck.

Table 1. Percentage ingredient composition of experimental diets[a].

Item	Diet Number[b]								
	1	2	3	4	5	6	7	8	9
Sorghum grain, milo	45.05	45.07	45.07	45.05	44.85	44.80	44.64	44.98	44.72
Alfalfa meal, dehydrated	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Cottonseed hulls	10.00	10.00	10.00	10.00	10.00	9.26	8.53	7.05	5.57
Cottonseed, ground Pima	--	--	--	--	--	1.99	3.98	7.97	11.96
Cottonseed meal, glandless	22.50	19.56	16.64	10.82	5.17	21.80	21.00	18.75	17.00
Cottonseed meal, direct solvent	--	2.92	5.84	11.68	17.53	--	--	--	--
Cottonseed oil	1.80	1.80	1.80	1.80	1.80	1.50	1.20	0.60	--
Molasses, sugar cane	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Calcium carbonate	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.75
Ammonium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin-mineral premix[c]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[a]All diets contained 50 mg thiamine mononitrate per pound to control polioencephalomalacia.
[b]All diets were fed at a daily rate of 3.5% of LW.
Diet 1 was fed to the control lambs and to all groups receiving gossypol acetic acid.
Diets 2, 3, 4 and 5 were fed to the lambs receiving 2.3, 4.5, 9.1 and 13.6 mg gossypol/lb LW/d, respectively, from direct solvent cottonseed meal.
Diets 6, 7, 8 and 9 were fed to the lambs receiving 2.3, 4.5, 9.1 and 13.6 mg gossypol/lb LW/d, respectively, from Pima cottonseed.
[c]The percentage ingredient composition of the premix was as follows: sodium chloride, 64.7; potassium chloride, 19.0; sulfur, 10.0; zinc oxide, 0.274; vitamin A (13.6×10^6 IU/lb), 0.73; vitamin D (13.6×10^6 IU/lb), 0.093; vitamin E (12.5×10^4 IU/lb), 0.72; chlortetracycline (50 g/lb), 3.0 and molasses, 1.5.

1.3 pound per day of the control diet (approximately 4 percent of live weight) for a short adaptation period. Upon completion of the adaptation period, lambs were assigned at random (within age/weight groups) to the experimental treatments. Diets were fed at a daily rate of 3.5 percent of LW. Water was provided *ad libitum* and water containers were cleaned daily. The duration of the study was 28 days.

Experimental Treatments. Treatments were 2.3, 4.5, 9.1 and 13.6 mg free gossypol/pound LW/d provided from three sources (gossypol acetic acid, GAA; direct solvent cottonseed meal, DSM; and Pima cottonseed, PCS). Four lambs received each level of gossypol from each source. Four additional lambs received a control diet based on glandless cottonseed meal (0 percent free gossypol). Experimental diets (Table 1) were formulated so that lambs consuming 3.5 percent of LW/day received the desired gossypol intake. The calculated nutrient values and gossypol levels in the experimental diets are given in Table 2. All diets needed for the study were mixed at one time.

Gossypol acetic acid was weighed out daily under subdued lighting and placed into gelatin capsules (size 000). The capsules were then placed in translucent plastic containers, covered to block out all light, and stored in a refrigerator. Each morning the capsules were removed from the refrigerator and stored in a dark room to attain ambient temperature. Capsules were then administered with a balling gun daily prior to feeding. The gossypol acetic acid was a 1:1 molar addition complex of gossypol and acetic acid containing 85.1 percent gossypol.

Observations and Analysis. All lambs were observed twice daily (0800 and 1600 h) to assess their general health and well-being. Animals that were off-feed or appeared sick were examined by a consulting veterinarian. Lambs were weighed initially and at 14-day intervals during the study. Free gossypol levels were measured in the direct solvent cottonseed meal and Pima cottonseed (7)[3].

Blood samples were collected by venipuncture at 0, 7, 14 and 28 days. Heparinized whole blood was used for determinations of osmotic fragility of erythrocytes (RBC) (6). Serum was examined for total protein, albumin,

[3]Pope Testing Laboratories, Inc., Dallas, Texas.

Table 2. Calculated nutrient and free gossypol values of experimental diets.

Item	Diet Number[a]								
	1	2	3	4	5	6	7	8	9
Dry matter, percent	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4
Digestible energy, Mcal/lb	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Crude protein, percent	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.4	19.4
Fat, percent	4.2	4.2	4.2	4.2	4.2	4.3	4.4	4.7	4.9
Crude fiber, percent	12.5	12.5	12.5	12.5	12.6	12.5	12.5	12.3	12.2
Calcium, percent	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.05
Phosphorus, percent	0.47	0.47	0.47	0.47	0.47	0.47	0.48	0.48	0.49
Free gossypol, ppm	--	159.8	319.5	639.1	959.1	159.6	319.2	639.3	959.3

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

globulin, calcium, phosphorus, glucose, total bilirubin, creatinine, creatine phosphokinase, alkaline phosphatase, lactic dehydrogenase, alanine aminotransferase and aspartate aminotransferase.

Upon completion of the study all lambs were killed by electrical stunning and exsanguination. Necropsy was performed by a consulting veterinarian and macroscopic pathologic findings were recorded.

Statistical Treatment of the Data. The General Linear Models Procedure of the Statistical Analysis System for personal computers and regression analysis were used in the statistical treatment of the data (9). The initial analysis included all the treatments. Subsequently, the control group was deleted and the experiment reanalyzed as a 3 x 4 factorial arrangement of treatments (three sources of gossypol, [GAA, DSM and PCS] and four levels of free gossypol [2.3, 4.5, 9.1 and 13.6 mg/pound LW/day]) in a randomized block design. Sources of variation separated out in the model were replicates, gossypol sources, gossypol levels and the gossypol source x level interaction.

Results

The average age of the lambs when the experimental treatments were started was 58.6 ± 2.7 days. The initial live weights averaged 29.3 ± 1.3 pounds. One lamb receiving the control diet ate erratically. The data for this lamb have been excluded from the summary. All lambs receiving the 9.1 and 13.6 mg/pound LW/day levels of GAA died or were euthanatized during the study. Average time of death was 15.8 ± 0.8 days and 13.2 ± 0.2 days for the 9.1 and 13.6 mg levels, respectively. One additional lamb receiving the 4.5 mg level of GAA died on the 26th day. A decision to euthanatize a lamb was based on failure to eat or drink for several days and an inability to get up without assistance. None of the lambs fed diets containing DSM or PCS exhibited any signs of gossypol poisoning.

Clinical signs prior to death were anorexia and chronic depression. Sudden death occurred in several lambs. Macroscopic lesions were consistent with gossypol poisoning and included excessive, often red-tinged, pericardial, thoracic and intraperitoneal fluid volumes; generalized icterus; enlarged flabby hearts; enlarged livers; and edematous lungs.

During the first 14 days there were significant gossypol source x level interactions for live weight change ($P < .05$) and feed intake ($P < .01$). Gossypol level did not affect live weight change or feed intake when either DSM or PCS was the source of free gossypol, but did affect these measurements when the source was GAA (Table 3). Lambs fed diets containing PCS gained 36.2 percent more ($P < .05$) during the first 14 days than lambs receiving DSM diets, but feed intakes of lambs fed these two sources of free gossypol were not different.

There were no 28-day data for the 9.1 and 13.6 mg levels of GAA since these lambs died during the experiment. Among the remaining treatments, there were no significant effects for gossypol source or level on live weight change or feed intake. The live weight change data for DSM and PCS exhibited a decrease with increasing free gossypol intakes but the response was not significant ($P = 0.18$).

In serum samples collected on day 7, there were no effects of gossypol sources and levels on any of the serum constituents measured. However, at 14 days, total protein, albumin, globulin and glucose were decreased by increasing levels of GAA. Phosphorus was elevated at the 13.6 mg level of GAA. Urea nitrogen, creatinine, total bilirubin, creatine phosphokinase, lactic dehydrogenase, alanine aminotransferase and aspartate aminotransferase were elevated at both the 9.1 and 13.6 mg levels of GAA. Neither DSM nor PCS had a significant effect on any serum constituents (Table 4). In serum samples collected from the surviving lambs at 28 days there were no significant treatment effects on any of the serum constituents (Table 5).

Percentage hemolysis of RBC in buffered (pH 7.4) saline solutions with decreasing salt concentrations is shown in Figure 1. This curve is a composite for all lambs sampled initially. All subsequent measurements were made only with the buffered solution containing 0.75 percent salt. Initially, the percentage of RBC hemolyzed in a

Table 3. Performance of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed.

		Gossypol Acetic Acid				Direct Solvent Cottonseed Meal				Pima Cottonseed				
		mg/lb LW/d				mg/lb LW/d				mg/lb LW/d				
Item	Control	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	SEM[a]
Lambs, number	3	4	4	4	4	4	4	4	4	4	4	4	4	
Initial age, days	58	58	55	56	62	62	57	63	59	56	60	58	57	2.7
Initial wt, pounds	27.3	28.3	29.5	26.8	27.8	31.8	29.3	29.0	29.3	29.5	32.3	29.5	29.8	1.3
14-day Summary														
Live wt gain, lb/day	0.190	0.196	0.179	-0.107	-0.161	0.196	0.179	0.143	0.143	0.268	0.250	0.232	0.286	0.063
Feed intake, lb/day	0.89	0.96	0.99	0.52	0.48	1.07	0.98	1.00	0.99	1.00	1.09	1.00	0.99	0.08
Gossypol intake, mg/lb LW/d	0	2.5	5.1	10.6	14.5	2.1	4.1	8.7	12.1	2.1	4.1	8.3	12.1	0.2
Lambs died, number	0	0	0	1	4	0	0	0	0	0	0	0	0	
28-day Summary														
Live wt gain, lb/day	0.214	0.179	0.179	-	-	0.241	0.223	0.152	0.143	0.250	0.250	0.232	0.214	0.034
Feed intake, lb/day	0.95	1.01	1.01	-	-	1.14	1.07	1.04	1.04	1.07	1.17	1.05	1.04	0.06
Gossypol intake, mg/lb LW/d	0	2.6	5.0	-	-	2.1	4.2	8.7	12.9	2.1	4.2	8.3	12.3	0.1
Lambs died, number	0	0	1	4	4	0	0	0	0	0	0	0	0	

[a]Standard error of the mean.

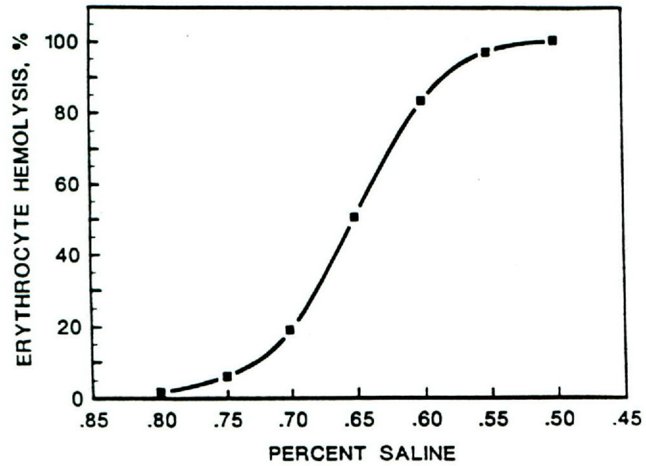

Figure 1. Osmotic fragility curve for erythrocytes of early-weaned lambs (58.6 ± 2.7 days of age and 29.3 ± 1.3 pound live weight).

0.75 percent saline solution averaged 7.0 ± 3.0. In blood samples collected at 7 days, sources and levels of gossypol did not affect RBC fragility. Averaged across all treatments, RBC fragility at 7 days was 8.2 ± 3.7 percent. At 14 days there was a linear increase in RBC fragility at gossypol intakes greater than 2.3 mg/pound LW/day for lambs receiving gossypol acetic acid. In contrast, free gossypol intake did not affect RBC fragility when the sources of free gossypol were either DSM or PCS (Table 6; Figure 2). Red blood cell fragility was increased by all sources of gossypol in blood samples collected at 28 days. However, the response was unique for each gossypol source. With gossypol acetic acid, there was a linear increase in RBC fragility as gossypol intake increased. With DSM, the response was quadratic; whereas, with PCS, there was a linear increase in RBC fragility at gossypol intakes greater than 4.5 mg/pound LW/day (Table 6; Figure 3).

Table 4. Serum constituents of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed.

		Gossypol Acetic Acid mg/lb LW/d				Direct Solvent Cottonseed Meal mg/lb LW/d				Pima Cottonseed mg/lb LW/d				
Item	Control	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	SEM[a]
14-day serum samples														
Total protein, g/dl	5.9	6.0	5.4	4.4	4.1	5.7	5.8	5.5	5.6	5.7	5.5	5.8	5.6	0.241
Albumin, g/dl	3.3	3.4	3.2	2.7	2.4	3.2	3.4	3.2	3.2	3.2	3.1	3.3	3.3	0.099
Globulin, g/dl	2.5	2.6	2.2	1.7	1.7	2.5	2.4	2.3	2.4	2.5	2.4	2.4	2.3	0.187
Calcium, mg/dl	11.5	11.7	11.8	10.1	9.8	11.4	11.6	11.6	11.1	10.8	11.2	11.4	10.9	0.321
Phosphorus, mg/dl	8.5	8.4	10.5	9.8	15.1	9.9	10.1	9.4	9.3	10.3	9.5	10.3	10.2	0.981
Glucose, mg/dl	71.7	69.5	70.3	24.3	48.7	75.5	68.8	68.0	66.0	70.5	76.5	73.0	77.5	4.77
Urea nitrogen, mg/dl	14.0	17.3	19.3	25.5	40.7	19.8	17.0	18.3	17.0	16.3	21.8	16.5	19.3	2.44
Creatinine, mg/dl	0.8	0.9	0.9	1.2	1.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.136
Total bilirubin, mg/dl	0	0.1	0.1	5.4	3.8	0	0	0.1	0.1	0	0.1	0.1	0	0.781
Alkaline phosphatase, u/l	327.0	308.0	369.0	470.3	250.7	266.8	326.8	298.5	320.5	286.0	342.8	303.0	335.8	63.3
Creatine phosphokinase, u/l	256.7	211.0	367.0	846.0	3,991.3	419.8	297.3	330.3	162.8	187.8	189.3	165.3	376.8	460.6
Lactic dehydrogenase, u/l	384.0	365.8	341.3	828.5	1,384.3	333.3	347.3	370.5	351.0	349.5	334.3	312.5	339.8	105.6
Alanine aminotransferase, u/l	9.0	14.3	12.3	24.5	29.3	11.5	9.0	11.0	7.8	8.0	9.8	8.3	11.5	3.35
Aspartate aminotransferase, u/l	108.7	104.3	86.3	220.5	633.7	73.5	84.5	76.8	69.0	72.3	63.0	72.5	79.0	40.4

[a]Standard error of the mean.

Table 5. Serum constituents of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed.

		Gossypol Acetic Acid mg/lb LW/d		Direct Solvent Cottonseed Meal mg/lb LW/d				Pima Cottonseed mg/lb LW/d				
Item	Control	2.3	4.5	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	SEM[a]
28-day serum samples												
Total protein, g/dl	5.9	5.7	5.1	5.5	5.8	5.5	5.7	5.5	5.5	5.8	5.6	0.121
Albumin, g/dl	3.3	3.2	3.0	3.1	3.3	3.1	3.2	3.1	3.1	3.2	3.3	0.069
Globulin, g/dl	2.6	2.5	2.1	2.4	2.5	2.4	2.6	2.4	2.4	2.6	2.4	0.119
Calcium, mg/dl	10.8	10.8	10.3	9.7	11.0	10.7	10.9	9.6	10.6	10.9	10.7	0.288
Phosphorus, mg/dl	8.6	9.2	9.8	9.2	8.8	9.1	8.8	10.0	8.8	9.8	9.0	0.469
Glucose, mg/dl	72.7	72.3	66.7	74.5	71.3	68.5	74.5	72.8	77.8	75.5	76.3	3.80
Urea nitrogen, mg/dl	13.7	18.3	18.3	23.3	17.8	16.3	15.3	18.5	20.5	16.0	17.0	1.58
Creatinine, mg/dl	0.8	0.8	0.9	0.9	0.8	0.9	0.8	0.8	0.9	0.8	0.9	0.035
Total bilirubin, mg/dl	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.025
Alkaline phosphatase, u/l	344.0	338.5	304.3	285.5	399.8	293.5	379.3	285.3	375.8	336.3	341.8	48.9
Creatine kinase, u/l	136.0	124.0	188.0	140.8	223.8	236.3	493.8	132.5	232.8	180.8	392.8	116.4
Lactic dehydrogenase, u/l	368.7	396.0	506.0	388.0	437.5	393.0	398.0	398.0	386.0	354.8	387.3	27.1
Alanine aminotransferase, u/l	9.0	12.0	13.3	11.0	12.8	13.8	13.3	12.5	9.5	10.3	12.3	2.06
Aspartate aminotransferase, u/l	81.0	78.8	105.0	71.3	80.5	76.5	74.8	79.3	72.3	74.5	65.5	5.78

[a]Standard error of the mean.

Table 6. Percentage hemolysis of erythrocytes of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed

		Gossypol Acetic Acid mg/lb LW/d				Direct Solvent Cottonseed Meal mg/lb LW/d				Pima Cottonseed mg/lb LW/d				
Item	Control	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	SEM[a]
Initial	9.1	4.8	4.7	10.2	7.8	7.1	10.1	5.1	3.6	12.2	4.9	8.5	3.8	3.0
7-day[b]	6.9	7.0	8.3	10.8	7.8	7.8	10.0	6.5	6.4	8.2	7.7	11.0	8.3	3.7
14-day[b]	8.0	11.0	21.5	71.3	87.3	11.8	15.9	9.6	7.5	8.6	9.6	17.7	14.3	6.0
28-day[b]	10.9	46.8	77.2	-	-	21.1	28.0	33.4	21.6	14.1	16.2	41.0	51.5	11.1

[a]Standard error of the mean.
[b]Means in these rows were adjusted by using initial percentage hemolysis as a covariate.

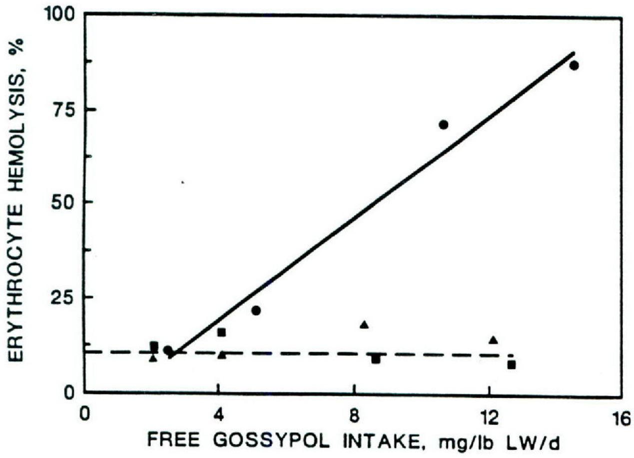

Figure 2. Effects of gossypol intakes on the percentage hemolysis of erythrocytes in 0.75 percent saline of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed for 14 days.

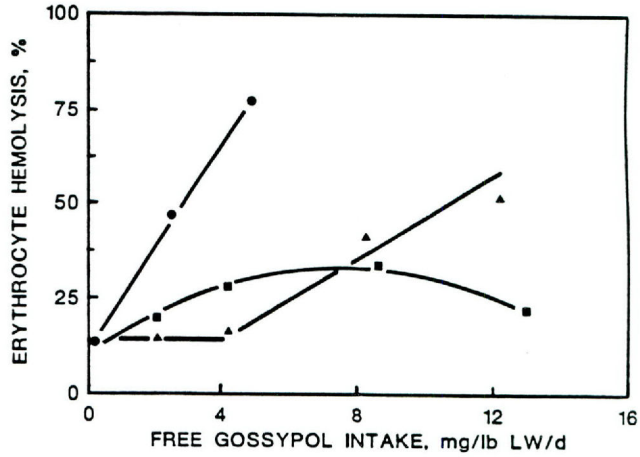

Figure 3. Effects of gossypol intakes on the percentage hemolysis of erythrocytes in 0.75 percent saline of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed for 28 days.

Kidney, liver and heart weights expressed as a percentage of live weights were increased for the 9.1 and 13.6 mg levels of gossypol acetic acid, but not for the other levels and sources of gossypol (Table 7).

Discussion

The responses observed in this study when GAA was administered to lambs, in a gelatin capsule, were similar to those reported by Morgan et al. (5). All lambs receiving 9.1 mg gossypol/pound LW/day were dead in less than 28 days. However, one additional lamb receiving only 4.5 mg/pound LW/day died on the 26th day, suggesting the possibility that the lambs used in this study may have been slightly more susceptible to GAA poisoning than those in the study reported by Morgan et al. (5). Signs of gossypol poisoning were consistent with those reported by others (1, 5) and were suggestive of congestive heart failure.

Since none of the lambs fed diets containing either DSM or PCS as the source of free gossypol exhibited signs of gossypol poisoning or died, it is apparent that oral dosing with GAA is considerably more toxic than feeding equal amounts of free gossypol from DSM or PCS. Thus, generalizations about the toxicity of gossypol, based on observations with GAA, are not valid when applied to DSM and PCS and probably would not be valid for free gossypol contained in other cottonseed products.

Increased hemolysis of RBC in animals receiving gossypol has been reported previously (1, 4). Quantifying the response by measuring the percentage hemolysis of RBC in a 0.75 percent buffered salt solution proved to be a very sensitive measure of gossypol intake in this study. In the case of GAA and PCS, where all the gossypol present was assumed to be free gossypol, the pattern of response was similar. In contrast, the different type of response observed

Table 7. Tissues as a percentage of live weights of lambs receiving gossypol as gossypol acetic acid or as free gossypol from either direct solvent cottonseed meal or Pima cottonseed.

		Gossypol Acetic Acid mg/lb LW/d				Direct Solvent Cottonseed Meal mg/lb LW/d				Pima Cottonseed mg/lb LW/d				
Item	Control	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	2.3	4.5	9.1	13.6	SEM[a]
Kidney, percent[b]	0.20	0.19	0.21	0.31	0.27	0.17	0.20	0.19	0.20	0.20	0.17	0.20	0.19	0.014
Liver, percent	1.8	2.0	2.1	2.7	2.9	1.9	1.9	1.8	1.9	1.8	1.9	1.9	1.9	0.096
Heart, percent	0.58	0.55	0.56	0.77	0.82	0.52	0.55	0.56	0.55	0.54	0.54	0.54	0.51	0.034

[a]Standard error of the mean.
[b]Kidney weight was based on the average wt of both kidneys.

with DSM may reflect the fact that a significant portion of the total gossypol present is bound gossypol. Although, bound gossypol is assumed to be non-toxic, there is good evidence that some bound gossypol may not stay bound and that the nature of the binding may vary with cottonseed meal processing method (1).

The exact physiological significance of increased RBC fragility is not known nor is the mechanism by which gossypol alters resistance of the RBC membrane to osmotic stress. Although increased osmotic fragility does not appear to be detrimental, in view of the short duration of this study and the fact that increased hemolysis precedes changes in other blood constituents, it would seem advisable to use caution in feeding DSM or PCS to early-weaned lambs.

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PR 4780

Increased Erythocyte Fragility in Cattle, Sheep and Goats Fed Whole Cottonseed

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Summary

Cottonseed increased osmotic fragility of erythrocytes (RBC) in Angora goats (8 months old) and yearling heifers fed in confinement and in mature sheep and goats grazing rangeland during the fall and winter of 1989-90. No other signs of gossypol poisoning were observed and reproductive performance was normal. All the animals examined were old enough to have normal rumen function; thus, increased osmotic fragility of RBC indicated either that not all the free gossypol was being bound (detoxified) in the rumen or that a portion of the bound gossypol was being released during digestion in the small intestine. Increased osmotic fragility of RBC precedes other known physiological effects of gossypol, but does not appear detrimental to the animals.

Introduction

Feeding cottonseed and/or cottonseed meal to cattle and sheep increases hemolysis of erythrocytes (RBC) (4, 5, 10). This response is related to the gossypol content of the cottonseed products fed (4, 5). Increased hemolysis of RBC has been demonstrated by mixing RBC with buffered solutions of varying salt concentrations and measuring the percentage hemolysis of RBC as the salt concentration decreases (11). Osmotic fragility of RBC, measured in this manner, is very sensitive to gossypol intake; preceding other gossypol-induced physiological and biochemical changes (increased respiration, depression, inanition, increased susceptibility to stress, sudden death) (4, 5). This suggests the possibility that RBC fragility might be a useful measurement to indicate when the mature ruminants ability to detoxify gossypol has been exceeded. Therefore, the purpose of this study was to measure osmotic fragility of RBC in cattle, sheep and goats fed cottonseed experimentally and under range conditions.

Experimental Procedure

Osmotic fragility of RBC was measured in blood samples collected from Angora goats and yearling heifers fed cottonseed in confinement and from Angora goats, sheep and cattle fed cottonseed during the fall and winter of 1989-90, while grazing rangeland.

Osmotic fragility of RBC was determined by measuring the percentage hemolysis of RBC in buffered (pH 7.4) saline solution (11). The "normal" osmotic fragility curves for cattle, sheep and goats shown in Figure 1 were generated by varying the salt concentration from 0.85 to 0.40 percent. Cattle RBC are more resistant to osmotic stress than are RBCs from sheep and goats; whereas, the response curves for sheep and goats are similar. To obtain the RBC hemolysis values presented in this report, sheep and goat RBC were incubated in a 0.75 percent saline solution. Cattle RBC were incubated in either 0.65 or 0.60 percent saline.

A brief description of the animals involved, the amounts of cottonseed fed and estimated free gossypol intakes are as follows:

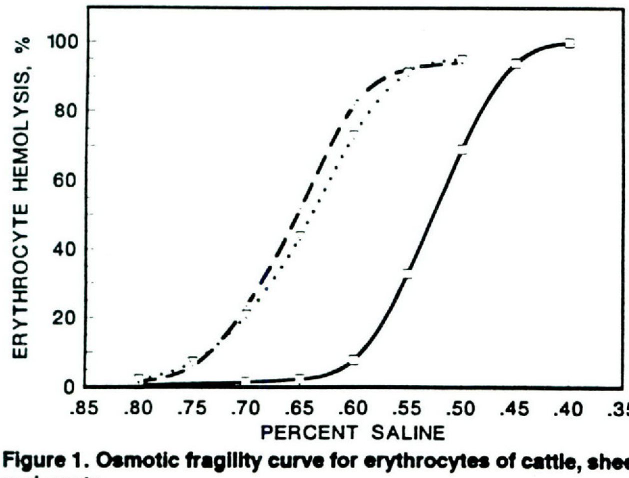

Figure 1. Osmotic fragility curve for erythrocytes of cattle, sheep and goats.

Angora Goat Experiment

Thirty female goats (approximately 8 months old) were placed in individual pens (November 1, 1989) and offered sorghum-sudangrass hay free choice. They were randomly assigned to one of the following supplements: (1) 0.5 pound of corn daily, (2) 0.5 pound corn and 0.5 pound cottonseed offered separately on alternate days or (3) 0.5 pound cottonseed daily. Because 50 percent of the goats refused to eat cottonseed, after 28 days all goats were switched to the following mixed diets containing ground sorghum - sudangrass hay and either (1) no cottonseed, (2) 12.5 percent cottonseed or (3) 25 percent cottonseed. Fuzzy cottonseed (0.49 percent free gossypol) was used for these diets. Sorting was a problem with the mixed diets and consumption of cottonseed continued to be erratic. Therefore, after 16 days the diets were once again changed. Sorghum-sudangrass hay was not used and complete diets were formulated using sorghum grain, cottonseed hulls and ground Pima cottonseed (0.73 percent free gossypol) at levels of 0, 12.5 and 25 percent for treatments 1, 2 and 3, respectively. Consumption of these diets was satisfactory and they were fed for the duration of the study. The total feeding period was 152 days.

Yearling Heifer Experiment

Twenty yearling heifers (Hereford x Brangus) were individually fed for 56 days (February 15, 1990 – April 12, 1990) complete diets containing 0, 10, 20 and 30 percent whole fuzzy cottonseed (0.49 percent free gossypol).

Grazing Studies

Kreig Ranch, Eden, Texas. This rancher started feeding cottonseed to Hereford cows on October 15, 1989, at a rate of 42 pound/cow/week (14 pound, 3 x/week). This was increased to 58 pound/cow/week (19.4 pound, 3 x/week) on November 1, 1989, and continued till February 18, 1990. Calves were born in September and October. Ninety-five percent of the cows bred calved. Average weight of the cows was approximately 1,300 pounds and calves weighed 300 to 350 pounds on February 27, 1990, when blood samples were collected.

Carlsbad/San Angelo, Texas Research Area. Groups of cattle, sheep and Angora goats were fed cottonseed in separate pastures at either the Carlsbad Research Area (Carlsbad, Texas) or at Texas A&M University's Research Center during the fall and winter of 1989-90. Blood samples were collected initially and upon completion of the feeding period from a random sample of animals representing the three species.

Cattle. Cottonseed was fed from December 6, 1989, to April 9, 1990, at a rate of 21 pounds/cow/week (10.5 pounds on Tuesdays and Fridays) to 15 first-calf heifers (Hereford-Brangus x Beefmaster) weighing approximately 1,000 pounds. Calves were born during the period from December 15, 1989, to January 15, 1990. The calf crop was 80 percent.

Sheep. Cottonseed was fed from December 20, 1989, to April 6, 1990, at a rate of 5.25 pounds/ewe/week (2.63

pounds on Tuesdays and Fridays) to 90 yearling Rambouillet ewes weighing approximately 145 pounds. Blood samples were collected from 17 randomly selected ewes for RBC fragility analysis. Their lambs were born during the period from February 1, 1990, to March 1, 1990. The lamb crop was 80 percent.

Angora goats. Cottonseed was fed from December 20, 1989, to April 10, 1990, at a rate of 3.5 pounds/goat/week (1.75 pounds on Tuesdays and Fridays) to 60 mature females weighing approximately 100 pounds. Blood samples were collected for RBC fragility analysis from 20 goats selected at random. Their kids were born during the period from March 2, 1990, to March 26, 1990. The kid crop was 107 percent.

Prior to February 8, 1990 all goats were grazing irrigated, fertilized Jose tall wheatgrass pasture. Subsequently, nine were placed on a saltbush-grass pasture and eight on grass only for the remainder of the period. Three additional goats were on a saltbush-grass pasture from February 8, 1990, until March 26, 1990, and were then placed on native rangeland until April 10, 1990.

Free gossypol concentrations of representative samples of fuzzy and Pima cottonseed were determined commercially using the procedure described by Pons (12).

Analysis of variance procedures for a completely random design were used in the statistical treatment of data from the Angora goat and yearling heifer confinement studies. Covariance analysis was used to adjust final RBC fragility measurements for differences in initial values. A paired t test was used to test for differences between initial and final values in the grazing studies (14).

Results

Angora Goat Experiment

Hemolysis of RBC in a buffered 0.75 percent saline solution averaged 5.3 $\pm$ 1.5 percent, initially. Feeding diets containing cottonseed for 152 days increased osmotic fragility of RBC ($P < .05$). Goats fed treatment 2 (12.5 percent cottonseed) consumed 13.2 mg free gossypol/pound LW/day during this period and hemolysis of RBC increased from 5.9 to 36.8 percent. Goats fed treatment 3 (25 percent cottonseed) consumed 23.3 mg free gossypol/pound LW/day and hemolysis of RBC increased from 3.7 to 31.6 percent. There were no signs of gossypol toxicity in any goats receiving diets with cottonseed (Table 1).

Yearling Heifer Experiment

Performance was improved by including whole cottonseed in diets fed to yearling heifers for 56 days. There was a linear increase in live weight gains ($P < .01$) and a linear decrease in feed requirements for gain ($P < .10$) as whole cottonseed levels in the diets increased from 0 to 30 percent. The overall improvement in gains was 12.5 percent and in feed efficiency 12.1 percent. Hemolysis of RBC in a buffered 0.60 percent saline solution averaged 7.2 $\pm$ 3.6 percent, initially. There was a linear increase in osmotic fragility as cottonseed levels in the diet increased ($P < 0.01$). There were no signs of gossypol toxicity in any heifers receiving diets with cottonseed (Table 2).

Table 1. Live weight, free gossypol intake and osmotic fragility of erythrocytes of Angora goats fed diets containing varying amounts of ground Pima cottonseed.

	Treatment Number[a]			
Criterion	1	2	3	SEM[b]
Initial live weight, lb	46.7	43.8	43.8	1.5
Final live weight, lb	55.7	54.8	51.3	2.0
Gossypol intake, mg/lb LW/day	0	13.3	23.3	0.49
Erythrocyte fragility[c]				
Initial, % hemolysis	6.2	5.9	3.7	1.5
Final, % hemolysis	7.9[d]	36.8[e]	31.6[e]	3.1

[a]Dietary treatments corresponding to treatment numbers are described in the Experimental Procedure section.
[b]Standard error of the mean.
[c]Percentage hemolysis of erythrocytes in a buffered 0.75% salt solution.
[d,e]Means in the same row without a common superscript are significantly different ($P < .05$).

Table 2. Performance, free gossypol intakes and osmotic fragility of erythrocytes of yearling heifers fed diets containing varying amounts of whole cottonseed for 56 days.

	Whole cottonseed, %				
Criterion	0	10	20	30	SEM[a]
Initial live weight, pounds	595	602	643	585	21.7
Live weight, gain, lb/d[b]	2.4	2.4	2.7	2.7	0.03
Feed intake, lb/d	21.5	20.8	23.1	21.7	0.80
Feed/gain[c]	9.1	8.6	8.6	8.0	0.44
Free gossypol intake,					
g/d	0	5.9	13.1	18.5	
mg/lb LW/d	0	8.8	18.2	27.9	0.21
Erythrocyte fragility[d]					
Initial, percent hemolysis	5.0	11.2	4.7	7.9	3.6
Final, percent hemolysis[b]	7.7	10.4	14.0	20.2	2.5

[a]Standard error of the mean.
[b]Linear response, $P < .01$.
[c]Linear response, $P < .10$.
[d]Percentage hemolysis of erythrocytes in a buffered 0.60% salt solution.

Grazing Studies

Kreig Ranch, Eden, Texas. Cattle at the Kreig Ranch have been fed cottonseed during late fall and winter for several years. With the exception of a 7 percent phosphorus mineral (free choice) and an occasional protein block, this has been the only supplemental feed used. There have been no breeding problems and 95 percent of the cows bred calved during the last 3 years. The feeding period lasted 136 days during the 1989-90 winter season. Based on the number of cows present, cottonseed intake was 8.0 pounds/cow/day. Uncertainty about this figure derives from the fact that calves were present during the feeding period. Regardless of the actual amounts of cottonseed consumed by individual cows and calves, three of 10 cows and nine of 10 calves sampled exhibited increased RBC fragility (percent hemolysis of RBC in buffered 0.6 percent saline solution >10). The RBC hemolysis values for the cows and calves were 13.9 ± 4.5 and 31.0 ± 6.4 percent, respectively (Table 3).

Table 3. Cottonseed consumption, free gossypol intake and osmotic fragility of erythrocytes of grazing cattle, sheep and goats.

Criterion	Kreig cattle	Carlsbad/San Angelo cattle	Carlsbad/San Angelo sheep	Carlsbad/San Angelo goats
Animals, number	10	13	17	20
Live weight, pounds	1,300	1,000	145	100
Feeding period, days	136	125	106	110
Cottonseed intake, lb/d	8.0	3.0	0.75	0.50
Gossypol intake,				
gram/day	17.9	6.7	1.7	1.1
mg/lb LW/d	13.8	6.7	11.6	11.1
Erythrocyte fragility[a]				
Initial, % hemolysis	-	3.0	7.0	21.0
Final, % hemolysis	13.9	3.2	22.0[b]	33.4[b]

[a]Percentage hemolysis of erythrocytes in a buffered saline solution (0.60% salt solution was used for the Kreig cattle and 0.65% salt for the Carlsbad/San Angelo cattle).
[b]Significantly different from initial value ($P<.01$).

Carlsbad/San Angelo, Texas Research Area.

Cattle. Feeding 3 pounds cottonseed/cow/day did not increase osmotic fragility of RBC during a 125-day feeding period (Table 3).

Sheep. Feeding 0.75 pound cottonseed/ewe/day increased RBC hemolysis from 7.0 to 22.0 percent during a 106-day feeding period ($P<.01$). This amount of cottonseed provided free gossypol intakes of 1.7 grams/day and 11.6 mg/pound LW (Table 3).

Angora Goats. There was considerable variation in initial RBC hemolysis measurements of these Angora goats, with about 50 percent exhibiting markedly elevated values (> 20 percent). The average initial value was 21.0 ± 4.4 percent. Feeding 0.5 pound cottonseed/goat/day for 110 days increased RBC hemolysis to 33.4 ± 5.8 ($P<.01$). Because the goats were not handled uniformly, responses were separated out according to grazing treatment. The average initial and final values for the eight goats that remained on grass were 11.3 and 17.8 percent, respectively. For those placed on a saltbush-grass pasture from February 8, 1990, until the end of the feeding period, initial and final values were 24.4 and 35.0 percent, respectively. The three goats grazing saltbush-grass from February 8 to March 26, 1990, and then returned to native pasture had initial and final values of 36.8 and 70.5 percent.

Discussion

Consumption of cottonseed increased osmotic fragility of RBC in Angora goats (8 months old) and yearling heifers fed in confinement and in sheep and goats grazing rangeland during the fall and winter of 1989-90. No other signs of gossypol toxicity were observed in any of these studies and the reproductive performance of the grazing animals was consistent with expected values for cattle, sheep and goats under range conditions.

The presence of calves, lambs and kids during the cottonseed-feeding period makes estimates of cottonseed/gossypol intakes by cows, ewes and nannies difficult. However, this probably only presents a real problem with the cattle. Lambs and kids were born late in the feeding period; whereas, calves were born as cottonseed feeding commenced (Kreig Ranch) or shortly afterward (Carlsbad/San Angelo, Texas Research Area). During the short time that lambs and kids were present, most likely they ate very little cottonseed. In contrast, calves were observed eating cottonseed along with the cows and nine of the 10 calves sampled at the Kreig Ranch exhibited elevated values for osmotic fragility of RBC (31.0 percent in 0.60 percent saline solution).

Assessment of increased osmotic fragility in the grazing studies was accomplished by either comparing final with initial values (Carlsbad/San Angelo Research Area) or with normal values for cattle (Kreig Ranch). Caution is necessary in making generalizations from these data because there were no control groups (animals grazing similar pasture areas and not fed cottonseed) for any of the species involved. Other plant constituents in the diet may also have produced a hemolytic effect. For example, saponins occur in a wide variety of plants and interact with cholesterol in the RBC membrane, producing a hemolytic effect (2). However, a similar increase in osmotic fragility of RBC was observed in Angora goats regardless of exposure to saltbush which contains high levels of saponins. The greater variation in osmotic fragility values for goat RBC may reflect the presence of variable percentages of fusiform RBC resembling sickle cells in Angora goats. Fusiform RBC have a greater resistance to osmotic stress than the normal, biconcave disk shaped RBC (9).

Increased osmotic fragility of RBC associated with gossypol intake has been observed consistently in early-weaned lambs either orally administered gossypol acetic acid or fed a variety of cottonseed products (4, 5). In studies with mature dairy cattle, Lindsey et al. (10) reported increased osmotic fragility, but Coppock et al. (6) and Hawkins et al. (8) reported no effect. The short duration (35 days) of the feeding period in Coppock's study may have been inadequate to allow an increase in RBC fragility. However, the cattle in Hawkins' study received 20 mg gossypol/pound LW/day for about 9 months which should have been sufficient for a rise in osmotic fragility to have occured.

The increased osmotic fragility observed in mature ruminants fed cottonseed indicates that at the levels fed in these studies the ability of the rumen to detoxify gossypol is exceeded (13). The mechanism by which gossypol exerts a physiological effect on RBC is unknown. However, gossypol is a very reactive molecule (1, 3) and may interact directly with some component of the RBC membrane (7). Increased osmotic fragility of RBC precedes other known physiological effects of gossypol (4, 5), but does not appear to be detrimental to the animals.

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Arsenic Toxicosis in Sheep

M.C. Calhoun, B.L. Cooper, G.R. Engdahl and L.P. Jones

Summary

Ortho arsenic acid, which is extensively used to desiccate cotton plants prior to harvest, results in arsenic (As) residues in cotton by-products available for use as animal feed. Twenty-eight castrated, male crossbred (Rambouillet x Suffolk) lambs (105.1 ± 2.4 pounds) were assigned at random to diets containing As levels of 0, 10, 20, 40, 80, 160 and 320 ppm (as-fed basis). Each diet was fed to four lambs for 56 days. Intake was restricted to 2.2 pounds per lamb per day. Actual As intakes corresponding to each of the above dietary levels were: 0.029, 0.122, 0.240, 0.332, 0.861, 1.71 and 2.07 mg As per pound LW per day. Live weight change was decreased ($P<.05$) and feed intake was depressed ($P<.05$), for lambs fed the highest level of As compared with the control. Packed red blood cell volume was lower ($P<.05$) throughout the study in lambs fed 160 and 320 ppm levels of As. Serum total protein, albumin, glucose, urea nitrogen, creatinine, alkaline phosphatase, creatine phosphokinase, lactic dehydrogenase, aspartate aminotransferase and alanine aminotransferase were unaffected by As intakes. Relative to the control group, serum calcium was decreased 13.8 percent ($P<.05$) and serum phosphorus increased 29.1 percent ($P<.05$) in lambs receiving the 320 ppm level of As for 56 days. The relationships between As intakes in mg per pound LW per day (X) and liver (Y_1), kidney (Y_2) and longissimus muscle (Y_3) As concentrations in mg As/g wet wt at completion of the 56-day study were: $Y_1 = 0.74 - 2.31X + 2.09X^2$ ($r = 0.92$, $P<.01$); $Y_2 = -.09 + 5.29X$ ($r = 0.98$, $P<.01$); and $Y_3 = 0.06 - 0.359X + 0.398X^2$ ($r = 0.97$, $P<.01$). Similar equations for As intake and liver (Y_4), kidney (Y_5) and muscle (Y_6) As concentrations 14 days after withdrawal from the As diets were: $Y_4 = 0.024 + 0.465X$ ($r = 0.92$, $P<.01$); $Y_5 = -.73 + 3.84X$ ($r = 0.91$, $P<.01$); and $Y_6 = -.025 + 0.128X$ ($r = 0.88$, $P<.01$).

Introduction

Ortho arsenic acid is used extensively to desiccate cotton plants prior to harvest and results in arsenic (As) residues in cotton by-products available for use as animal feed. Gin trash frequently contains 100 to 200 ppm of As. Because of various factors, the concentration of As may be as low as 40 ppm or as high as 500 ppm (2, 4). The amount of residual As in gin trash is a function of the amount of As applied per acre, rainfall, time after spraying and the relative amounts of cotton burrs and leaves in gin trash (2).

Studies with rats indicate As is accumulated in body tissues and slowly excreted. In contrast, most domestic animals and humans rapidly excrete absorbed As from the body. As a result, there is little storage of As in body tissues and body stores are rapidly depleted when As is removed from the diet. For example, 6 weeks were adequate to deplete body tissues of As when animals were repeatedly exposed to excessive levels of the element over a long period of time. Although there are suggested differences in tolerance to As among species, the maximum tolerable dietary levels set by the National Research Council are 50 ppm for inorganic forms and 100 ppm for organic forms of As fed to domestic animals (5).

The purpose of this research was to determine the effects of As on lambs fed a diet based on gin trash.

Experimental Procedures

Twenty-eight castrated male crossbred (Rambouillet x Suffolk) lambs (105.1 ± 2.4 pounds) were randomly assigned to pens (one lamb per pen) at the Angelo State University Management, Instruction and Research Center and fed a uniformity diet (Table 1) for a 21-day adjustment period. Following the adjustment period, lambs were weighed, blood was collected by venipuncture and lambs were randomly assigned to diets containing one of seven As levels for a 56-day feeding period. The treatments consisted of a basal diet (Table 1) and the basal diet with added As (10, 20, 40, 80, 160, and 320 ppm)[1].

Table 1. Composition (percent) of the basal diet.

Ingredients	Percent
Sorghum grain, milo	21.0
Gin trash, ground pellets	58.0
Dehydrated alfalfa meal	10.0
Cottonseed meal	5.0
Molasses	4.0
Mono-dicalcium phosphate	0.5
Ammonium chloride	0.5
Vitamin-mineral premix[a]	1.0
Nutrients	
Total digestible nutrients	53.7
Crude protein	11.0
Crude fiber	22.8

[a]The percentage ingredient composition of the premix was as follows: sodium chloride, 64.7; potassium chloride, 19.0; sulfur, 10.0; zinc oxide, .274; vitamin A (13.6 x 10^6 IU/pound), 0.73; vitamin D (13.6 x 10^6 IU/pound), 0.093; vitamin E (12.5 x 10^4 IU/pound), 0.72; chlortetracyline, 3.0 and molasses, 1.5.

[1]Hi-Yield, H-10 with t-49, Voluntary Purchasing Groups, Inc. Bonham, Texas, 75 percent arsenic acid.

Although care was taken to obtain the gin trash from an area where As was not used, the basal diet contained a small amount of As (4.0 ± 1.3 ppm). With the exception of the 40 ppm diet all diets contained slightly more As than planned (Table 2).

Table 2. Actual arsenic content of diets.

Diet	Arsenic content ppm
Basal	4.0 ± 1.3
10	13.1 ± 1.4
20	25.5 ± 1.2
40	35.2 ± 2.2
80	94.8 ± 4.2
160	191.9 ± 6.4
320	346.8 ± 5.5

Clean, fresh water was provided free-choice during the experiment and feed (2.2 pounds per lamb) was fed daily. Feed refusals were collected and weighed at 7-day intervals. Live weights were obtained at 2-week intervals. Serum obtained from blood samples collected bi-weekly were stored frozen and subsequently analyzed for protein, albumin, calcium, phosphorus, glucose, urea nitrogen, creatinine, total bilirubin, alkaline phosphatase, creatine phosphokinase, lactic dehydrogenase, alanine aminotransferase and aspartate aminotransferase by the Texas Veterinary Medical Diagnostic Laboratory in College Station, Texas. The percentage of red blood cells (hematocrit) was also determined using heparinized whole blood.

Upon completion of the 56-day feeding period, 14 lambs were randomly selected for slaughter, two from each As level. The remaining 14 lambs were maintained on the basal diet for a 2-week withdrawal period and then slaughtered. The kidneys and liver were removed, weighed and stored frozen, and a section of the *longissimus* muscle, which was not weighed, was also removed and frozen. Subsequently, representative samples of liver, kidneys, and *longissimus* muscle were analyzed for As.

Samples of all feeds and tissues were tested for As content using standard AOAC procedures (1). In the statistical treatment of the data, procedures outlined by Steel and Torrie (7) for the analysis of variance of a completely random design were used. Regression analyses were employed to separate out the linear, quadratic and residual effects of As intakes.

Results

The effects of ortho arsenic acid on performance of growing-finishing lambs are summarized in Table 3. The only evidence of As toxicity occurred in lambs fed the two highest levels of As. Lambs receiving these levels initially ate the feed that was offered but then went off-feed. Subsequently, they resumed eating, but at a reduced rate throughout the study for lambs receiving the 320 ppm diet. Live weight change was decreased ($P < .05$) and feed intake was depressed ($P < .05$) for lambs fed the highest level of As compared with those fed the control diet.

Packed red blood cell volume (hematocrit, percent) was lower ($P < .05$) throughout the study in lambs fed the 160 and 320 ppm levels of As (Table 4). Serum total protein,

Table 3. Effects of ortho arsenic acid on performance of growing-finishing lambs.

	Dietary arsenic levels, ppm (as-fed basis)							
Criterion	0	10	20	40	80	160	320	SEM[a]
Lambs, number	4	4	4	4	4	4	4	
Initial weight, pounds	103.7	105.0	104.5	103.0	108.2	106.7	104.5	2.4
1-28 days								
Live wt gain, pound/day	0.09	0.09	0.05	0.15	0.15	-0.01	-0.14[b]	0.07
Feed intake, pound/day	2.20	2.20	2.20	2.20	2.20	1.96	1.38[b]	0.09
Arsenic intake, mg/pound LW/day	0.03	0.12	0.24	0.34	0.86	1.61	2.12	0.11
29-56 days								
Live wt gain, pound/day	0.01	0.04	0.06	0.06	-0.01	0.08	-0.02	0.04
Feed intake, pound/day	2.20	2.20	2.20	2.20	2.20	2.18	1.58[b]	0.06
Arsenic intake, mg/pound LW/day	0.03	0.12	0.24	0.33	0.85	1.76	2.48	0.09
1-56 days								
Live wt gain, pound/day	0.05	0.06	0.06	0.11	0.07	0.04	-0.08[b]	0.03
Feed intake, pound/day	2.20	2.20	2.20	2.20	2.20	2.07	1.48[b]	0.07
Arsenic intake, mg/pound LW/day	0.03	0.12	0.24	0.33	0.86	1.68	2.28	0.10

[a]Standard error of the mean.
[b]Significantly different from the 0 ppm arsenic diet ($P < .05$).

Table 4. Packed red blood cell volume (hematocrit, percent) lambs fed varying levels of arsenic for 56 days.

	Dietary arsenic levels, ppm (as-fed basis)							
Sampling time, days	0	10	20	40	80	160	320	SEM[a]
0	41.3	39.4	44.8	45.8	39.5	39.9	37.8	2.81
14	37.7	37.3	37.8	40.2	35.6	27.9[b]	24.6[b]	2.73
28	41.7	38.5	41.6	39.5	34.9	30.6[b]	29.8[b]	2.97
42	39.8	36.0	39.0	37.0	35.8	30.7	25.2[b]	3.22
56	44.4	38.0	45.8	42.3	40.2	33.9[b]	26.3[b]	2.77

[a]Standard error of the mean.
[b]Significantly different from the 0 ppm arsenic diet ($P < .05$).

albumin, glucose, urea nitrogen, creatinine, alkaline phosphatase, creatine phosphokinase, lactic dehydrogenase, aspartate aminotransferase and alanine aminotransferase were unaffected by As intakes. The initial and final values for the serum measurements unaffected by dietary As levels are summarized in Table 5. Serum calcium concentrations were decreased at 42 and 56 days ($P < .05$) in lambs fed the 320 ppm As diet (Table 6). Serum phosphorus concentrations were increased at 28 and 56 days ($P < .05$) in lambs fed the 320 ppm As diet (Table 7). There were also increases in serum total bilirubin concentrations associated with As levels. However, these effects were not as consistent as for calcium and phosphorus (Table 8). At 14 days, there was an increase in total bilirubin in lambs fed the 160 ppm As diet, but this increase was due to a very high level for one lamb. At 56 days, there were increases in total bilirubin concentrations for lambs fed the 20, 160 and 320 ppm As diets. The reason for the increased level of bilirubin in lambs fed 20 ppm of As is unclear; however, the increases observed in lambs fed 160 and 320 ppm of As are probably due to As. (Table 8).

Table 5. Initial and final blood serum measurements.

Item	Initial	Final[a]
Total protein, gram/day	5.9 ± 0.60	6.4 ± 0.17
Albumin, gram/day	3.6 ± 0.22	3.8 ± 0.12
Glucose, mg/dl	58.3 ± 6.7	72.2 ± 3.8
Urea nitrogen, mg/dl	9.4 ± 0.92	12.1 ± 1.5
Creatinine, mg/dl	1.21 ± 0.10	1.24 ± 0.09
Alkaline phosphatase, IU/l	131.0 ± 20.9	148.0 ± 27.3
Creatine phosphokinase, IU/l	312.0 ± 99.0	415.0 ± 65.0
Lactic dehydrogenase, IU/l	499.0- ± 57.0	525.0 ± 37.0
Aspartate aminotransferase, IU/l	129.0 ± 15.1	117.0 ± 9.0
Alanine aminotransferase, IU/l	20.3 ± 3.5	51.1 ± 7.3

[a]Initial and final values were not affected by As concentrations in the diets.

The associations between As intakes (X) and tissue As concentrations (Y) for liver, muscle and kidney before and after a 14-day withdrawal period are presented in Figures 1, 2 and 3, respectively. Prior to As withdrawal, the association between As intake and liver As concentrations was quadratic ($Y = 0.74 - 2.31X + 2.09X^2$ [$r = 0.92, P < .01$]) (Figure 1). During the 14-day withdrawal period, liver As levels dropped considerably. Prior to withdrawal, the highest liver As was 7.6 mg/gram wet weight of tissue, corresponding to an As intake of 2.4 mg per pound LW per day. Fourteen days later, the highest liver As was 1.4 mg/gram of wet tissue weight, corresponding to an As intake of 2.9 mg per pound LW per day. The relationship between As intake, during the trial, and liver As 14 days after withdrawal was $Y = 0.024 + 0.465X$ ($r = 0.92$, $P < .01$) (Figure 1).

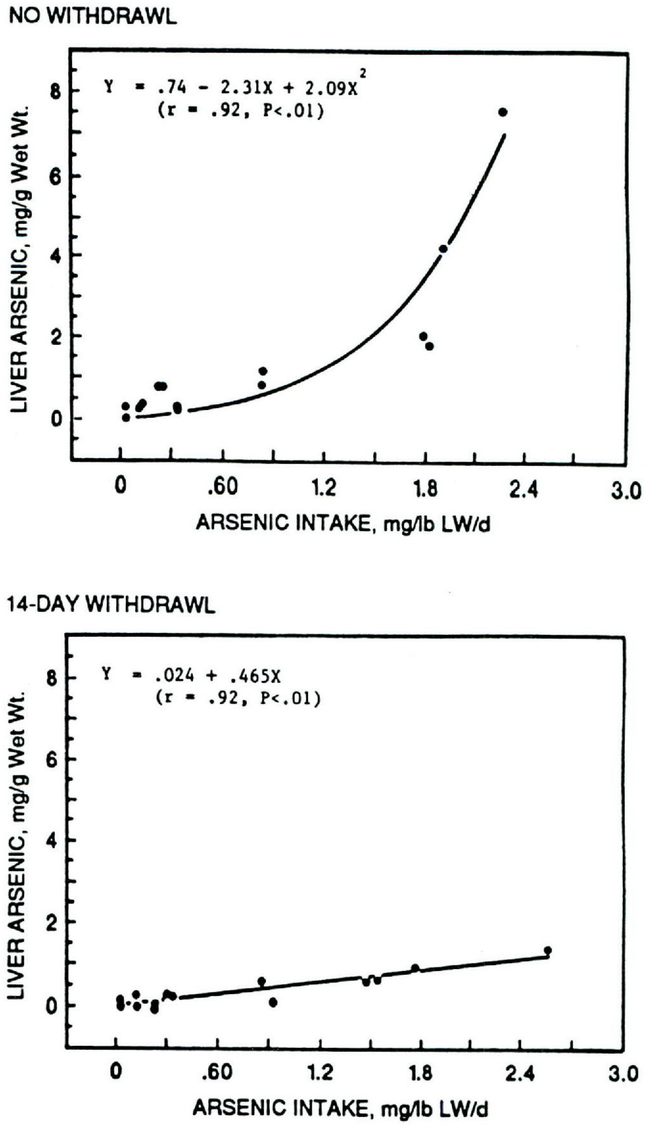

Figure 1. Associations between dietary arsenic intake in mg per pound LW per day (X) and liver arsenic concentations in mg As/gram wet liver wt (Y) prior to (no withdrawal) and following a 14-day withdrawal from diets containing arsenic.

Table 6. Serum calcium concentrations (mg/dl) of lambs fed varying levels of arsenic for 56 days.

	Dietary arsenic levels, ppm (as-fed basis)							
Sampling time, days	0	10	20	40	80	160	320	SEM[a]
0	9.1	9.7	9.9	10.4	10.5	10.3	9.1	0.55
14	10.6	10.4	10.2	10.4	10.3	9.7	10.3	0.20
28	10.3	10.2	10.3	10.4	10.1	9.6	9.6	0.24
42	10.6	10.2	10.5	10.3	10.4	10.1	9.8[b]	0.20
56	10.9	10.4	10.6	10.7	10.6	10.3	9.5[b]	0.22

[a]Standard error of the mean.
[b]Significantly different from the 0 ppm arsenic diet ($P < .05$).

Table 7. Serum phosphorus concentrations (mg/dl) of lambs fed varying levels of arsenic for 56 days.

	Dietary arsenic levels, ppm (as-fed basis)							
Sampling time, days	0	10	20	40	80	160	320	SEM[a]
0	6.6	6.3	6.6	6.6	6.4	6.7	6.4	0.37
14	6.7	6.4	7.2	6.5	6.2	6.6	7.3	0.63
28	5.8	5.4	6.1	6.1	5.5	6.6	8.0[b]	0.52
42	6.5	5.9	6.5	6.0	6.2	6.8	7.5	0.56
56	6.6	6.1	6.1	6.1	5.7	7.0	8.6[b]	0.45

[a]Standard error of the mean.
[b]Significantly different from the 0 ppm arsenic diet ($P < .05$).

Table 8. Serum total bilirubin concentrations (mg/dl) of lambs fed varying levels of arsenic for 56 days.

	Dietary arsenic levels, ppm (as-fed basis)							
Sampling time, days	0	10	20	40	80	160	320	SEM[a]
0	0.16	0.16	0.16	0.16	0.21	0.22	0.10	0.03
14	0.27	0.27	0.26	0.30	0.22	0.72[b]	0.32	0.13
28	0.26	0.25	0.27	0.29	0.25	0.54	0.24	0.10
42	0.30	0.28	0.26	0.23	0.27	0.26	0.31	0.04
56	0.25	0.31	0.35[b]	0.33	0.29	0.36[b]	0.35[b]	0.02

[a]Standard error of the mean.
[b]Significantly different from the 0 ppm arsenic diet ($P < .05$).

A similar pattern of response was observed for muscle As concentrations. Prior to As withdrawal, the association between As intake and muscle As was quadratic ($Y = 0.06 - 0.359X + 0.398X^2$ [$r = 0.97$, $P < .01$]) and the highest muscle As concentration in mg/gram wet tissue weight was 1.4. Following the 14-day withdrawal period, the relationship between As intake and muscle As in mg/gram wet tissue was linear ($Y = -.025 + 0.128X$ [$r = 0.88$, $P < .01$]) and the highest muscle As concentration was 0.3 mg/gram wet weight (Figure 2). The relationships between As intake and kidney As concentrations were linear initially, and after the 14-day withdrawal period. In contrast to liver and muscle, there was little decrease in kidney As during the 14-day withdrawal (Figure 3).

Discussion

The rapid elimination of As from liver and muscle tissues of lambs after As was removed from the diet, observed in this study, was similar to results previously reported for dairy cattle fed ortho arsenic acid (6) and in contrast to studies with rats where As was found to be slowly excreted from body tissues (5). Based on the results of this study, lambs appear to be fairly tolerant of As and the safe tolerable level of As from ortho arsenic acid appears to be less than 160 ppm. Although, reduction of gains and feed intakes apparent in lambs fed the 160 ppm level of As were not significant, the lack of a significant effect at this level probably reflects the effect of restricting intake to 2.2 pounds per lamb per day. This was done to ensure uniform As intakes within treatments, but it undoubtedly masked possible effects of As on intake and live weight gains for diets containing less than 320 ppm As which might have been apparent with *ad libitum* feeding. In comparison, the maximum tolerable dietary levels set by the National Research Council are 50 ppm for inorganic forms and 100 ppm for organic forms of arsenic fed to domestic animals.

Aside from the animal safety considerations, the United States Food and Drug Administration has established 4 ppm as the maximum allowable concentration of As on whole cottonseed and its products which are destined for use as animal feed. Where ortho arsenic acid is applied as a cotton plant dessicant it is almost certain the level of As on cotton burrs and gin trash will be in excess of 100 ppm (4). Because of this, it would appear unwise to include cotton burrs and gin trash in the rations of meat-producing animals unless it is determined that the As content is below the value allowed by law. In contrast, As residues are

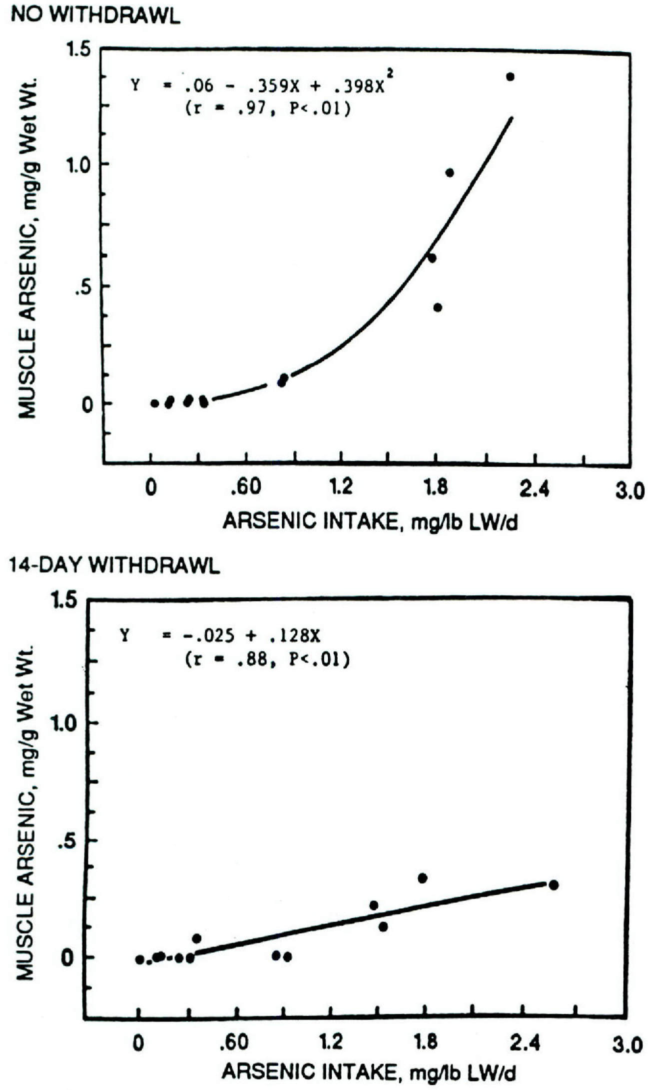

Figure 2.Associations between dietary arsenic intake in mg per pound LW per day (X) and muscle arsenic concentations in mg As/gram wet muscle wt (Y) prior to (no withdrawal) and following a 14-day withdrawal from diets containing arsenic.

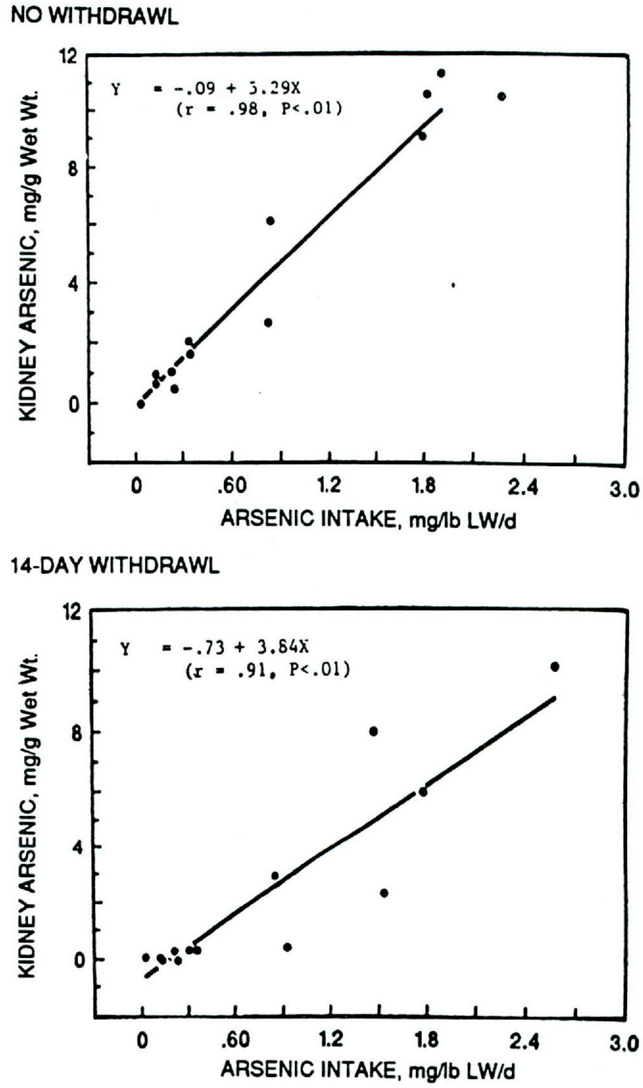

Figure 3.Associations between dietary arsenic intake in mg per pound LW per day (X) and kidney arsenic concentations in mg As/gram wet kidney wt (Y) prior to (no withdrawal) and following a 14-day withdrawal from diets containing arsenic

generally negligible on those products derived from cottonseed such as cottonseed meal or cake and cottonseed hulls (3). Cottonseed appears to be protected from the As spray by the cotton lint; however, cottonseed might contain appreciable quantities of As when immature bolls are sprayed or when rain occurs after the crop is sprayed. (4).

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PR 4782

Range and Sheep Management for Reducing Pearmouth and Other Pricklypear-related Health Problems in Sheep Flocks

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Summary

Ingestion of pricklypear by sheep and goats results in health problems that cause serious economic losses and management problems for producers. A long-term study was initiated in 1988 at the Texas Range Station in Crockett County to evaluate the fire/picloram pricklypear control system as a tool for reducing these health problems, and to develop decision aids to help ranchers integrate this effective pricklypear management practice into their grazing and livestock management programs. A 180-acre pasture in a seven-pasture, intensive-management system was burned in March 1989 and picloram at 0.13 pound/acre was aerially applied in early May 1989 for pricklypear control. Ewes in the intensive-management system were grazed on this pasture during late August through September while ewes in a conventional-management system were grazed on pricklypear-infested rangeland. In late September, all ewes from the conventional-management system had lesions covering both the upper and lower lips, and 13 percent of these ewes also had lesions on their gums and/or tongue. Almost half the ewes grazed on the burned-sprayed pasture were free from pearmouth lesions and none had total involvement of either lip. The data demonstrate that severe pearmouth problems can be eliminated quickly with implementation of effective prickly-pear control and by strategic timing of use of treated pastures. Significant positive responses in ewe weights, death losses and reproductive efficiency did not occur in the first year of this long-term study.

Introduction

Pricklypear (*Opuntia* spp.) causes severe economic losses to sheep and goat producers. Ripe fruits and pads are readily eaten by sheep and goats, especially when quality of desirable range forages is low. The small spines (glochids) cause bacterial infection in the mouths (pearmouth) and gastrointestinal tracts, and the hard seeds cause rumen impaction (3, 4) resulting in death losses, reduced productivity, and excessive culling of ewes. Dense pricklypear stands also interfere with handling and movement of livestock (2), interfere with forage utilization (1, 5) and compete with desirable forage plants.

Pricklypear infestations can be managed with prescribed fire, aerial sprays of picloram applied at 0.5 pound/acre, high-volume foliar sprays containing 1 percent picloram and 10 percent diesel fuel applied as individual plant treatments, or by the sequential application of prescribed fire and aerial sprays of picloram applied at 0.13 to 0.25 pound/acre. The fire/picloram system has proven most effective, reducing live pricklypear cover by more than 95 percent, and it has been economically acceptable to many ranchers ($9 to $14/acre). The effective treatment life of this practice is estimated to be at least 15 years (6).

A study was initiated in 1988 at the Texas Range Station in Crockett County to evaluate the fire/picloram system as a tool for reducing pearmouth in sheep grazing tobosagrass (*Hilaria mutica*)—mesquite (*Prosopis glandulosa* var. *glandulosa*) rangeland, and to develop decision aids to help ranchers integrate this pricklypear management practice into their grazing and livestock management systems.

Experimental Procedures

The Texas Range Station was re-fenced in 1987 to facilitate comparisons of livestock performance and economic returns from "conventional" versus "intensive" range and livestock management. The conventional-management system (CMS) is a 1,170-acre area with no cross fencing that is grazed continuously at a moderate stocking rate. Range and livestock management practices that are the "norm" for ranchers in the region are utilized in the CMS. The CMS offers little flexibility because livestock graze the area year-round. The intensive-management system (IMS) is a 1,260-acre area, cross fenced with electric fences into seven 180-acre pastures, to allow flexibility for integration of new range and livestock management practices. Both systems are grazed by a combination of Rambouillet sheep and cattle, and both have moderate-to-severe pricklypear infestations.

One pasture in the IMS is burned during late winter each year to rejuvenate tobosagrass and improve its utilization by livestock. The burned pasture is aerially sprayed with picloram at 0.13 pound/acre on about May 1, subsequent to burning, for pricklypear control. The treated pasture is grazed by cattle and/or sheep during April to early May to utilize the palatable new growth of tobosagrass, rested until mid-August, then grazed with sheep during late August through September when prickly-pear fruits ("pear apples") are ripe in adjacent, unburned-unsprayed pastures. The sheep graze untreated pastures until early February; then, they are returned to the burned-sprayed pastures to graze during lambing season and during the bitterweed (*Hymenoxys odorata*) "hazard" period, which usually coincides with lambing season.

Pasture 6 in the IMS was burned on March 9, 1989, with winds of 9 to 12 miles/hour, 25 percent relative humidity, 75° F air temperature, and a fine fuel load (dry grass) of about 2,200 pounds/acre. Picloram was applied at 0.13 pound/acre in a total volume of 3 gallons/acre of a diesel fuel:water (1:6) emulsion carrier with a fixed-wing aircraft on May 1, 1989.

Cattle were grazed on the burned-sprayed pasture during April 6 - May 2, 1989. Ewes (90 head) from the IMS were grazed on the pasture during August 22 - September 29, 1989, while pear apples were ripe in adjacent, untreated pastures. Ewes (83 head) in the CMS grazed untreated rangeland, where pear apples were abundant, throughout the pear apple hazard period.

The ewes in both management systems were gathered on September 29, 1989, and each ewe was examined and scored for severity of ulceration in the lips and mouth. The scoring system is described below:

Pearmouth Score	Description
0	No lesions or all lesions healed
1	One lesion on either lip
2	Two lesions to entire upper lip involvement
3	Lesions on upper and lower lips
4	Lesions on both lips, gums and/or tongue

Average pearmouth scores for the two treatments were calculated as were the percentages of ewes within each score category. Individual weights of the ewes were taken on September 29, 1989, and average weights were calculated. Ewe death losses during the period September 1, 1989 - April 17, 1990, were calculated as were lamb crops present in late April 1990.

Results and Discussion

Ripe pricklypear fruits were extremely abundant in the CMS and in untreated pastures in the IMS during late August - mid-September 1989, but they were rare in the burned-sprayed IMS pasture. Ewes in the CMS consumed pear apples readily. Data on pearmouth severity and incidence is presented in Table 1.

Table 1. Severity of pearmouth in rambouillet ewes on September 29, 1989, under conventional- versus intensive-management systems.

	Management System	
	Conventional	Intensive
	3.1	0.8
Average pearmouth score	Percentage of flock	
0	0	44
1	0	28
2	0	28
3	87	0
4	13	0

The severity of pearmouth was about four times greater in the CMS than in the IMS (average scores 3.1 versus 0.8) (Table 1). All of the ewes in the CMS had lesions on the entire upper and lower lips (scores of 3 and 4) that bled when the animals' mouths were opened to examine the tongue and gums. Lesions were present on the tongues and/or gums of 13 percent of the ewes from the CMS. In contrast, the maximum pearmouth score among ewes from the IMS was 2, and none of the IMS ewes had lesions on the entire upper lip. There were no lesions at all on 44 percent of the IMS ewes.

Although ewe weights were similar (123 pounds/head for IMS versus 120 pounds/head for CMS), ewes from the IMS were more vigorous and difficult to handle during examination. Ewes in both management systems were provided supplemental feed during September in preparation for the breeding season because of poor growing conditions.

Lamb crops present in late April 1990 were 67 percent in the CMS compared to 75 percent in the IMS. Low lamb crops in both management systems are attributed largely to isolated incidents of inclement weather during the lambing season, although other management problems such as the high percentage of older ewes in the flocks and possible poor vigor of all ewes resulting from heavy consumption of pricklypear and/or bitterweed in prior years probably contribute to the problem. Ewe death losses during September 1, 1989, through mid-April 1990 were slightly higher in the IMS (6.6 percent) than in the CMS (4.7 percent).

These data demonstrate that implementation of intensive management, including use of the fire/picloram prickly-pear control system and strategic timing of use of burned-sprayed pastures during the pear apple hazard period can reduce pricklypear consumption and health problems in ewes. Significant positive responses in ewe weights, death losses and reproductive efficiency following implementation of intensive management did not occur in this experiment, but may become evident as the procedures are repeated in subsequent years and as other management problems are identified and corrected. This work will continue for several more years.

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PR 4783

Shoot Demography and Elongation of Two South Texas Acacias in Response to Grazing by Angora Goats

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Summary

Uneven grazing distribution in large pastures results in some plants receiving heavy use while others receive little or no use. The impact of such uneven use on shrub leader initiation and growth was evaluated over a period of 16 months for two species: guajillo (*Acacia berlandieri*) and blackbrush (*A. rigidula*). Two replications of four treatments (zero, four, eight and 12 goats for 6 months) were established in 5-acre pastures on a shallow ridge range site. Twenty branches of each species were mapped and observed monthly for leader initiation and growth within each pasture. Shoots of both species on heavily grazed sites were shorter during 1988 ($\bar{x}$ = 24 mm) and 1989 ($\bar{x}$ = 26 mm) than on ungrazed sites ($\bar{x}$ = 43 and 39 mm, respectively). The total number of leaders was also greatest on the heaviest grazed sites (479 and 599) compared to the ungrazed sites (422 and 354). Shoot mortality was also higher on plants that were heavily grazed. These results imply that with continued heavy grazing, access could be restricted for grazing animals due to many branches with short stems.

Introduction

Shoot recruitment, survival and elongation patterns of desirable shrub species are needed to estimate the effects of grazing on shrub morphology, physiology and future grazing potential. Shoot elongation patterns are needed because many shrubs have a high proportion of long shoots and can easily be overgrazed (3, 13). Grazing animals consume short shoots differently than long shoots because "The entire leaf component of plants with long shoots is vulnerable to removal by grazing whereas plants with short shoots may to a large degree escape grazing" (10, 13). Short shoots may be denser than long shoots and may produce a branched "porcupine" morphology which could result in smaller bite size and slower biting rate. When the increased density is coupled with a number of spines, grazing access could be restricted because it would result in twigs with numerous spines rather than occasional prickles. Many thorns or sharp stems would prevent or make grazing access more difficult (5).

Resprouting of many palatable shoots that are inaccessible to the grazing animal or are short lived could be related to lower grazing potential and undesirable community changes for the grazing animals. Low shoot survival may cause increased shrub mortality which would allow other components of the plant community to increase or establish. There is evidence that aspen plants exposed to grazing by elk may have higher shoot mortality than ungrazed plants (1), which may eventually lead to morphological changes, different grazing access, or plant death. Such a response is not seen on all shrubs since two nonleguminous species that have been examined in the Sonoran desert produced more leaders following grazing (11, 12). Some acacias decrease under even light grazing pressure (2) and these acacias may be similar to some grasses which when thinned in a competitive environment never regain their status in the community (8). In South Africa, thorn production of *Acacia tortilis* increased following grazing under dry conditions (7). Plant accessibility following grazing may change because of morphological adaptations that permit plants to endure repeated defoliation (13).

Acacias are important forage species throughout the tropics and subtropics of the world (6), but autoecological investigations of responses for South Texas acacias after grazing are not available. This study was designed to determine the impact of grazing on leader recruitment, survival and growth of guajillo (*Acacia berlandieri*) and blackbrush (*A. rigidula*).

Experimental Procedure

Two primary, multi-stemmed species were selected from a brush-dominated rangeland on the George Lyles ranch in Zavala County. Guajillo has large fern-like leaves with small recurved thorns while blackbrush has small leaves with long spines. Both species can grow to 15 feet tall (15) but are usually much shorter. Crude protein for guajillo is slightly higher than for blackbrush (24.5 percent versus 17.8 percent), but both species are considered palatable (14). These two species of acacia along with shrubby blue sage (*Salvia bullotaeflora*), cenizo (*Leucophyllum frutescens*) and kidneywood (*Eysenhardtia texana*) comprised over 80 percent of the vegetation cover. Long-term annual precipitation is about 22 inches per year, most of which falls in the spring and fall. Soils on the study site are shallow and the range site is classified as a shallow ridge.

Leader response variables monitored monthly were initiation, survival and elongation. The demographic parameters were analyzed using hierarchical categorical data analysis where high order nonsignificant interactions were deleted from the model. A chi-square statistic (X^2) was used to test the model for goodness-of-fit ($P < 0.05$). Differences in leader growth were tested using the Kruskal-Wallis nonparametric statistic.

Eight 5-acre pastures were selected for four treatments and two replications. The pastures, like most others in the area, were treated to reduce brush density in the early 1970's. The four grazing treatments of zero, four, eight and 12 goats were chosen to reflect the varying intensities of use normally found in large pastures. The heaviest stocking treatment (12 goats) represented areas normally found near water or in the pasture corners of the prevailing wind. The moderate (eight goats) treatment reflects the use found near cenderos or roads. The lightest stocking rates represent the actual desired stocking (four goats) and areas which receive no use (zero goats). The 5-acre size was chosen to ensure similar animal utilization on plants within a treatment. The grazing periods were from March to August in 1988 and 1989.

Within each pasture, 10 shrubs of each species were randomly selected in April 1988 and two twigs on each plant were permanently marked using paint. Each twig had approximately 20 nodes which were initially mapped and then observed monthly for identification of new shoots and measurement of shoot growth. Whenever mortality or partial twig death occurred, the length of the remaining live leader was recorded and the cause of mortality noted.

Results and Discussion

Leader Initiation

The majority of leader initiation occurred in the spring with a second flush of initiation in early fall. Guajillo leader initiation and survival was influenced by an interaction between animal stocking rate and the time of year both in 1988 (X^2 = 48.6, df = 36) and in 1989 (X^2 = 42.9, df = 28). More leaders were initiated during the grazing season than after the animals had been removed from the pasture for all of the grazing treatments during 1988 and 1989 (Table 1). Later in the year, leader initiation was highest in the heaviest grazed pastures. In both years, a major rainfall occurred soon after the goats were removed from the experimental pastures and leader initiation was higher on treated pastures than untreated pastures, particularly in 1989.

Blackbrush leader initiation was apparently different than the response noted for guajillo. Blackbrush was grazed to a much lesser extent than guajillo (35 percent versus 75 percent use, respectively (9)), has larger thorns and is generally not considered as palatable as guajillo. Initiation was affected by an interaction between the grazing period and animal stocking rate in 1988 (X^2 = 10.9, df = 8), whereas initiation in 1989 was also affected by the animal stocking rate and the grazing period but not by an interaction (X^2 = 19.1, df = 12). Most of the initiation was during the grazing period with a small number of leaders emerging later (Table 1). Blackbrush initiation was not influenced by the grazing treatment within the first year of the trials. Initiation during the growing season was highest in the ungrazed control pasture with 65 leaders initiated and lowest in the light and moderately grazed pastures (35 leaders). Initiation following removal of goats from the pastures was highest in the heaviest grazed pasture (41 leaders) while there was little difference between the other three treatments.

Blackbrush leader initiation was higher in 1989 than in 1988 except in the control pasture. The small number of new leaders in the control pasture may indicate that initiation may have been limited because of environmental conditions during the winter of 1988-1989. In all of the grazed pastures, however, initiation was higher in 1989 than in 1988 which indicates that grazing had a direct influence on leader initiation in the year following the grazing event. Shrubs in the moderately and heavily grazed pastures during 1989 had the highest total initiation with 122 and 114 new leaders during the grazing period, respectively. Blackbrush did not respond to grazing within a single growing season at the time the apical buds were removed but increased leader initiation in the next year.

Table 1. Initiation and survival rates of guajillo and blackbrush leaders under different grazing intensities.

	Grazing				Post grazing			
	Goats/5 acres				Goats/5 acres			
	0	4	8	12	0	4	8	12
Guajillo								
Number leaders								
1988	257	150	166	265	68	45	47	121
1989	265	263	264	282	33	68	74	166
Percent survival								
1988	0.19^{b}	0.51^{a}	0.40^{a}	0.15^{b}	0.10^{b}	0.33^{a}	0.47^{a}	0.38^{a}
1989	0.51^{c}	0.45^{c}	0.25^{d}	0.07^{e}	0.91^{ab}	0.94^{a}	0.85^{ab}	0.77^{b}
Blackbrush								
Number leaders								
1988	65	35	36	52	32	25	20	41
1989	48	72	122	114	8	18	17	37
Percent Survival								
1988	0.09^{ab}	0.17^{ab}	0.17^{ab}	0.02^{b}	0.16^{ab}	0.12^{ab}	0.40^{a}	0.17^{ab}
1989	0.84^{ab}	0.79^{b}	0.56^{b}	0.42^{c}	0.88^{ab}	1.00^{a}	1.00^{a}	0.73^{b}

Numbers within each row followed by different letters are significantly different at $P < 0.05$.

Leader Survival

Guajillo leader survival in 1988 was characterized by an interaction between the animal stocking rate and the time of leader initiation. Within the grazed pastures, there was no significant difference in survival rates between any of the grazing or post-grazing periods except for the leaders initiated in the heaviest stocking rate during the grazing period. Probability of survival for that one group was significantly lower (0.15) than for any other group in a grazed pasture (Table 1). The low leader survival for both the grazing and post-grazing periods in the control pastures was not expected but may be a reflection of intraplant competition. Only 7.5 inches of rain fell in 1988 and the ungrazed pastures produced more new leaders than the light and moderate grazed pastures (Table 1), which may have resulted in increased competition among leaders within individual plants.

Leader survival in 1989 was affected by an interaction between stocking rate and time of emergence (X^2 = 6.4, df = 4). An inverse relationship between stocking rate and survival was evident (Table 1). Survival rates for leaders in either the ungrazed control or the lightly grazed pastures during the grazing period were not significantly different and were approximately the same as in the lightly grazed pastures in 1988. As the stocking rate increased, survival rates declined until survival was less than 10 percent for leaders in the heaviest stocking rate. The plants responded to the combination of destocking and precipitation. Survival of leaders emerging after the goats had been removed from the pastures (August 1989) was much higher in all grazing treatments and in the control pasture. Survival was slightly lower in heaviest grazing treatment but still significantly higher than during the grazing period.

Blackbrush leader survival was slightly lower than guajillo survival in 1988. There were few significant differences between the cohorts for either the grazing period or the stocking rates (Table 1). The extremely low survival rates found in the heaviest grazed pastures during the grazing period were the only significant effect in 1988. During 1989, survival rates were much higher and a distinct grazing treatment effect was evident during the grazing period. As stocking rates in 1989 increased, shoot mortality also increased until fewer than one-half of all shoots survived in the heaviest grazing treatment. Similar increasing survival rates in the post-grazing period were found for blackbrush as previously described for guajillo. However, for blackbrush in the post-grazing period, neither low or moderate prior grazing had any effect on survival rates. Leaders in the heaviest grazed pastures experienced the lowest survival rates of all leaders.

Leader Growth

Leader growth data are not available for 1988. The mean growth per guajillo leader was affected by the stocking rate during the 1989 growing season (Figure 1). Shrubs in pastures which had no or light grazing had significantly higher leader growth rates than shrubs in the two heavier grazed pastures. Average leader length in 1989 ranged from 43 mm on the lightly grazed pasture to 28 mm on heaviest grazed pasture. Compared to ungrazed pastures there may have been a slight increase in productivity of guajillo in the pasture stocked at the traditional rate (four goats), but any additional grazing resulted in a decrease in total leader growth (Figure 1). The distribution of growth was very different however. As stocking rates increased, growth was concentrated on many short branches rather than a few long branches.

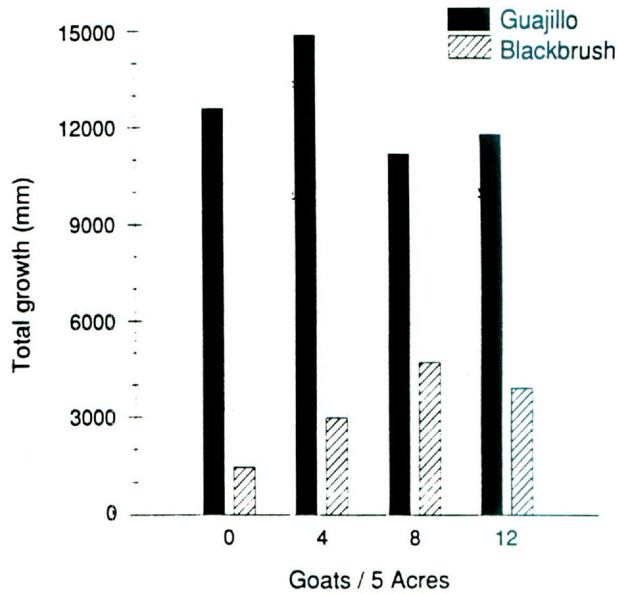

Figure 1. Total leader growth of guajillo and blackbrush in 1989.

Blackbrush leader growth was not affected by the grazing treatment. Average leader length varied from 26 to 32 mm with no significant differences between treatments. The high leader initiation and low survival rates reported in the moderate and heavy grazing treatments had a net result of more leader growth in the grazed pastures than in the ungrazed controls.

Conclusions

Goat grazing influenced the forage base of guajillo and blackbrush differently. Guajillo is a palatable forage plant which experienced high utilization. Regrowth was limited to many short branches in heavily grazed pastures rather than the few long leaders found in ungrazed or lightly grazed situations. This shift in morphology may alter the presentation and availability of forage. Blackbrush is a slightly less palatable species and was not used to the same extent as guajillo. The combination of leader initiation, survival rates and growth rates resulted in more new leader material being available in moderate and heavy grazed pastures than in ungrazed pastures.

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PR 4784

Effects of Grazing Systems on Production Characteristics of Rambouillet Ewes

C.A. Taylor, Jr., T.D. Brooks, N.E. Garza, Jr. and R.A. Moen

Summary

Wool and lamb production from two experiments were measured from registered Rambouillet ewes randomly assigned to intensive (short-duration grazing) and deferred-rotation grazing systems (four-pasture, three-herd) on the Sonora Research Station from 1983 through 1988. Stocking rate and animal species mixture were identical for all treatments within each experiment. Wool production from ewes in the four-pasture three-herd grazing systems was significantly greater ($P < 0.05$) than that from ewes in the 14-pasture short-duration grazing system (SDG). Lamb production from the deferred-rotation grazing systems was greater ($P < 0.10$) than lamb production from the 14-pasture SDG systems. Lamb production from ewes grazing in the SDG grazing systems increased when number of pastures/system was reduced from 14 to seven.

Introduction

Various forms of rotational grazing systems (movement of grazing animals from one area into another) have been practiced for centuries. Furthermore, there are an infinite number of grazing systems that could be developed from different combinations of herds and pastures. For this study livestock response from two different kinds of rotational grazing systems (1) intensive grazing system (i.e., short-duration and high-intensity, low-frequency) and (2) deferred rotation (i.e., four-pasture, three-herd) are presented. The principal objectives of deferred-rotation grazing systems are to improve or maintain the vigor and productivity of the forage resource and to improve livestock production. Originally, the principal objectives of intensive grazing systems developed for use on improved pastures were to increase efficiency of forage harvest to and maximize livestock production. More recently, these principles have been modified so that intensive grazing systems could be successfully applied to semi-arid rangelands.

Experimental Procedure

Experiment #1. During 2 years (1984-85) four grazing systems were evaluated, two of which were intensive grazing systems with 14 pastures and one herd of livestock. One intensive system had a 49-day cycle while the other had a flexible grazing cycle that varied from 50 to 90 days depending upon plant growth. The remaining two grazing systems were four-pasture three-herd grazing systems. The brush had been controlled in 1969 in one while the other had no previous brush control treatment.

Experiment #2. For 3 years (1986-88) five grazing systems were evaluated. This experiment included continuation of the two four-pasture systems along with the 14-pasture, one-herd flexible SDG system. The 14-pasture system with the 49-day cycle was divided into two seven-pasture one-herd systems, thus a total of five grazing systems. One of the seven-pasture systems had a 49-day graze cycle while the other had a 98-day graze cycle.

Statistical analysis for all experiments consisted of the General Linear Model Procedure (1). Orthogonal contrasts were used to test significance ($P<0.10$) between grazing treatments.

Results and Discussion

Data from these experiments were used to make comparisons between: (1) intensive grazing systems versus deferred grazing systems; and (2) fixed grazing cycle versus flexible for the SDG grazing systems. Data gathered from these experiments then tell us if the more intensive grazing systems, when properly managed, actually provide greater livestock production than the less intensively managed deferred-rotation grazing systems.

Wool production. Individual fleece weights minus the belly and skirted wool were measured from each ewe each year of the study. For both experiments ewes produced more wool ($P<0.10$) from the four-pasture deferred grazing systems than the intensive SDG grazing systems (Figure 1). For experiment #1, ewes from the SDG system (flexible cycle) produced significantly less wool ($P<0.10$) than the other grazing systems (8.8 versus 9.2 pounds, respectively).

Lamb production. Lamb production, expressed as pounds of lamb weaned per acre, was analyzed separately for each experiment. For experiment #1, lamb production was greater ($P<0.10$) from the deferred rotation systems compared to the SDG systems (Figure 2). Lamb production was significantly greater ($P<0.10$) from the fixed compared to the flexible grazing cycle (6.4 versus 4.7 pounds/acre, respectively). For experiment #2, lamb production was greater ($P<0.10$) from the deferred-rotation grazing systems compared to the SDG systems. Lamb production was significantly greater ($P<0.10$) from the fixed cycle treatments compared to the flexible grazing cycle (6.3 versus 4.5 pounds/acre, respectively).

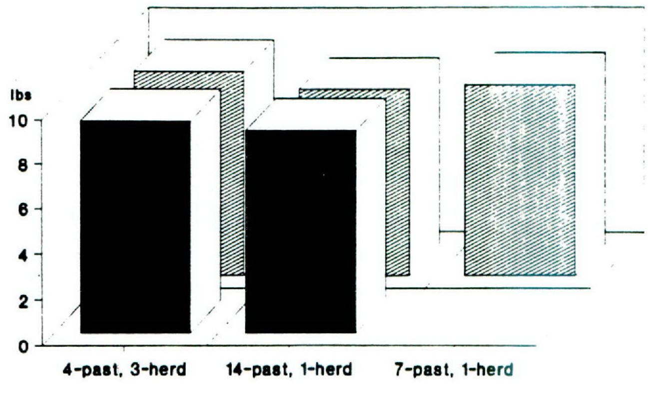

Figure 1. Rambouillet ewe fleece production from deferred-rotation and intensive grazing systems.

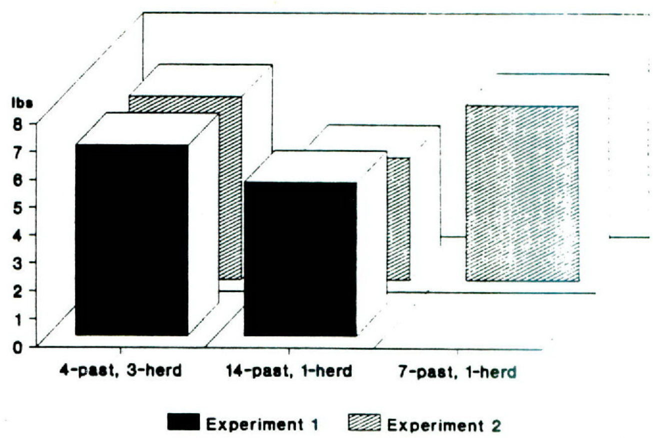

Figure 2. Lamb production (pound/acre) from deferred-rotation and intensive grazing systems.

The 14-pasture SDG system with the flexible grazing cycle length had the lowest lamb production of all treatments for each year of experiments #1 and #2. Vegetation in this system was monitored in each pasture and livestock movement was based on the available vegetation. The cycle length varied from 45 days to approximately 90 days depending upon the season of year and growing conditions of the vegetation. Stocking rate and animal mixture were identical to those in the other treatments and plant composition was also very similar. The only significant differences between this system and the others were the flexible movement of livestock, number of pastures and animal density (the number of animals per unit-area of land at any instant). We believe that the flexible grazing cycle had nothing to do with reducing livestock production but that the number of pastures could be the factor contributing to reduced livestock performance. This same phenomenon also occurred with the 14-pasture 49-day fixed cycle SDG system in experiment #1. Its livestock production was increased relative to the deferred rotation grazing systems after it was split into two seven-pasture systems for experiment #2.

We believe that sheep production was improved when pasture numbers were reduced from 14 to seven because of four factors: less frequent moves, less stress associated with these moves, less disruption of grazing activity and less grazing pressure per pasture by reducing herd size, thereby permitting increased selection of palatable plants. Grazing systems based on the rotation of livestock with periodic grazing and resting of pastures represent only a part of grazing management. Recall that SDG systems were originally developed for high-productive tame pasture management. The implementation of them on semi-arid rangelands without a full understanding of rangeland ecology could lead to less than optimum results.

As previously mentioned, the brush had been controlled in 1969 in one of the deferred-rotation grazing systems. Lamb and wool production from this grazing system was significantly greater than from the other grazing treatments. Even though brush control was not included as a treatment effect, we believe that it may have influenced sheep production more than the actual grazing treatments.

Conclusions

These research studies were initiated to determine the positive characteristics of both SDG and deferred-rotation grazing systems on semi-arid rangelands. Our results indicate that both grazing systems can be successfully implemented on Edwards Plateau rangeland if a few rules are remembered:

1. The most important is that both systems must be stocked at a moderate stocking rate. Moderate stocking rate is when 25 percent or less of the vegetation grown in a year is consumed by the livestock.
2. Use existing fences as much as possible. If a grazing distribution problem does not exist, further subdivision of existing pastures may not increase livestock efficiency.
3. Seven to eight pastures is the maximum number of pastures needed to optimally manage SDG systems.
4. Long rest periods (approximately 90 days) should be employed during the major growth period from approximately mid-April to mid-September.
5. Rest periods of approximately 50 days should be employed from approximately mid-September until mid-January.
6. Continuous grazing should be implemented from mid-January until mid-April for ranches that carry breeding sheep and/or goats (this is based on lambing and kidding dates). Also, distributing sheep and goats among all pastures during the winter period will increase the efficiency of harvest of annual forbs.
7. Integrate the most economical method of controlling brush into the ranch operation.

Grazing systems are only one component of grazing management. Selecting the most appropriate grazing plan should be one of the final of many decisions in ranch management (i.e., grazing systems should facilitate the implementation of biologically and economically sound grazing management principles).

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PR 4785

Performance of Yearling Angora Does Grazing Fourwing Saltbush During Winter

D.N. Ueckert, B.K. Lawrence, J.L. Petersen and J.E. Huston

Summary

A 57-day grazing trial was conducted during the dry winter of 1989-90 to quantify the value of fourwing saltbush (*Atriplex canescens*), a native, evergreen, drought-tolerant shrub, as a source of supplemental protein for yearling Angora does. The performance (weight change) of yearling Angoras grazing in pastures with a saltbush-grass mixture was significantly better than that of those grazing in WW-Spar bluestem (*Bothriochloa ischaemum* var. *ischaemum*) pastures. Yearling goats grazing the saltbush-grass mixtures gained 0.13 pounds/head whereas those grazing only bluestem lost 2.2 pound/head. The data suggest that plantings of fourwing saltbush would be of value for providing supplemental nutrients for Angora goats during winter, although performance of the goats appears less than expected from the crude protein and digestibility values of fourwing saltbush. Additional experiments will be conducted during the winters of 1991 and 1992.

Introduction

Fourwing saltbush (*Atriplex canescens*), a native, drought-tolerant, evergreen shrub, is recognized worldwide as a valuable browse for livestock and wildlife because of its wide range of adaptation, palatability and high nutritional value. Our laboratory analyses indicated that the winter leaves of western Texas accessions of fourwing saltbush contained 17 to 18 percent crude protein, 0.13 to 0.14 percent phosphorus and 58 to 59 percent *in vitro* digestible organic matter (2). These data indicate that fourwing saltbush plantings, reserved for winter grazing as a source of supplemental nutrients, might be valuable in Angora goat production systems since nutrient concentrations in rangeland forages during winter are usually below those required to satisfy the nutritional requirements of Angora goats.

Researchers in New Mexico concluded that fourwing saltbush was an excellent nutrient source for range livestock and big game animals, based on an *in vivo* digestibility trial in which Angora goats were fed diets containing 30 percent dried saltbush leaves or 30 percent alfalfa hay (1). Angoras fed mixtures containing fourwing saltbush leaves had significantly higher intake and nitrogen retention values than did those fed mixtures containing alfalfa hay. Results from our *in vivo* digestibility trial in which Angora goats were fed fresh, succulent, fourwing saltbush current growth (leaves and stems) *ad libitum* alone or with 32 percent crude protein concentrate (3) were not in agreement with those from the New Mexico study. Total feed intake and nitrogen retention were significantly lower in Angoras fed fresh fourwing saltbush than in those fed fresh saltbush plus concentrate. Furthermore, results from our grazing trial with Angora weanling kids during September-October 1985 suggested that fourwing saltbush was relatively unpalatable to Angora kids and that weanling kids did not receive adequate nutrition from saltbush during this period to maintain their weight (3). Further research is warranted to quantify the feeding value of western Texas accessions of fourwing saltbush relative to its effects on Angora goat performance. This report presents results from a grazing experiment conducted during the winter of 1989-90.

Experimental Procedure

Sixty yearling Angora does (average weight 41 pounds) were utilized in a grazing trial during December 6, 1989, through February 1, 1990 (57 days). The does were randomly divided into uniform groups of five or 10 head each and the groups were randomly assigned to two grazing treatments: 1) WW-Spar old world bluestem (*Bothriochloa ischaemum* var. *ischaemum*); or 2) a mixture of fourwing saltbush and various grasses (sand dropseed [*Sporobolus cryptandrus*], slim tridens [*Tridens muticus*], kleingrass [*Panicum coloratum*] and silver bluestem [*Bothriochloa saccharoides*]). Growing conditions were very poor and there was no green herbaceous forage in either treatment. Dormant, weathered grasses were abundant in both treatments and fourwing saltbush was abundant in the saltbush-grass pastures. Four replications of each treatment were stocked at one goat/0.5 acre. Ten goats were placed in each of four 5-acre pastures containing the saltbush-grass mixture and five goats were placed in each of four 2.5-acre bluestem pastures on December 6, 1989, after initial weights of the goats were recorded following a 14-hour fasting. The goats were treated with levamisole for internal parasite control prior to initiation of the trial. Supplemental feed (20 percent crude protein grain cubes at 0.5 pound/head and alfalfa hay at 1 pound/head) was provided to all goats in both treatments only during extremely cold or cold-wet weather (December 11, 15, 16, 21 and 22, 1989, and January 19, 1990) and temporary, plastic shelters were provided in the bluestem pastures to avoid unnecessary death losses. Weather conditions were unusually mild during most of the trial. Water, salt and a mineral supplement containing 12 percent phosphorus and 12 percent calcium were provided *ad libitum*. The goats were removed from the pastures on February 1, 1990, and final weights were recorded after a 14-hour fast.

Results and Discussion

The yearling Angora does in the saltbush-grass mixture pastures appeared to readily consume fourwing saltbush throughout the 57-day trial. There was no death loss in either treatment. Yearling Angoras grazing saltbush-grass mixtures gained 0.13 pound/head during the 57-day trial, whereas those grazing dormant bluestem pastures lost 2.20 pounds/head. Performance of yearling Angoras grazing saltbush-grass mixtures was significantly greater ($P \leq .05$) than that of those grazing dormant bluestem pastures. The performance of yearling goats grazing saltbush-grass mixture pastures was less than would be expected based on the laboratory-determined crude protein and digestibility values of fourwing saltbush forage. We speculate that there may be secondary metabolites in western Texas fourwing saltbush forage that interfere with nutrient utilization or intake, or that the protein nitrogen in the forage may be rapidly hydrolyzed in the rumen, absorbed as ammonia and excreted in the urine. However, these data indicate that fourwing saltbush pastures would be of value in Angora goat production systems, if used during dry winters to provide a portion of the supplemental protein requirements for yearling Angora does. We plan to repeat this experiment in the winters of 1990-91 and 1991-92.

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PR 4786

Relative Value of Fourwing Saltbush as a Source of Supplemental Protein for Yearling Ewes During Winter

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

Summary

Laboratory analyses suggested that the winter leaves of fourwing saltbush (*Atriplex canescens*), a native, drought-tolerant, evergreen shrub should provide a diet of sufficient quality for growth of young sheep, and hence that fourwing saltbush pastures could possibly serve as an alternative to feeding concentrated supplemental feeds on dormant rangeland. Grazing trials were conducted during the winters of 1987, 1988 and 1989 to determine the relative value of fourwing saltbush pastures for yearling ewes. Yearling ewes readily consumed fourwing saltbush during dry winters, but browse consumption was low in a wet winter in pastures where annual forbs were available. Averaged over the three trials, yearling ewes grazing winter-dormant WW-Spar bluestem (*Bothriochloa ischaemum* var. *ischaemum*) lost 9.3 pounds/head; those rotated among bluestem and fourwing saltbush pastures on 1- to 2-day rotations lost 0.3 pound/head; those grazed on grass-saltbush mixtures gained 5.4 pounds/head; and those grazed on rangeland or improved pastures and receiving concentrated supplemental feed gained 9.3 pounds/head. These data suggest that fourwing saltbush plantings would be of value as a source of supplemental nutrients during the winter for sheep, but that the feeding value of the shrub to sheep is less than that suggested by its laboratory-determined nutritional value.

Introduction

Nutrient concentrations in rangeland forages are often below that required to satisfy the nutritional requirements of grazing livestock. As a result, concentrated supplemental feeds must often be provided to attain acceptable levels of livestock performance. A potential alternative to supplemental feeding involves the grazing of high quality shrubs during critical periods. Plantings of oldman saltbush (*Atriplex nummularia*) are currently being utilized in South Africa to alleviate nutrient deficiencies in grasslands during dry summers. Research has shown oldman saltbush pastures to have a 3-month, dry-season, carrying capacity of about four to five sheep/acre (1). Fourwing saltbush (*Atriplex canescens*), a native, evergreen, drought-tolerant shrub has long been recognized as a valuable source of supplemental nutrients for livestock and wildlife. The winter leaves of western Texas accessions of fourwing saltbush contained an average of 17.9 percent crude protein, 0.14 percent phosphorus and 59 percent *in vitro* digestible organic matter (4). Fourwing saltbush is readily consumed by cattle (6, 7), and when present, supplemental feed requirements tend to decline (2). It is generally concluded that fourwing saltbush is an excellent protein source for range livestock and big game animals (3). However, the actual feeding value of fourwing saltbush to livestock has not been quantified relative to its effects on animal performance. We conducted grazing trials during 1987, 1988 and 1989 to evaluate fourwing saltbush as a source of supplemental nutrients for sheep during the winter.

Experimental Procedures

Plantings of western Texas ecotypes of fourwing saltbush were established by direct seeding or transplanting containerized seedlings during 1981-84 at the Texas A&M University Agricultural Research and Extension Center near San Angelo. Stocking rates in all grazing trials were set at light-to-moderate levels to assure forage availability would not limit consumption. Salt and a mineral supplement containing 12 percent phosphorus and 12 percent calcium were provided *ad libitum* in all grazing trials. The animals were fasted 15 hours prior to taking initial and final weights. Data were subjected to analyses of variance and means were separated by Duncan's multiple range test where appropriate.

1987 Grazing Trial. Forty-nine yearling Rambouillet ewes were utilized in a grazing trial during January 8 - March 9, 1987. The ewes were divided into uniform groups of seven head each, and the groups were randomly assigned to four treatments:

1. WW-Spar bluestem (*Bothriochloa ischaemum* var. *ischaemum*)
2. Fourwing saltbush/WW-Spar bluestem rotation (1 to 2 days on saltbush rotating with 1 to 2 days on bluestem)
3. Fourwing saltbush-sideoats grama (*Bouteloua curtipendula*) mixture
4. Rangeland + 23 percent crude protein (CP) supplement fed at 0.3 pound/ewe/day

There were two replications of all treatments except the fourwing saltbush-sideoats grama mixture. The 23 percent CP supplement feed contained cottonseed meal (45 percent), ground milo (40 percent) and salt (15 percent). The native rangeland supported sand dropseed (*Sporobolus cryptandrus*), sideoats grama, silver bluestem (*Bothriochloa saccharoides*), slim tridens (*Tridens muticus*), redseed plaintain (*Plantago rhodosperma*), huisachedaisy (*Amblyolepis setigera*) and plains dozedaisy (*Aphanostephus ramossissimus*). Percentage of fourwing saltbush forage utilized by sheep in each plot was visually estimated at the end of the trial.

1988 Grazing Trial. Ninety yearling Rambouillet ewes were utilized in a grazing trial during January 12 - March 14, 1988. The ewes were divided into uniform groups of 10 head each, and the groups were randomly assigned to five treatments:

1. WW-Spar bluestem
2. Fourwing saltbush/WW-Spar bluestem rotation
3. Fourwing saltbush-sideoats grama mixture
4. Seeded pasture
5. Seeded pasture + 23 percent CP supplement (described above) fed at 0.3 pound/ewe/day

The seeded pasture was a mixture of kleingrass (*Panicum coloratum*), WW-Spar bluestem and Wilman lovegrass (*Eragrostis superba*). There were two replications of all treatments except the fourwing saltbush-sideoats grama mixture.

1989 Grazing Trial. Eighty yearling Rambouillet ewes were utilized in a grazing trial during December 20, 1988 - February 23, 1989. The ewes were divided into uniform groups of 10 head each and the groups were randomly assigned to five treatments:

1. WW-Spar bluestem
2. Fourwing saltbush/WW-Spar bluestem rotation
3. Fourwing saltbush-sideoats grama mixture
4. Grass- fourwing saltbush mixture
5. Seeded pasture (mixture of kleingrass, WW-Spar bluestem and Wilman lovegrass)

Grasses in the grass-fourwing saltbush mixture pastures included sand dropseed, slim tridens, kleingrass and silver bluestem. There were two replications of all treatments except the fourwing saltbush-sideoats grama mixture and the seeded pasture.

Results and Discussion

Yearling ewes grazing WW-Spar bluestem pastures lost 3.2 pounds during the 60-day grazing trial in 1987, compared to a gain of 5.8 pounds for those in the saltbush/bluestem rotation (Figure 1). The bluestem was dormant during the first half of the grazing trial, but a small quantity of new basal growth was available for grazing during the second half of the trial. Annual forbs (redseed plaintain, plains dozedaisy, huisachedaisy) were abundant in the fourwing saltbush pastures used in the bluestem/saltbush rotation, and appeared to be preferred over saltbush by the sheep. Less than 5 percent of the available fourwing saltbush browse was utilized by sheep rotated among the bluestem and saltbush pastures. Ewes receiving the 23 percent CP concentrate and grazing the rangeland where annual forbs were also abundant gained 14.1 pounds (Figure 1). Forbs were rare in the fourwing saltbush-sideoats grama mixture pasture and the sheep readily consumed fourwing saltbush, utilizing about 40 percent of the available browse. Sheep grazing the saltbush-sideoats grama pasture gained 10.2 ± 2.8 pounds (mean ± SD) (n = 10) (data not shown).

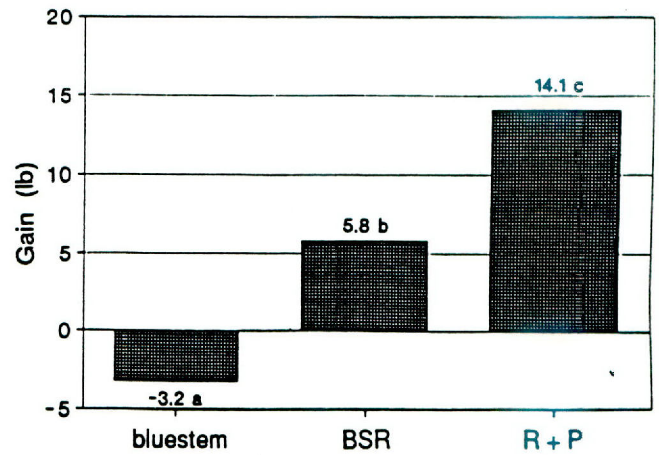

Figure 1. Gains (pounds) of yearling Rambouillet ewes grazing WW-Spar bluestem, a WW-Spar bluestem/fourwing saltbush rotation (BSR), or rangeland (mixed grasses + annual forbs) + a 23 percent crude protein supplement fed at 0.3 pound/ewe/day (R+P) during January 8 - March 9, 1987. Means followed by different lower case letters are significantly different ($P < 0.05$).

Growing conditions were very poor and there were no forbs in any of the pastures during the 1988 grazing trial. Fourwing saltbush was readily browsed by the ewes in all pastures where it was available. Ewes grazing the WW-Spar bluestem pastures lost 11 pounds during the 62-day trial (Figure 2). Yearling ewes rotated between bluestem and fourwing saltbush pastures lost 4.4 pounds, which was significantly ($P < .05$) less weight loss than that of ewes grazing only bluestem (Figure 2). By comparison, ewes grazing the seeded pastures lost only 0.1 pound, which was significantly less weight loss than that of ewes in the bluestem/saltbush rotation. Ewes grazing the seeded pastures and receiving 23 percent CP supplement gained 4.4 pounds (Figure 2). Improved performance of ewes on the seeded pastures compared to that of those on the WW-Spar bluestem pastures was probably related to cultural practices. The seeded pastures had been shredded twice during the previous growing season whereas the bluestem pastures were neither shredded nor grazed. The shredding appeared to enhance growth late in the growing season which in turn probably improved nutritional quality during the winter months. The poor performance of ewes in the bluestem/saltbush rotation relative to those grazing the seeded pasture was unexpected and the reason is unclear. Ewes grazing the saltbush-sideoats grama pasture lost 2.1 ± 3.8 pounds (n = 10) (data not shown).

Growing conditions were also poor during the 65-day grazing trial initiated in late December 1988; thus, no annual forbs were present in any of the treatment pastures. Fourwing saltbush was readily consumed by the ewes in pastures where it was available. Ewes grazing WW-Spar bluestem lost 13.8 pounds (Figure 3). Ewes rotated among bluestem and fourwing saltbush pastures lost 2.3 pounds,

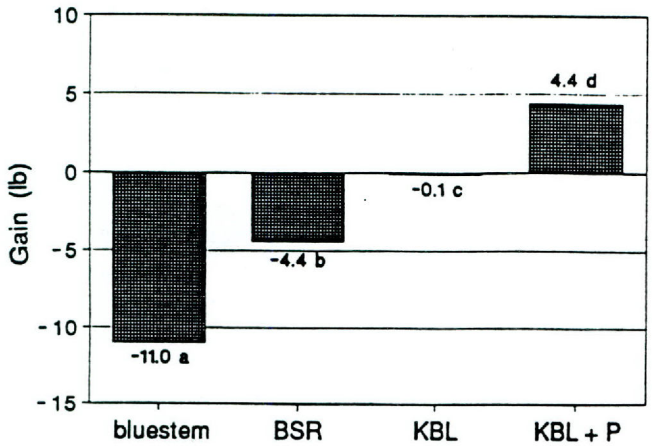

Figure 2. Gains (pounds) of yearling Rambouillet ewes grazing WW-Spar bluestem, a WW-Spar bluestem/fourwing saltbush rotation (BSR), seeded pasture (mixture of kleingrass, WW-Spar bluestem and Wilman lovegrass) (KBL), or seeded pasture + a 23 percent crude protein supplement provided at 0.3 pound/ewe/day (KBL+P) during January 12 - March 14, 1988. Means followed by different lower case letters are significantly different ($P<0.05$).

which was significantly less weight loss than that of ewes grazing only bluestem. Ewes grazing the mixture of grasses and fourwing saltbush gained 7.6 pounds during the 65-day trial (Figure 3). Ewes grazing the fourwing saltbush-sideoats grama pasture gained 5.7 ± 2.8 pounds ($n = 10$) and those grazing the kleingrass-bluestem-lovegrass mixture gained 2.8 ± 3.7 pounds ($n=10$) (data not shown).

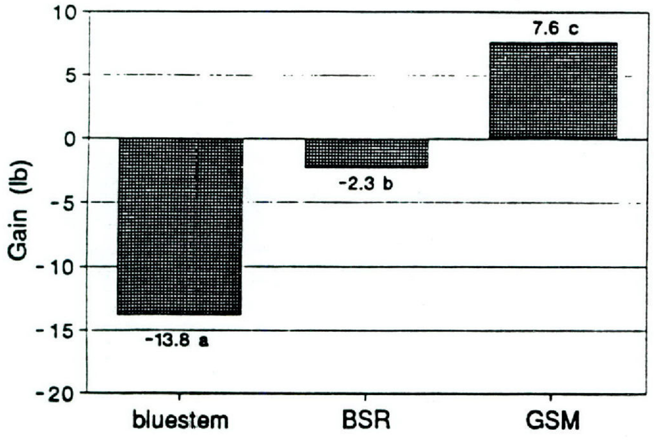

Figure 3. Gains (pounds) of yearling Rambouillet ewes grazing WW-Spar bluestem, a WW-Spar bluestem/fourwing saltbush rotation (BSR), or a grass-fourwing saltbush mixture (GSM) during December 20, 1988 - February 23, 1989. Means followed by different lower case letters are significantly different ($P<0.05$).

Laboratory analyses (4) suggested that the fourwing saltbush leaves should have provided a diet of sufficient quality for growth of young sheep. Fourwing saltbush appeared relatively palatable to yearling ewes except in the 1987 trial when annual forbs were abundant. Low palatability of some assessions of fourwing saltbush has been associated with high concentrations of saponins (5). Qualitative tests indicate that saponins are present in western Texas accessions of fourwing saltbush.

Weight changes of yearling ewes grazing in winter-dormant grass-saltbush mixtures or rotations were generally superior to those of ewes grazing only dormant bluestem. The ewes grazing dormant grass-saltbush mixtures generally performed better (lost less weight or gained more weight) than those in 1- to 2-day rotations among dormant grass and fourwing saltbush pastures. However, the dormant grass-saltbush mixtures or rotations did not consistently provide diets of sufficient quality to meet the maintenance requirements of the young ewes. Performance of yearling ewes grazing dormant grass-saltbush mixtures or rotations was significantly lower than that of ewes grazing dormant grasses and receiving protein supplement.

These data suggest that fourwing saltbush plantings would be of value as a source of supplemental nutrients during the winter for sheep. However, the feeding value of the shrub to sheep is considerable less than is suggested by its laboratory-determined nutritional value, probably because of plant secondary metabolites or other inherent plant characteristics that interfere with nutrient utilization and/or forage intake. These findings suggest that researchers and resource managers should be cautious in predicting the feeding value of plants to livestock and wildlife from laboratory analyses.

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PR 4787

Effects of Supplemental Feeding of Ewes Before Lambing on Birth Weights of Lambs and Wool Characteristics

J.E. Huston, C.J. Lupton and M. Shelton

Summary

Fifty each of finewool (Rambouillet) and crossbred (Rambouillet x Booroola Merino-Coopworth) ewes were assigned equally across ten treatment groups to study the effects of supplemental feeding of ewes on rangeland during late pregnancy. Feed treatments included a negative control (NC; no feed) and feeding of high protein, low energy (H/L); low protein, high energy (L/H); and high protein, high energy (H/H) for either 60, 40 or 20 days before lambing. Fleeces were analyzed for clean wool, fiber diameter, staple length and staple strength. Feeding of ewes in late gestation resulted in heavier birth weights but neither the type of feed (protein:energy ratio) nor length of feeding period (20, 40 or 60 days) appeared to have an effect. Feeding during this relatively short period appeared to have little if any effect on 12-month wool characteristics. Rambouillet ewes had heavier lambs and finer fleeces compared with the Rambouillet x Booroola-Coopworth ewes. Fleeces from the crossbred ewes had greater staple length and staple strength compared with finewool fleeces. Single lambs were consistently heavier than twin lambs. Ewes giving birth to twin lambs produced a finer and shorter staple fleece that tended to be lower in total clean weight.

Introduction

Sheep that are managed under Texas rangeland conditions consume diets that, over the annual cycle, fluctuate in nutritional value above and below the determined requirements for normal productivity (1). Ewes consuming diets that are higher in nutrients than needed can store energy as fat which can be used at a later time when the diet does not provide adequate nutrients. Ewes that are bred during September and October for February-March lambs generally consume diets during the fall that meet or exceed requirements for early pregnancy. After the first fall frost and the onset of winter, the average West Texas range drops in nutritional value below that required by ewes that are in late stages of pregnancy. Low nutrition during late pregnancy can result in pregnancy toxemia or in the birth of small, unthrifty lambs that have a reduced probability of survival. Wool defects (breaks) often correspond with severe nutritional stress. A study was conducted to compare birth weights of lambs and characteristics of fleeces from Rambouillet and Rambouillet x Booroola Merino-Coopworth ewes subjected to various supplemental feeding practices.

Experimental Procedure

A flock of Rambouillet ewes and a separate flock of Rambouillet x Booroola Merino-Coopworth ewes were bred beginning September 1 to Rambouillet rams fitted with marking harnesses. Ram marks indicated breeding dates. At a fetal age between 35 and 75 days the ewes were examined by ultrasound (2) to determine fetal number. Fifty ewes of each breed were selected and assigned to 10 treatment groups equalizing the breed type and prospective litter size for all groups. Treatment groups included a negative control (NC) which did not receive supplemental feed before lambing and groups that were fed a high protein, low energy (H/L), a low protein, high energy (L/H) or a high protein, high energy (H/H) supplement (Table 1) for either 60, 40 or 20 days prior to lambing. The ewes were managed together on rangeland before and during imposition of the experimental treatments. All ewes were penned three times each week, fed the appropriate supplement in individual stalls and then released to graze as a flock. As ewes lambed, birth weights of lambs were recorded and ewes and lambs were removed to a separate pasture and given uniform management until regular shearing, approximately 60 days after average lambing date. Fleeces were weighed and analyzed for yield, average fiber diameter, staple length and staple strength. Data were analyzed by a general linear model and Duncan's means separation (4).

Table 1. Supplemental feeds and feeding levels for finewool and crossbred ewes carrying single or twin fetuses.

	Rations		
	1	2	3
Ingredients, percent:			
Cottonseed meal	93		33
Sorghum grain		93	60
Molasses	5	5	5
Salt	2	2	2
	100	100	100
Composition:			
Crude protein, percent	39.20	9.45	20.00
Digestible energy, Mcal/pound	1.28	1.55	1.45
Feeding level (130-pound ewe)[a]			
Supplement, pound/day	0.8	1.4	1.5
Crude protein, pound/day	0.3	0.1	0.3
Digestible energy, Mcal/day	1.0	2.2	2.2

[a]Actual feeding levels were adjusted to body weight to provide constant proportions of protein and energy requirements.

Results and Discussion

Results of this study are reported in Tables 2 and 3. Data from animals that did not conform to the criteria of the study were eliminated. These included data from animals with excessive feed refusals, those giving birth to premature fetuses and others for which the breeding dates were incorrectly determined. Interactions between feed type, length of feeding period, ewe genotype and size of litter were not found. Only the main effects will be discussed.

Birth weights of lambs were affected by feeding, genotype of the ewes and size of litter (Table 2). Ewes receiving L/H feed (Table 1) gave birth to heavier lambs compared with those from NC ewes ($P < .05$). Lambs from ewes receiving H/L and H/H feeds were intermediate in birth weight and not significantly different from either L/H or NC lambs. Lambs from Rambouillet ewes were heavier than those from crossbred ewes ($P < .05$) and single lambs were heavier than twins ($P < .05$; Table 2).

The effects of feeding period are reported for only the Rambouillet genotype (Table 3) because of the very small number of crossbred ewes that conformed to the criteria of the study. There appeared to be an effect of feeding on lamb birth weight that approached statistical significance. However, length of feeding period had no effect on birth weight. Again, single lambs were heavier at birth compared with twin lambs ($P < .05$).

Effects of experimental treatments on wool characteristics were minimal except for the obvious, expected differences (Tables 2 and 3). Rambouillet ewes produced finer but shorter wool ($P < .05$) compared with crossbred ewes. Ewes giving birth to twins produced finer and shorter wool compared with those producing singles when both genotypes were considered ($P < .05$; Table 2). No effects from litter size were observed in fineness and length within the Rambouillet flock (Table 3). Wool production (expressed as clean fleece weight, CFW) tended to increase with increases in both protein and energy feeding (Table 2) and with length of feeding period (Table 3). Both of these effects approached statistical significance. No differences related to treatment were detected for fiber strength for sound wool (30 N/ktex). However, all treatment means exceeded what is considered adequate strength. Crossbred fleeces were slightly stronger compared with finewool fleeces ($P < .05$; Table 2).

These data do not support results of Ripley et al. (3) which showed increases in birth weight of lambs as a result of both increased protein intake and extended feeding period. However, the more recent study was conducted

Table 2. Effects of feeding, type of feed, genotype of ewe and litter size on birth weights of lambs and wool characteristics of ewes on rangeland.

Treatments	Number of ewes	Birth weights (pounds)	Diameter (micrometer)	Ewe fleece characteristics CFW (pounds)	Length (inches)	Strength (N/ktex)
Feed treatments						
Control	10	8.04[a]	23.2[a,b]	4.47	3.05[a]	50.5
H/L	13	9.23[a,b]	22.3[b]	4.58	2.77[b]	36.4
L/H	11	9.47[b]	24.6[a]	5.10	2.99[a,b]	42.0
H/H	17	8.96[a,b]	22.8[b]	5.39	3.02[a]	39.6
Genotypes						
Finewool	31	9.88[a]	21.6[a]	5.03	2.89[a]	39.1[a]
Crossbred	20	7.54[b]	25.6[b]	4.81	3.07[b]	45.0[b]
Size of litter						
Singles	25	10.04[a]	23.8[a]	5.02	3.06[a]	41.4
Twins	26	7.92[b]	22.5[b]	4.87	2.86[b]	41.5

[a,b] Individual means for each comparison within a column that do not share a common superscript are different ($P < .05$).

Table 3. Effects of length of feeding period and size of litter on birth weights of lambs and wool characteristics of finewool ewes on rangeland.

Treatments	Number of ewes	Birth weights (pounds)	Ewe fleece characteristics Diameter (micrometer)	CFW (pounds)	Length (inches)	Strength (N/ktex)
Feed period, days						
0	5	8.92	20.7	4.29	2.94	43.5
20	7	10.11	21.2	4.03	2.80	45.7
40	26	10.06	21.7	5.17	2.88	38.2
60	4	10.00	21.0	5.28	3.05	42.6
Size of litter						
Singles	21	11.08[a]	21.6	4.90	2.94	41.3
Twins	21	8.78[b]	21.3	4.88	2.84	39.7

[a,b] Individual means for each comparison within a column that do not share a common superscript are different ($P < .05$).

during a year that was considered above average in availability and quality of forage and below average in climatic severity. Negative control ewes produced lambs that were generally adequate in size and fleeces of acceptable weight and strength. Thus, it would be expected that effects which were detectable would be magnified during a more severe reproductive season. The absence of a clear protein effect on lamb birth weight and fleece characteristics, especially fiber diameter, is puzzling. A similar study is being planned in which greater uniformity of genotype will help reduce variation within the data and aid in identifying responses to experimental treatments.

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PR 4788

Investigating Additives to Whole Sorghum Grain for Free-choice Feeding to Sheep on Rangeland

J. E. Huston and K. W. Bales

Summary

An experiment and a field test were conducted to investigate feeding of whole grain with various additives to adult ewes on rangeland. Each of 10 rations were fed to five ewes individually during a 1-hour period on 5 consecutive days. The ewes were grazed on dormant rangeland except during the feeding periods. The ewes offered the control ration (without a buffer or limiter) overate initially, became ill and went off feed. Lime at 1, 2 and 4 percent, urea at 3 percent and monensin at 33, 66 and 99 grams/ton were evaluated for effects on limiting intake and preventing adverse effects of initial overeating. Selected mixtures were field-tested in adult Rambouillet ewes. The mixtures fed in the field test were offered free-choice to ewes that had not been adapted to grain feeding. No initial adverse effects of feeding were observed. The ewes consumed 2.2 pounds of feed/day over 143 days (October 24 - March 16), lambed normally and produced relatively heavy, strong fleeces. The results were encouraging and studies in this general area will continue.

Introduction

Supplemental feeding is an accepted, essential management practice in livestock enterprises in Texas, especially in enterprises that include grazing of rangelands during dormant seasons. With careful considerations of type of animal, stocking rate and breeding date, grazing herds and/or flocks can be fitted to the range resource so that periods of high requirements fall during periods of good forage quality, thwarting major shortfalls in level of nutrition. Exceptions, of course, are frequent. On rangelands, unavoidable exceptions result from climatic influences. Temperature and moisture and their uncertainty are major causes of periods of low nutrient content of range forages (4). Other causes include management error (excessive stocking rate, etc.) and economic decisions (out-of-season lambing for an improved market). Once the nutritional stress is observed in grazing animals, or preferably foreseen, options regarding feeding must be considered.

Traditional supplemental feeding practices for sheep include "hand feeding" and "free-choice feeding." Hand feeding a predetermined amount to sheep daily, every second day, every third day, etc., would appear to be the preferred method of feeding except for labor and equipment costs. Free-choice feeding requires little labor and equipment but also allows less control over feeding rate and distribution. Neither method is totally satisfactory and both have important disadvantages. Although hand feeding accurately provides the feeding level for the flock, studies with cattle (2) indicate a rather large variation in consumption among the individuals within the entire group. The more frequent the cows were fed (daily, three times per week, or weekly), the greater was the discrepancy in intake level among the individuals. Free-choice feeding requires that consumption be held to within safe limits either by inclusion of a filler or an intake limiting agent such as salt. Even free-choice feeding can result in variability in intake if the supplements contain one or more ingredients that are variably acceptable to individuals within the flock (5).

Previous studies in supplemental feeding of sheep on rangeland showed that both high protein feed (soybean meal) and high energy grain (barley) could effectively support weights and increase wool production although the high protein feed was generally more effective (1). However, differences in prices between high protein feeds such as cottonseed meal and locally produced grain (sorghum grain) suggest a potential for increased use of grain feeding under range situations. Previous attempts to feed whole grain to sheep on rangeland resulted in excessive consumption during the first 2 days which caused severe acidosis followed by lingering anorexia and some deaths. Therefore, a study was planned and conducted that included an experiment to find a mixture, including whole sorghum grain, that could be self-fed to ewes on rangeland and a field test of selected mixtures under practical conditions.

Experimental Procedure

Experiment

Fifty adult Rambouillet ewes were assigned randomly to 10 equal groups of five and offered experimental feeds (Table 1) once per day over a 5-day period. The ewes grazed together on rangeland when not being fed. Each afternoon for 5 consecutive days (January 31 - February 4) the ewes were gathered, placed in individual stalls and offered up to 5 pounds of the appropriate feed mixture for a period of 1 hour. Ewes were then released and feed refusals were recorded. Ewes offered feeds containing urea were restricted to amounts that would not contain a lethal dose of urea. The amounts were determined for each individual animal based on body weight. Ewes given rations which did not contain urea were offered 5 pounds at each feeding. Average daily consumption and variation (CV) in daily consumption were recorded (Table 2). The feeds were mixed in a Hobart bowl-type mixer in small amounts (<50 pounds) to assure proper weighing and blending. The feeds appeared as whole sorghum grain kernels encrusted with the other ingredients held attached by the sticky character of the molasses.

Field Test

Results of the above experiment were used to formulate a feeding program for a practical situation. This feeding program was evaluated using fall-lambing ewes between October 24, 1989, and March 23, 1990. Seventy-two adult Rambouillet ewes bred for November lambs were fed the experimental rations free-choice beginning October 24. The ewes had not been fed a concentrated feed since the previous winter. Initially, ration 1 (Table 3) was offered in an open bunker trough and in a self-feeder in excess. Subsequently, feed was available only in a self-feeder. After approximately 3 weeks, ration 2 replaced ration 1 and was fed during the remaining experimental period. During the last half of the period, the feed in the self-feeder was allowed to be depleted for up to 3 days and then replenished with excess feed. Observations included feed consumption (Table 4) and general health and behavior of the ewes.

Table 1. Rations containing whole grain and various other ingredients and limiters fed to adult ewes free-choice.

	Supplement									
Ingredients	**C**	**L-1**	**L-2**	**L-4**	**LU-1**	**LU-2**	**LU-4**	**LUM-33**	**LUM-66**	**LUM-99**
Whole grain[a]	85	84	83	81	81	80	78	81	81	81
Dehydrated alfalfa	5	5	5	5	5	5	5	5	5	5
Cottonseed meal	5	5	5	5	5	5	5	5	5	5
Molasses	5	5	5	5	5	5	5	5	5	5
Lime		1	2	4	1	2	4	1	1	1
Urea					3	3	3	3	3	3
Monensin[b]								+	++	+++

[a]Sorghum grain.
[b]Rumensin® a product of Eli Lilly and Co. contains 60 g monensin sodium/pound of premix. This premix was added to supplements LUM-33, LUM-66 and LUM-99 at levels to give 33, 66 and 99 g of monensin/ton of supplement, respectively.

Table 2. Average consumption and variability of consumption of various feed mixtures containing whole grain.

Treatment[a]	Statistic[b]	Day 1	Day 2	Day 3	Day 4	Day 5
Control	Mean	3.9	4.1	2.4	1.5	0.9
	CV	20	20	56	78	77
L-1	Mean	1.1	2.8	2.3	3.8	1.5
	CV	85	67	8	23	73
L-2	Mean	1.2	2.9	3.4	3.1	2.2
	CV	84	37	25	33	36
L-4	Mean	0.2	1.3	1.8	3.4	2.0
	CV	133	69	18	33	66
LU-1	Mean	1.1	2.1	0.7	1.3	1.1
	CV	47	17	58	43	62
LU-2	Mean	0.8	1.6	1.6	1.6	1.4
	CV	64	38	36	53	33
LU-4	Mean	0.4	1.1	1.5	1.8	1.4
	CV	37	51	21	26	39
LUM-33	Mean	0.5	1.6	0.8	1.1	0.8
	CV	52	30	70	61	29
LUM-66	Mean	0.9	1.7	1.2	1.4	1.5
	CV	75	20	55	15	32
LUM-99	Mean	0.4	1.4	0.2	1.0	0.9
	CV	19	29	132	44	36

[a] Treatment mixtures described in Table 1.
[b] Mean is the average daily consumption (pound/day) and CV is the coefficient of variation, an indication of increasing variability as the number increases from 0 to 100 or greater.

Table 3. Rations used in a study to investigate the use of self-limiting, whole grain feed for sheep on dormant rangeland.

Ingredients	Ration 1	Ration 2
Sorghum grain, whole	87	80
Dehydrated alfalfa	5	5
Molasses	5	5
Urea	1	2
Lime	2	3
Salt		5
Monensin[a]	+	++
	100	100
Calculated nutrient values:		
Energy, Mcal/pound	1.52	1.41
Crude protein, percent	12.6	14.7

[a] Monensin added at levels of 66 and 99 g active ingredient per ton to rations 1 and 2, respectively. See Table 1 for definition.

Table 4. Results of free-choice feeding self-limiting whole grain feed to pregnant and lactating rambouillet ewes on rangeland.

Total ewe days, number	7839
Total feed consumed, pounds	16500
Daily consumption, pounds/ewe/day	2.2
Feed cost (ingredients only), cents/pound	4.6
Feeding cost, cents/ewe/day	10

Results and Discussion

The ewes fed in the experiment had been trained in previous years to eat while confined in the individual stalls. Only three of the 50 ewes did not consume at least some of the feed offered on day 1. Each of these three ewes consumed feed on day 2. The data reported in Table 2 and Figures 1, 2, 3 and 4 are considered reflections of the acceptability of the feeds to the ewes and the ewes' tendency to resume consumption at the next opportunity.

Consumption of the control ration (Table 1) was high for the first 2 days and then declined steadily over the next 3 days (Table 2). This pattern was in general contrast to the consumption of rations containing lime at all levels (Table 2; Figure 1). Rations containing lime were consumed at a relatively low level on day 1 and at increasing levels on subsequent days before a substantial reduction on day 5. Figure 2 illustrates that including urea in the supplement mixes (averages for groups 5, 6 and 7) changed the consumption pattern from mixes without urea (average of groups 2, 3 and 4). Although the ewes consuming urea-containing rations were prevented from excessive consumption to protect against urea toxicity, in only two of the 75 feeding opportunities did the ewes consume all that was offered. Thus, the differences in feeding patterns (Figure 2) are considered a good indication of the effects of urea on the consumption of these rations. The inclusion of monensin did not appear to have a linear effect on consumption rate (Figure 3) although consumption was lowest at the highest concentration (99 grams/ton) of monensin. In a previous study, monensin was shown to decrease intake of supplement with increasing concentrations between 30 and 150 grams/ton (3). In that study, goats were much less sensitive to monensin concentrations than sheep.

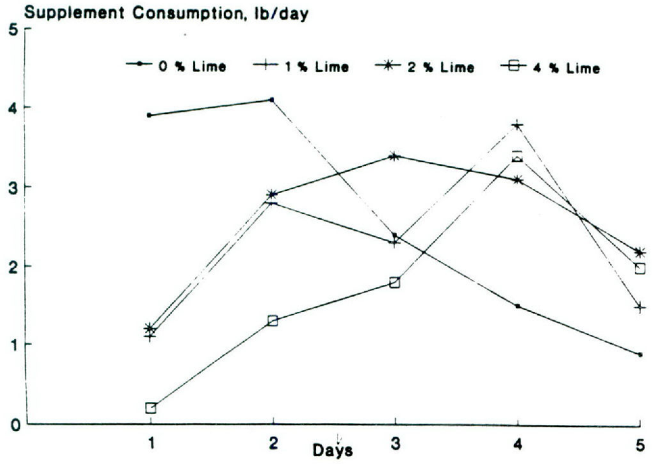

Figure 1. Consumption levels by sheep of supplelments containing increasing concentrations of lime.

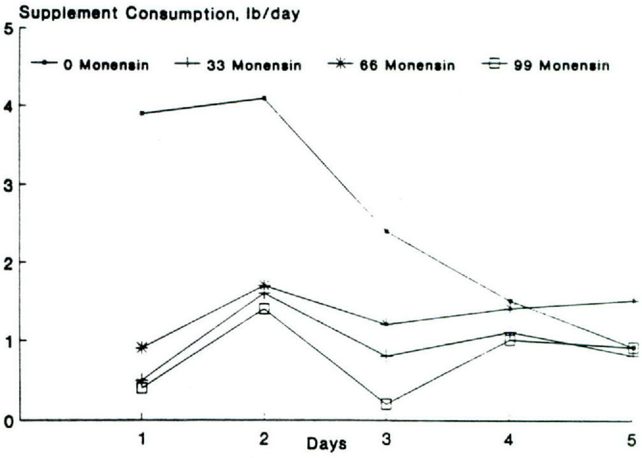

Figure 3. Consumption levels by sheep of supplements containing increasing concentrations of monensin.

Figure 4 illustrates effects of lime, urea and monensin as each was added stepwise. The control ration was consumed heavily during the first 2 days with progressively less amounts consumed thereafter. The variation in consumption rate as indicated by the coefficient of variation (CV; Table 2) suggested that some animals "overate" and became sick (probably lactic acidosis). The ewes offered the ration containing lime (L-1) had an average low but variable consumption initially but increasing and less variable consumption to day 4. Likely, some ewes became sick after the very high consumption on day 4. On day 5, the ewes consumed much less feed in a highly variable pattern. Including urea in the ration (LU-1) resulted in a more stable consumption pattern. The lower offering rate (discussed earlier) may have had a suppressing effect on day 2 but not on day 1 nor days 3, 4 or 5. The monensin-containing ration (LUM-33) resulted in the lowest average consumption rate, and by day 5 was consumed with the least amount of among-ewe variation (CV = 29 percent). Generally, the data depicted in Figure 4 indicate that consumption rates of feeds are reduced when they contain lime, urea and monensin at the indicated concentrations. It appears that the ewes adapted quickly to the lime content and proceeded to overeat on day 4. This did not occur when either urea or urea and monensin were added to the lime-containing mixture. The general trend in variability of intake (Table 2) was inverse for the control group and groups containing consumption-modifying ingredients. The control ration was eaten heavily and uniformly on day 1 and day 2 and less heavily and more variably on subsequent days. Those containing consumption modifiers were consumed at low levels in highly variable patterns on day 1. Generally, consumption increased to a level point and became less variable by day 5.

Data from the field test in which ewes were fed whole grain rations free-choice without an adaptation period is encouraging. During the first 3 weeks, consumption of ration 1 (Table 3) increased from about 1/2 pound/ewe/day to about 3 pounds/ewe/day. Ration 2 replaced ration 1 and consumption decreased to about 1 pound/ewe/day before gradually increasing and holding at just above 2 pounds/ewe/day. On several occasions during the last half of the feeding period, the feed supply was depleted and not replaced for up to 3 days. In each case, the feed was replenished in excess amounts to allow free-choice consumption. Neither at the beginning of the field test nor at any of the within-trial feed depletion points were any ewes observed to be adversely affected by over consumption of

Figure 2. Average consumption levels by sheep of supplements containing lime with or without urea.

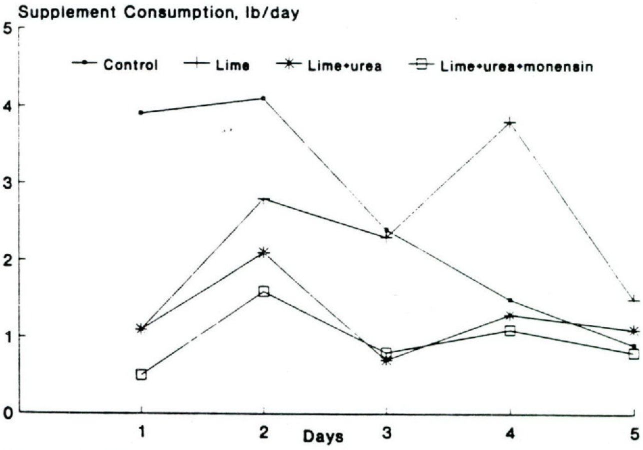

Figure 4. Consumption levels by sheep of a basal supplement (control), basal + lime, basal + lime + urea and basal + lime + urea + monensin.

the whole grain mixture. The ewes lambed normally, the lamb crop was within the range of expectation and pregnancy toxemia was not observed within the flock.

Sheep producers could make use of a low-cost, safe and highly concentrated feed for critical periods. Several attempts at feeding whole sorghum grain to adult sheep on rangeland have led these researchers to the following conclusions:

1. Whole grain can be fed safely to ewes free-choice once they are adapted to the diet.
2. Adapting ewes to the high intake of whole grain on rangeland is hazardous and time consuming.
3. Once adapted to consuming whole grain on rangeland, free-choice feeding results in over consumption and inefficiencies.

The data being reported indicate that whole grain treated in some way to retard consumption can be fed free-choice, perhaps without major concern of initial overeating and without adaptation. This experiment and field test, although less than totally successful, indicate that such feeds may be possible. Studies in this general area will continue.

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PR 4789

Effects of Four Supplemental Feeds on Voluntary Intake, Weight Gain, Mohair Quality and Production of Angora Kids

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Summary

One hundred and twenty-seven Angora females (average age 6.5 $\pm$ 1.0 months) were assigned across five treatment groups to study the effects of supplemental feeding on voluntary intake, weight gain, mohair quality and production. The treatments included a negative control (NC; no supplement); corn (C); whole cottonseed (CS); a corn/cottonseed meal mixture (C/CSM); and, a corn/cottonseed meal/fish meal mixture (CSM/FM). The composition and feeding levels of each supplement were adjusted to supply 0.8 Mcal/day of digestible energy and 18 (C), 36 (CS), 72 (C/CSM) and 72 (CSM/FM) grams/day of crude protein. The kids were maintained on rangeland for the duration (92 days) of the study (September 18 to December 20, 1989). Kids in each treatment group were penned separately for 6 hours, three times/week for feeding. The goats were shorn and weighed before the start and at the end of the study. Fleeces were weighed and analyzed for clean mohair, fiber diameter, staple length and medullation. Kids in the NC group lost weight (0.6 pound/head), whereas kids provided supplemental feed gained 2.4 (C), 4.0 (CS), 8.8 (C/CSM) and 7.1 (CSM/FM) pounds/head. Goats in the C/CSM and CSM/FM supplemented groups produced more mohair ($P < .05$) than NC goats, but there were only small differences in fiber diameter, staple length and medullation. Consumption of supplemental crude protein was positively correlated with weight gain ($P < .01$), mohair production and staple length ($P < .05$). Supplemental digestible energy consumed was not significantly correlated with weight gain, fleece production or fiber properties.

Introduction

The nutritive values of range plants in western Texas vary seasonally and with environmental conditions, and are such that Angora goats require additional nutrients to achieve satisfactory levels of reproduction and mohair production (8). The ability of a yearling female to conceive and raise a kid is a critical factor affecting its lifetime production efficiency (11). It is usually necessary to provide supplemental nutrients to nannie kids during their first winter to allow them to attain adequate physical maturity to breed. A minimum body weight of 65 pounds was suggested for yearling does to achieve satisfactory reproductive performance (6). If a kid is deprived of nutrition during this early development stage, the animal may become stunted and never attain its potential size or production capability.

Dietary energy is required to maintain good health and vigor and to promote a desired level of production, functions that are difficult to separate in fiber-producing animals. Similarly with protein, which is required to maintain or replace protein in body tissue and which is also a major component of mohair. It is generally recognized that supplementing Angora goats above the maintenance level with protein and energy results in the production of more mohair having greater fiber diameter (5, 8). Thus, feeding nannie kids may result in lower quality (coarser), less valuable kid–mohair on a price per unit weight basis. This disadvantage might be offset to some degree by increased mohair production. Ideally, a supplemental feed would result in the desired gain in body weight and increased mohair production without affecting fiber diameter. Theoretically, such a feed might be formulated with the proper nutrients to produce the desired effects. With this objective, an experiment was designed to study the effects of four supplemental feeds on voluntary intake, weight gain, mohair quality and production of Angora doe kids.

Experimental Procedure

A flock of 127 Angora female kids (6.5 $\pm$ 1.0 months) were assigned randomly across five treatment groups to study the effects of supplemental feeds containing different amounts and sources of protein on voluntary intake, weight gain, mohair quality and production. The treatments included: a negative control (NC, no supplement); corn (C); whole cottonseed (CS); a corn/cottonseed meal mixture (C/CSM); and, a corn/cottonseed meal/fish meal mixture (CSM/FM). The feed ingredients, calculated compositions of nutrients, and feeding levels of the four rations are shown in Table 1. The rations were designed to provide the same amount of digestible energy (0.8 Mcal/day), three levels of crude protein (18, 36 and 72 grams/day) and two high (72 grams/day) levels of protein from different sources. The number of animals assigned to each group was 14 (NC), 28 (C), 29 (CS), 28 (C/CSM) and 28 (CSM/FM). Animals in the five treatment groups were maintained on rangeland for the 92 days duration of the study (September 18 to December 20, 1989) at the Texas A&M University Agricultural Research Station at Sonora in Sutton and Edwards counties. Kids were penned in groups three times/week for feeding. The control animals were held for the same period of time without feed. After 6 hours, the goats were recombined into a single flock and returned to the range. Uneaten portions of the rations were weighed for each treatment group.

Table 1. Ingredient and nutrient composition of supplements and feed levels.

	Supplements[a]				
Item	**NC**	**C**	**CS**	**C/SM**	**CSM/FM**
Ingredients (percent):					
Corn	–	100	–	37	45
Cottonseed	–	–	100	–	–
Cottonseed meal	–	–	–	60	35
Fish meal	–	–	–	–	17
Molasses	–	–	–	3	3
Total	–	100	100	100	100
Composition:					
Digestible energy, Mcal/pound		1.60	1.92	1.41	1.45
Crude protein, percent		8.0	19.0	28.0	29.0
Target feeding levels:					
pound/day		0.50	0.42	0.57	0.55
pound/3 times/week		1.17	0.97	1.32	1.29

[a]NC, negative control, no supplement
C, corn
CS, whole cottonseed
C/CSM, corn/cottonseed meal
CSM/FM, corn/cottonseed meal/fishmeal

In preparation for the experiment, the kids were originally shorn on August 8, 1989. The trial was initiated September 18, 1989, and terminated December 19, 1989. All goats were shorn on December 20, 1989. Fleeces were weighed, subsampled and analyzed for clean mohair fiber present (1), average fiber diameter (9), staple length (2) and medullation (3).

The Statistical Analysis System (SAS, 10) General Linear Models procedures were used to analyze the data generated in this study. Duncan's Multiple Range Test was used to identify significant differences between mean values. Linear regression analyses (12) were used to establish correlation coefficients for supplemental crude protein and digestible energy intakes versus fleece production and mohair fiber properties.

The data were analyzed assuming the consumed amounts of the supplements were distributed equally across all individuals within the treatment groups. Intakes of forage and supplements will be estimated for individual animals using indigestible marker procedures. However, the necessary analyses have not yet been completed and individual intake estimates are not available. When the completed data are analyzed, the statistical inferences may vary from those presented here, but the average values will not change.

Results and Discussion

The daily requirements of the goats in this trial were estimated to be 2.4 Mcal/day of digestible energy and 90 grams/day of crude protein. Thus, the supplemental treatments were designed to supply zero and one-third of the daily energy and 0, 20, 40 and 80 percent of the protein requirement (Table 2). Actual levels of consumption

(Table 2) showed the relatively high palatability of C and C/CSM rations (93.5 and 95.7 percent consumption, respectively) versus CSM/FM (77.4 percent) and CS (69.0 percent).

Table 2. Target versus actual nutrients consumed.

Item	Supplements[a]			
	C	CS	C/CSM	CSM/FM
Target nutrients offered:				
Digestible energy, Mcal/day	0.8	0.8	0.8	0.8
Crude protein, grams/day	18	36	72	72
Actual nutrients consumed:				
Digestible energy, Mcal/day	0.75	0.55	0.76	0.62
Crude protein, grams/day	16.80	24.80	68.90	55.70

[a]NC, negative control, no supplement
C, corn
CS, whole cottonseed
C/CSM, corn/cottonseed meal
CSM/FM, corn/cottonseed meal/fishmeal

Weight changes during the 92-day trial are summarized in Table 3. The NC group lost 0.6 pound/head during the trial. Supplemented groups gained from 2.4 to 8.8 pounds/head. Average weight gain was highly correlated (r = 0.99, P < .01) with the average amount of supplemental crude protein consumed. Weight gains were lower for groups consuming C and CS rations compared with those consuming C/CSM and CSM/FM rations (P < .05). Differences in weight gains between the C and CS groups and between the C/CSM and CSM/FM groups were not statistically different (P > .05).

Fleece and fiber parameters are summarized in Table 4. All supplemented groups produced more mohair than the NC group although the increases were statistically significant only for the C/CSM and CSM/FM groups (P < .05). The CSM/FM group produced more mohair than either the C or CS groups (P < .05) and the C/CSM goats produced more than those fed CS (P < .05). Although the difference was not significant, the CSM/FM group produced more mohair than the C/CSM group, even with lower supplemental energy and protein intakes (Table 2).

Fish meal has been shown to be resilient to rumen degradation and to provide greater amounts of amino acids to the site of protein digestion, the small intestine (7). In another study (4), weight gain in steers grazing range forage was increased by increasing the proportion of blood meal (another source of resilient protein) in supplements. Apparently, the fish meal provided more amino acids to the follicle and enhanced keratin growth compared with proteins in corn and cottonseed meal contained in the C/CSM ration. Mohair production was correlated (P < .05) with protein consumption, as shown in Table 5. Both protein and energy intake were related to yield in an inverse manner, though the energy relationship alone approached significance.

With respect to fiber quality, goats fed the rations containing the highest protein content (C/CSM and CSM/FM) tended to produce slightly coarser fiber than goats in the NC, C and CS treatments. In contrast, there were no significant differences between the diameters of fibers in the NC, C and CS groups. Again, the ration containing the fish meal appeared to enhance fiber production to a greater extent than the other rations. Treatment mean fiber diameters were more highly correlated with average consumption of crude protein (r = 0.84) than with digestible energy (r = 0.30). The effect of supplementation on staple length was very small. However, crude protein consumption was significantly correlated (r = 0.88, P < .05) with staple length. The inclusion of fish meal into a ration did not appear to affect staple length although it increased mohair production and fiber diameter. Since the greater weight of mohair produced by goats in the CSM/FM group cannot be explained in terms of increased diameter alone, it may be hypothesized that greater mohair production was the result of increased follicle activity in this group of kid goats. If more follicles were stimulated to grow mohair at this relatively early stage of development, it is possible that this increased mohair production could persist throughout the productive life of the goat. This hypothesis will be tested in follow-up experiments.

Providing supplementary rations to kid goats did not affect med production. In contrast, there was a trend for supplemented goats to produce slightly more kemp fibers than the NC group. This observation on young female Angoras is contrary to the findings of Calhoun (5) who studied mohair production of intact and castrated males

Table 3. Treatment means of weights and weight gains.

Treatment*	Number goats in group	Inital weight (pounds)	Final weight (pounds)	Weight gain (pounds)
NC	14	37.6[a]	37.1[b]	-0.6[c]
C	28	35.3[a]	37.7[b]	2.4[b]
CS	29	35.1[a]	39.1[a,b]	4.0[b]
C/CSM	28	34.6[a]	43.4[a]	8.8[a]
CSM/FM	28	35.2[a]	42.4[a]	7.1[a]

[a,b,c]Within a column, means with the same superscript do not differ significantly (P > .05).

*NC, negative control, no supplement
C, corn
CS, whole cottonseed
C/CSM, corn/cottonseed meal
CSM/FM, corn/cottonseed meal/fishmeal

Table 4. Treatment means of fleece and fiber properties.

Treatment*	Number of goats	Grease fleece weight (pound)	Yield (percent)	Clean fleece weight (pound)	Fiber diameter (um)	Staple length (inches)	Med fibers (percent)	Kemp fibers (percent)
NC	14	2.06^{c}	78.9^{a}	1.63^{c}	$25.7^{b,c}$	3.10^{b}	0.58^{a}	0.19^{b}
C	28	$2.42^{b,c}$	75.4^{b}	$1.82^{b,c}$	25.4^{c}	3.08^{b}	0.47^{a}	$0.30^{a,b}$
CS	29	2.27^{c}	$76.6^{a,b}$	1.73^{c}	$25.8^{b,c}$	3.12^{b}	0.69^{a}	$0.32^{a,b}$
C/CSM	28	$2.69^{a,b}$	$77.1^{a,b}$	$2.07^{a,b}$	$26.8^{a,b}$	3.31^{a}	0.62^{a}	0.44^{a}
CSM/FM	28	2.94^{a}	$76.1^{a,b}$	2.22^{a}	27.5^{a}	3.17^{b}	0.65^{a}	$0.28^{a,b}$

a,b,c Within a column, means with the same superscript are not significantly different ($P > .05$).

*NC, negative control, no supplement
C, corn
CS, whole cottonseed
C/CSM, corn/cottonseed meal
CSM/FM, corn/cottonseed meal/fish meal

Table 5. Correlation coefficients for supplemental crude protein (grams/day) and digestible energy (mcal/day) intakes versus fleece production and mohair fiber properties.

	Grease fleece weight (pound)	Yield (percent)	Clean fleece weight (pound)	Fiber diameter (μm)	Staple length (inches)	Med fibers (percent)	Kemp fibers (percent)
Crude protein	0.88**	-0.33	0.90**	0.84	0.88**	0.41	0.79
Digestible energy	0.68	-0.86	0.62	0.30	0.42	-0.07	0.79

**Significant correlation ($P < .05$)

older than 1 year and concluded that the proportions of med and kemp fibers in mohair fleeces were unaffected by energy intake and dietary protein levels.

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Effects of Cottonseed Meal Source and Dietary Crude Protein on Performance of Early-weaned Lambs: with Observations on Gossypol Toxicity

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Summary

Four sources of cottonseed meal were used in diets fed to 180 Rambouillet lambs of mixed sex to determine the effects of processing method and free gossypol intake on performance. Initially, lambs were 8 to 20 weeks old and weighed 44.1 $\pm$ 0.7 pounds. Diets (1.45 Mcal DE/pound) contained 11.2 or 22.6 percent of either glandless (GL), expeller (EX), expander (EP) or direct solvent (DS) cottonseed meal. The crude protein contents of the diets were 15 and 19 percent for the 11.2 and 22.6 percent levels of cottonseed meal, respectively. A diet containing no cottonseed meal (11 percent CP) was included as a control. Four pens of lambs (five lambs/pen) were fed each dietary treatment for 98 days. Regardless of the cottonseed meal source, during the first 56 days of the study, diets containing additional protein increased live weight gains ($P = 0.001$) and feed intakes ($P = 0.032$) and decreased feed to gain ratios ($P = 0.005$) compared with the control diet. However, increasing dietary CP from 15 to 19 percent only increased gains for lambs receiving the EP and DS diets. Response to protein diminished as the experiment progressed. Overall for the 98-day study increasing CP from 15 to 19 percent generally decreased efficiency of feed conversion, but the effect was only significant for the EX diets ($P = 0.003$). Lambs receiving the 19 percent DS diet had a free gossypol intake of 17.6 mg/pound LW/day during the 98-day study. Although this level of gossypol did not adversely affect performance until after the first 56 days, 20 percent of lambs fed the 19 percent CP DS diet died from 50 to 98 days. Clinical signs, gross lesions and histopathologic changes were consistent with gossypol poisoning. These results indicate a diet containing about 400 ppm (0.04 percent) free gossypol can be fed safely to lambs after weaning ($\geq$ 8 weeks old), provided they have been consuming dry feed for several weeks prior to weaning.

Introduction

From 1945 to the present time, commercial processing of cottonseed changed from predominantly hydraulic pressing to predominantly direct solvent extraction (1). This change was accompanied by an increase in the free gossypol content of cottonseed meal available to livestock producers. Cottonseed meals produced by any of the pressing methods (hydraulic, screw and prepress solvent) generally contain less than 0.1 percent free gossypol; whereas, meals produced by direct solvent extraction of the oil are much higher in free gossypol (0.1 to 0.5 percent) (1).

Although the possibility of gossypol poisoning has been recognized as a problem for many years with nonruminants and is the reason caution is necessary when cottonseed products are fed to poultry and swine, it generally has been considered that animals with a functioning rumen can detoxify gossypol (12). However, several recent reports of gossypol poisoning in young, as well as, mature ruminants, coinciding with the increased use of direct solvent cottonseed meal (DS), have caused producers to be concerned about the safety of feeding cottonseed products to ruminants (5, 6, 8, 9, 14).

This study was initiated to determine the safety of feeding cottonseed meal processed by different methods to early-weaned lambs.

Experimental Procedure

Animals and Feeding. One hundred eighty Rambouillet lambs of mixed sex (ewe and ram) were obtained from the Texas Agricultural Experiment Station's ewe flocks and transported to the Experiment Station's Research Center at San Angelo. These lambs were weaned at an earlier age than is typical for lambs from range sheep flocks in Texas. Since lambing dates were not recorded, the exact ages of the lambs used are not known; however, the lightest lambs (replicate 1) were 6 to 10 weeks old and the heavier lambs (replicate 4) 16 to 20 weeks old. On arrival they were ear-tagged, drenched (Tramisol®)[1], vaccinated with *Clostridium perfringens* (Types C and D) toxoid[2], blocked into four groups of increasing weight and randomly assigned within weight groups to 36 pens (five lambs/pen)[3].

Pens were assigned to treatments at random within-weight groups. Treatments consisted of diets formulated

[1]Levamisole hydrochloride, American Cyanamid Co., Tramisol®, 0.25 gram of levamisole hydrochloride was given to each lamb in 20 ml of water, using an automatic drench gun.

[2]**Clostridium perfringens** Types C and D toxoid, Anchor Laboratories, Inc. Lamb-Vax, 2 ml per lamb was injected subcutaneously in the neck.

[3]Pens were 7.9 x 21.8 ft with a dirt floor and a 6 x 1 ft feed trough; one-third of the pen surface (over feeder) was covered by an open shed roof.

using cottonseed meal from four sources (glandless, GL; expeller, EX; expander, EP; and direct solvent, DS). Each source was used to formulate diets containing 15 and 19 percent crude protein (dry matter basis). One additional diet (control diet, C) was formulated with 11 percent crude protein and contained no cottonseed meal (Table 1). The free gossypol values for the GL, EX, EP and DS cottonseed meals used in this study were 0.037, 0.032, 0.100 and 0.364 percent, respectively. Free gossypol content of the diets formulated with these cottonseed meal sources ranged from 1.2 ppm for the control diet to 824.4 ppm for the 19 percent CP diet containing DS cottonseed meal (Table 2). Each of the nine dietary treatments was fed to four pens of lambs for 98 days. Feed and water was provided *ad libitum* during the study.

Observations and Analysis. Lambs were observed twice daily to assess their general health and well being. Animals that appeared sick were examined by a veterinarian. Lambs were weighed at 14-day intervals. All diets fed and refused were weighed to the nearest 0.5 pound. Free gossypol was measured in representative samples of the four cottonseed meal sources[4].

Blood samples were collected by venipuncture from two lambs selected at random in each pen at 28 and 42 days and from all lambs at 56 and 84 days. Whole blood was used to determine osmotic fragility of erythrocytes (10). Serum obtained from blood samples collected at 28 and 56 days was immediately frozen and shipped frozen to the Texas Veterinary Medical Diagnostic Laboratory for analyses of total protein, albumin, globulin, calcium, phosphorus, glucose, total bilirubin, creatinine, creatine phosphokinase, alkaline phosphatase, lactic dehydrogenase, alanine aminotransferase and aspartate aminotransferase.

Statistical Treatment of the Data. The General Linear Models Procedure of the Statistical Analyses System (13) was used in the statistical treatment of the data. Sources of variation separated out in the model were replicates, treat-

[4]Pope Testing Laboratories, Inc., Dallas, Texas.

Table 1. Percentage ingredient composition of experimental diets.

	Control Diet	Cottonseed Meal Processing Method							
		Glandless		Expeller		Expander		Direct Solvent	
Criterion	11% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19%CP	15% CP	19% CP
Sorghum grain, milo	68.57	57.48	46.19	57.76	46.75	57.36	45.94	57.48	46.19
Dehydrated alfalfa meal, 17 percent	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
Cottonseed hulls	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Cottonseed meal	--	11.20	22.60	11.20	22.60	11.20	22.60	11.20	22.60
Cottonseed oil	0.43	0.57	0.71	0.29	0.15	0.69	0.96	0.57	0.71
Molasses, sugar cane	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ammonium chloride	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Calcium carbonate	1.00	1.25	1.50	1.25	1.50	1.25	1.50	1.25	1.50
Dicalcium phosphate	1.00	0.50	--	0.50	--	0.50	--	0.50	--
Vitamin-mineral premix[a]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[a] The percentage ingredient composition of the premix was as follows: sodium chloride, 64.7; potassium chloride, 19.0; sulfur, 10.0; zinc oxide, 0.274; vitamin A (13.6 x 10^6 IU/pound), 0.73; vitamin D (13.6 x 10^6 IU/pound), 0.093; vitamin E (12.5 x 10^4 IU/pound), 0.72; chlortetracycline, 3.0 and molasses, 1.5.

Table 2. Nutritional values and free gossypol contents of experimental diets[a].

	Control Diet	Cottonseed Meal Processing Method							
		Glandless		Expander		Expeller		Direct Solvent	
Criterion	11% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP
Dry matter, percent	88.60	88.91	89.25	89.10	89.64	88.92	89.27	88.91	89.25
Total digestible nutrients, percent[b]	74.40	73.38	72.30	73.51	72.57	73.53	72.60	73.38	72.30
Crude protein, percent	10.90	14.94	19.01	14.94	19.00	14.92	18.98	14.94	19.01
Calcium, percent	0.95	0.95	0.94	0.95	0.95	0.94	0.94	0.95	0.94
Phosphorus, percent	0.48	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Free gossypol, ppm	1.2	42.8	85.3	41.0	81.1	127.8	255.7	460.1	824.4

[a]All values are on a dry matter basis.
[b]Total digestible nutrient values in this table were calculated from the coefficients of the individual feed components.

ments and experimental error (variation among pens within treatments). The following set of orthogonal contrasts was also separated out and tested: (1) C versus GL + EX + EP + DS, (2) GL versus EX + EP + DS, (3) EX versus EP + DS, (4) EP versus DS, (5) GL_{15} (15 percent CP) versus GL_{19} (19 percent CP), (6) EX_{15} versus EX_{19}, (7) EP_{15} versus EP_{19} and (8) DS_{15} versus DS_{19}.

Results

Sixteen lambs died or were removed during the 98-day study. The causes of death and/or removal from the study are summarized in Table 3. Four lambs were diagnosed as dying from gossypol poisoning; the first lamb on the 50th day, followed by one each on day 57, 69 and 90. All lambs that died from gossypol poisoning received the 19 percent CP DS cottonseed meal diet. Cumulative gossypol intakes of the lambs on this treatment were 18.7, 19.4 and 17.6 mg/pound LW/day, for the periods 1-28, 1-56 and 1-98 days, respectively (Table 4). Signs prior to death were consistent with gossypol poisoning and were supported by gross pathologic and histopathologic changes.

Table 3. Causes of lamb deaths and (or) removal from experiment.

Diagnosis	Days on experiment	Pen	Treatment[a]
Anal prolapse	62	3	9
Fleece worms	7	19	9
Gossypool poisoning	50	14	9
	57	14	9
	69	14	9
	90	14	9
Starvation	27	8	5
Polioencephalomalacia	34	8	5
	39	5	4
	39	30	4
	70	17	1
Unknown	34	7	2
	36	24	2
	61	26	7
	83	26	7
Urinary calculi	46	33	3

[a]Treatments were as follows: 1, control (11 percent CP); 2, glandless (15 percent CP); 3, glandless (19 percent CP); 4, expeller (15 percent CP); 5, expeller (19 percent CP); 7, expander (19 percent CP); 9, direct solvent (19 percent CP).

Polioencephalomalacia was a persistent problem and four lambs died from this illness. Initial treatment was an injectable thiamine preparation[5]. Although this produced immediate improvement in most affected lambs, repeated treatment was necessary. Subsequently, thiamine mononitrate[6] was added to all diets at a rate of 100 grams per ton of feed for the duration of the study. This level effectively controlled the problem.

The effects of cottonseed meal source and dietary crude protein levels on performance and free gossypol intakes are presented in Table 4. Average initial weight was 44.1 ± 0.7 pounds. Performance data in Table 4 are cumulative for the periods 1-28, 1-56 and 1-98 days. Regardless of the cottonseed meal source, during the first 56 days of this study, diets containing additional protein increased live weight gains ($P = 0.001$) and feed intakes ($P = 0.032$) and decreased feed to gain ratios ($P = 0.005$) compared with the control diet (C versus GL + EX + EP + DS). Increasing the dietary crude protein from 15 to 19 percent only increased live weight gains for lambs receiving the EP (EP_{15} versus EP_{19} : 1 to 28 days, $P = 0.013$; 1 to 56 days, $P = 0.018$) and DS (DS_{15} versus DS_{19} : 1 to 56 days, $P = 0.051$) diets. Overall for the 98-day study, protein level and cottonseed meal source did not affect live weight gains.

Feed intakes of lambs fed the GL diets were less throughout the study than for lambs fed diets containing the other cottonseed meal sources (GL versus EX + EP + DS : 1 to 28 days, $P = 0.020$; 1 to 56 days, $P = 0.035$; 1 to 98 days, $P = 0.016$). Increasing dietary crude protein from 15 to 19 percent only increased feed intake for lambs receiving the EX (EX_{15} versus EX_{19} : 1 to 28 days, $P = 0.009$) and EP (EP_{15} versus EP_{19} : 1 to 28 days, $P = 0.017$; 1 to 56 days, $P = 0.017$; 1 to 98 days, $P = 0.032$) diets.

Feed to gain ratios were less at 56 ($P = 0.058$) and 98 days ($P = 0.001$) for lambs fed the GL than for lambs fed the other cottonseed meal sources (GL versus EX + EP + DS), and lambs fed EP were more efficient overall than lambs receiving diets containing DS cottonseed meal (EP versus DS : 1 to 56 days, $P = 0.007$).

During the first 28 days, with the exception of EX, increasing dietary crude protein from 15 to 19 percent improved feed efficiency; however, the responses were not significant. In the case of EX, raising crude protein from 15 to 19 percent increased the feed to gain ratio ($P = 0.045$). Overall for the 98-day study, increasing crude protein generally decreased efficiency of feed conversion, regardless of cottonseed meal source, but the difference was only significant for EX (EX_{15} versus EX_{19}, $P = 0.003$).

With the exception of urea nitrogen, cottonseed meal sources and dietary crude protein levels did not affect serum constituents measured at 28 days (Tables 5 and 6). Serum urea nitrogen was increased by increasing the dietary crude protein for all comparisons except EX_{15} versus EX_{19} at 28 days.

At 56 days, increasing crude protein decreased serum alkaline phosphatase enzyme activity (C versus GL + EX + EP + DS, $P = 0.001$) and increased serum urea nitrogen for all comparisons.

The only evidence of an adverse effect of gossypol intake on serum constituents was increased lactic dehydrogenase enzyme activity, observed at 56 days in lambs receiving the 19 percent crude protein DS diet (EP versus DS, $P = 0.026$; DS_{15} versus DS_{19}, $P = 0.049$). The cumulative free gossypol intake of these lambs for the first 56 days was 19.4 mg/pound LW/day.

Free gossypol increased erythrocyte (RBC) hemolysis in a buffered, 0.75 percent saline solution. At 42 days, the response was linear when DS cottonseed meal was the source of free gossypol. Hemolysis of RBC was also in-

[5]Thiamine hydrochloride injectable: one ml (200 mg/ml) injected intramuscular per day. Treatment was repeated as necessary.

[6]Thiamine mononitrate USP-FCC, Roche Chemical Div., Hoffman-LaRoche Inc., Nutley, New Jersey.

Table 4. Effects of cottonseed meal processing method and dietary protein level on performance of early-weaned lambs.

	Control Diet	Cottonseed Meal Processing Method								
		Glandless		Expeller		Expander		Direct Solvent		
Criterion	11% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	SEM[a]
Lambs, number	20	20	20	20	20	20	20	20	20	
Initial weight, pound	44.2	44.0	44.1	44.0	44.9	43.7	43.5	44.1	44.1	
1-28 days										
Live weight gain, pound/day	0.504	0.618	0.655	0.612	0.601	0.570	0.704	0.625	0.707	0.035
Feed intake, pound/day	2.25	2.41	2.41	2.45	2.88	2.40	2.78	2.51	2.71	0.106
Feed/gain	4.5	3.9	3.7	4.0	4.9	4.3	4.0	4.1	3.8	0.290
Gossypol, mg/pound LW/day	0.02	0.88	1.77	0.77	1.61	2.40	5.43	8.92	18.70	0.154
1-56 days										
Live weight gain, pound/day	0.461	0.544	0.547	0.535	0.525	0.515	0.596	0.544	0.609	0.023
Feed intake, pound/day	2.64	2.75	2.75	2.77	2.88	2.76	3.14	2.94	3.16	0.105
Feed/gain	5.7	5.1	5.0	5.2	5.5	5.4	5.3	5.4	5.2	0.149
Gossypol, mg/pound LW/day	0.02	0.90	1.81	0.78	1.59	2.46	5.43	9.25	19.38	0.198
1-98 days										
Live weigt gain, pound/day	0.501	0.549	0.525	0.553	0.516	0.526	0.579	0.516	0.499	0.026
Feed intake, pound/day	2.93	2.99	3.02	3.14	3.30	3.10	3.46	3.23	3.22	0.112
Feed/gain	5.9	5.5	5.8	5.7	6.4	5.9	6.0	6.3	6.5	0.158
Gossypol, mg/pound LW/day	0.02	0.82	1.68	0.73	1.56	2.31	5.00	8.72	17.59	0.268

[a]Standard error of the mean

Table 5. Serum constituents of lambs fed diets containing cottonseed meal processed by different methods and containing varying levels of free gossypol.

		Control Diet	Cottonseed Meal Processing Method								
			Glandless		Expeller		Expander		Direct Solvent		
Serum Constituents	Days	11% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	SEM[a]
Total protein, grams/dl	28	5.7	5.7	5.7	5.8	5.6	5.9	5.7	5.7	5.6	0.12
	56	6.2	5.9	6.2	6.2	6.2	6.3	6.1	5.8	6.6	0.13
Albumin, grams/dl	28	3.0	3.1	3.2	3.1	3.2	3.1	3.2	3.1	3.2	0.07
	56	2.9	3.0	3.1	2.9	3.3	2.9	3.1	2.9	3.2	0.08
Globulin, grams/dl	28	2.6	2.6	2.6	2.7	2.5	2.8	2.5	2.6	2.4	0.12
	56	3.3	3.0	3.1	3.3	2.9	3.4	3.1	2.9	3.4	0.13
Calcium, mg/dl	28	10.9	10.8	10.7	10.8	10.6	11.1	10.8	10.8	10.8	0.20
	56	11.5	11.2	11.5	10.9	10.8	11.4	11.1	11.1	11.6	0.16
Phosphorus, mg/dl	28	10.0	9.9	10.3	9.9	9.7	9.0	9.8	10.2	9.9	0.45
	56	8.2	9.3	8.8	10.0	9.9	9.2	9.2	9.0	9.3	0.38
Glucose, mg/dl	28	60.6	56.1	64.5	58.0	61.5	59.6	58.5	59.8	63.4	3.2
	56	77.6	71.0	81.1	72.8	78.0	75.4	79.8	73.9	75.5	2.4
Urea nitrogen, mg/dl	28	9.1	18.9	25.6	18.0	20.0	13.9	19.0	16.1	22.6	1.5
	56	9.3	17.0	27.1	16.3	20.6	13.8	19.0	16.4	22.4	1.3
Creatinine, mg/dl	28	0.9	1.0	0.9	1.0	0.9	1.0	0.9	0.9	0.9	0.04
	56	0.9	1.0	1.0	1.0	1.0	0.9	0.9	1.0	1.0	0.03
Total bilirubin, mg/dl	28	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.04
	56	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.3	0.2	0.05

[a]Standard error of the mean.

Table 6. Enzyme activities in serum of lambs fed diets containing cottonseed meal processed by different methods and containing varying levels of free gossypol

		Control Diet	Cottonseed Meal Processing Method								
			Glandless		Expeller		Expander		Direct Solvent		
Serum Constituents	Days	11% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	15% CP	19% CP	SEM[a]
Alkaline phosphotase, u/l	28	345.1	286.8	309.5	362.1	243.1	271.5	283.3	365.1	289.4	43.9
	56	444.9	335.4	309.8	334.5	215.6	312.3	249.9	296.8	233.8	39.7
Creatine phosphokinase, u/l	28	210.1	275.5	169.3	170.0	174.6	162.0	141.8	299.5	133.1	53.5
	56	151.6	111.5	112.0	113.9	105.8	109.5	115.6	146.1	175.9	24.0
Lactic dehydrogenase, u/l	28	438.0	408.1	424.1	431.8	392.0	411.4	432.1	452.6	476.3	35.5
	56	462.5	447.8	484.3	412.0	400.8	495.9	469.5	445.0	707.6	58.1
Alanine aminotransferase, u/l	28	8.0	9.0	9.1	7.5	7.8	7.6	7.1	9.6	8.3	0.57
	56	7.6	7.6	7.6	7.3	6.5	7.1	7.8	8.3	10.9	0.90
Aspartate aminotransferase, u/l	28	72.4	80.1	79.1	66.9	67.1	69.8	78.0	81.1	72.9	6.4
	56	72.1	92.4	92.1	73.0	70.6	76.8	94.4	82.8	83.3	6.9

[a]Standard error of the mean.

creased for the 19 percent CP EX and EP diets, but not for the 15 percent CP EX and EP diets nor when GL cottonseed meal was the source of free gossypol (Figure 1).

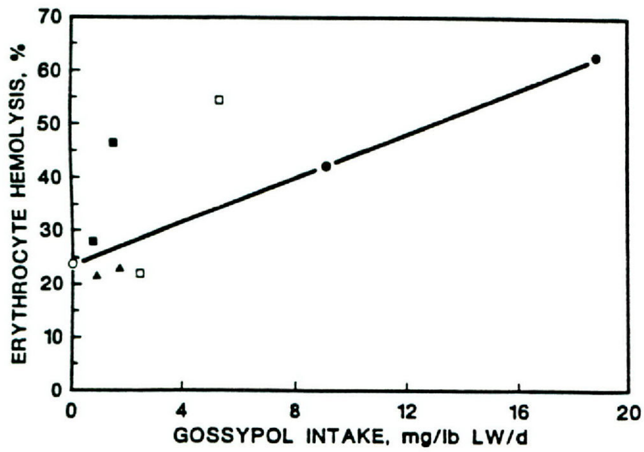

Figure 1. Relationship between percentage erythrocyte hemolysis and free gossypol intake of lambs fed diets containing four sources of cottonseed meal for 42 days.

At 84 days, RBC hemolysis was increased for both the 15 and 19 percent CP EX and EP diets. The responses appeared to be linear for both sources, but the slope of the response was less for the EP than the EX diets (Figure 2). Lambs fed the 15 and 19 percent CP DS diets also exhibited increased RBC hemolysis; however, in contrast to the linear response observed at 42 days, at 84 days the percentage RBC hemolysis was not different for the 15 and 19 percent CP DS diets. Erythrocyte hemolysis was not increased by GL cottonseed meal.

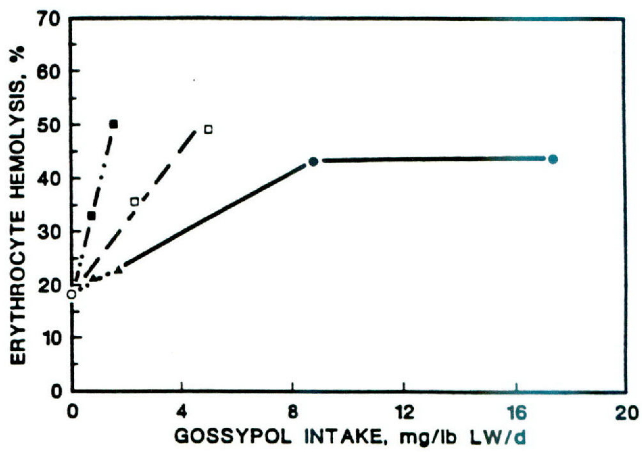

Figure 2. Relationship between percentage erythrocyte hemolysis and free gossypol intake of lambs fed diets containing four sources of cottonseed meal for 84 days.

Discussion

Lambs, prior to the development of normal rumen function, are susceptible to gossypol poisoning (1). In contrast, mature ruminants can detoxify appreciable quantities of gossypol (3, 4). Development of the rumen begins at the time lambs start to consume dry feed and is probably not completed until after weaning (15). Since the lambs used in this study had access to forage from birth it is assumed their rumens were functional. This is supported by the excellent performance obtained when they were weaned and switched to the experimental diets.

During the first 28 days, there were no signs of gossypol toxicity and no changes in serum constituents resulting from feeding any of the sources and levels of cottonseed meal. In fact live weight gains during this period were highest for lambs fed the 19 percent CP DS cottonseed meal diet which contained 736 ppm (0.074 percent) free gossypol on an as-fed basis. The free gossypol intake of these lambs was 18.7 mg/pound LW/day during the first 28 days of the study. These results agree with the study of Calhoun et al. (2) in which early-weaned lambs (59 days old and 29 pounds LW) showed no signs of poisoning when Pima cottonseed and DS cottonseed meal were the sources of free gossypol in diets containing 960 ppm gossypol. In contrast, both Morgan et al. (9) and Calhoun et al. (2) reported all lambs (approximately 8 weeks of age) orally administered gossypol acetic acid at levels $\geq$9 mg/pound LW/day died in less than 28 days.

Signs of gossypol poisoning and the deaths of four lambs, attributable to gossypol, that occurred after 28 days in lambs fed the 19 percent CP DS cottonseed meal diet demonstrate the cumulative nature of gossypol poisoning and establish that prolonged feeding of a diet containing 736 ppm free gossypol is toxic to early-weaned lambs (8 to 20 weeks old). Feeding a diet containing 414 ppm free gossypol (0.041 percent) for 98 days resulted in no signs of gossypol poisoning and no deaths. Therefore, this level would appear to be safe for early-weaned Rambouillet lambs fed diets similar to those in this study.

Free gossypol levels in cottonseed meals vary not only with the processing method used for oil extraction, but also among and within plants using the same method. The processing methods in current use in the United States and the corresponding ranges for free gossypol values are as follows: (1) expeller process, 0.02 to 0.05 percent; prepress solvent extraction, 0.02 to 0.07 percent; direct solvent, 0.1 to 0.5 percent and the expander modification of the direct solvent process, 0.05 to 0.1 percent. Direct solvent cottonseed meal is the highest and most variable in free gossypol content and is the only processing method likely to cause toxicity problems when fed to early-weaned lambs. Fortunately most of the direct solvent plants have incorporated expanders into their oil extraction procedures. This conversion has dramatically reduced free gossypol levels in most cottonseed meal available to producers. However, of the 15 cottonseed oil processing plants currently operating in Texas, three are still direct solvent mills. Therefore, it would be wise for sheep producers to determine the processing method and/or gossypol level before adding large amounts of cottonseed meal to the diets of young lambs. Prior to weaning, lambs should not be fed diets containing more than 100 ppm (0.01 percent) free gossypol. This is the same level recommended for non-ruminants (poultry and swine). When lambs are weaned they can be safely fed diets containing about 400 ppm (0.04 percent) free gossypol.

As reported previously (2) RBC hemolysis is sensitive to free gossypol intake. With the exception of GL, all sources of gossypol increased the percentage hemolysis of RBC in a buffered 0.75 percent saline solution. However, the responses were unique for the different sources of gossypol, demonstrating a lack of correspondence between free gossypol measured by the standard American Oil Chemists Society procedure (11) and free gossypol actually available to the animal (Figures 1 and 2). A possible explanation for this observation is that some of the bound gossypol does not stay bound during digestion by ruminants and that the amount of bound gossypol released during digestion varies with processing method.

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PR 4791

Effects of Milo and Corn Based Diets Fed at ad libitum and Restricted Intakes on Performance and Carcass Composition of Feedlot Lambs

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Summary

Forty-eight Rambouillet and 32 crossbred (Rambouillet x Suffolk) ewe lambs were used in this study to examine the effects of milo- and corn-based diets fed at *ad libitum* and restricted intakes on the performance and carcass composition of feedlot lambs. Minimum roughage diets (15 percent) were formulated with either milo or corn as the energy source and cottonseed meal to balance the protein content and fed to lambs at either *ad libitum* or 92.5 percent of *ad libitum* intake for 56 days. Upon completion of the feeding trial, carcass information was obtained for 24 of the 32 crossbred lambs. The complete experiment was a 2 x 2 factorial arrangement of treatments in a completely random design. The main factors were grain source (corn versus milo) and feeding level (*ad libitum* versus restricted). There were no significant grain source x feeding level interactions for either the performance or carcass data. Grain source did not affect average daily gains or feed conversion for gain; however, feed intake was significantly higher during the 1 to 28 day-periods. ($P < .05$) and 1 to 56 day-periods ($P < .10$) for lambs fed the milo diets compared with those fed the corn diets. Actual feed consumed by the restricted group was 87.7 percent of the amount consumed by the group fed *ad libitum*. Overall, lambs fed the *ad libitum* intake gained 37.1 percent faster ($P < .01$) and required 16.4 percent less feed per pound of gain ($P < .01$) than lambs fed the restricted intake. Dressing percentages ($P < .05$) and estimated percentages of kidney and pelvic fat ($P < .10$) were slightly greater for lambs fed the milo diets. None of the other carcass characteristics were affected by grain source. Dressing percent was higher ($P < .05$) and estimated percent kidney and pelvic fat was lower ($P < .10$) for lambs fed the restricted diet compared with lambs fed *ad libitum*. None of the other carcass characteristics were affected by level of feed intake.

Introduction

Grain sorghum (milo) and corn are the major grains used in feeding sheep and cattle in the United States. Milo is used in the southwestern states and corn is used in the midwestern, eastern and southeastern states. These grains generally are used in areas where they are grown, but occasionally corn is available in the southwest at a price competitive with milo. Decisions concerning substituting corn for milo in lamb diets require knowledge of the relative feeding value of corn and milo when these grains are used in high energy diets (60-80 percent grain) typical of those currently fed to finishing lambs.

Improved performance of growing-finishing sheep and cattle has been obtained by restricting feed intake to 92.5 percent of *ad libitum*. Improvements have been reported in feed conversion, diet digestibility and reductions in gastrointestinal disturbances. This study was designed to compare milo- and corn-based diets when fed *ad libitum* or at 92.5 percent of *ad libitum*.

Experimental Procedure

Forty-eight Rambouillet and 32 crossbred (Rambouillet x Suffolk) ewe lambs were randomly assigned within breed to 16 pens with three Rambouillet and two crossbred lambs per pen. During a 2-week adjustment period, lambs were shorn, weighed, administered an anthelmintic[1], vaccinated[2] and switched from a 45 percent to a 15 percent roughage diet by decreasing the roughage 10 percent at

[1]Levamisole hydrochloride, American Cyanamid Co., Tramisol®, 0.25 g of levamisole hydrochloride were given to each lamb in 20 ml of water, using an automatic drench gun.

[2]Clostridium perfringens Type C & D Toxoid®, Anchor Laboratories, Inc., 2 ml per lamb were injected subcutaneously.

days 5, 9 and 12 (Table 1). Following the adjustment period, diets based on corn or milo were offered at either *ad libitum* or 92.5 percent of *ad libitum* intake for 56 days. Cottonseed meal was used to equalize protein intakes of lambs fed the restricted and *ad libitum* diets.

The lambs were weighed (unshrunk) on 2 consecutive days, initially, and at 28-day intervals during the study. Restricted intake levels were adjusted weekly at 92.5 percent of the previous weeks *ad libitum* intake for the respective grain source. All feeds were fed daily and clean, fresh water was provided free-choice during the experiment. Shade was provided by polyurethane tarps (10 ft x 10 ft) across the middle of each pen, covering the water troughs.

Upon completion of the feeding trial, the 32 crossbred lambs were slaughtered at Swift Independent Packing Company[3]. Carcass weights, quality grades, yield grades[4], leg conformation scores, fat thickness over the *longissimus* muscle and estimated percentage of kidney and pelvic fat were obtained for the chilled carcasses with the assistance of a USDA grader. In addition to carcass information, liver, heart and kidney weights were taken. Carcass data for eight lambs were lost during processing due to an earlier than expected starting time at the slaughter plant.

The data were analyzed as a 2 x 2 factorial arrangement of treatments in a completely random design using the General Linear Model procedure of SAS (11).

diets. The total digestible nutrient, crude protein and mineral values for all of these diets exceeds the values recommended by the National Research Council for growing lambs weighing 77 pounds and gaining 0.5 pound/day.

The simple effects of feeding corn- and milo-based diets at *ad libitum* and restricted intakes on performance of lambs are presented in Table 3. Since there were no significant grain source x feeding level interactions for any of the performance criteria, the data are presented and discussed in terms of the main effects of grain source and feeding level in Tables 4 and 5, respectively. Grain source did not affect average daily gains. However, feed intake was significantly higher during the 1-to 28-day ($P < .05$) and 1- to 56-day periods ($P < .10$) for lambs fed the milo diets compared with those fed the corn diets. Feed conversions, expressed as pound of feed per pound of live weight gain, were not affected by grain source (Table 4).

Throughout the experiment, average daily gains were significantly greater for lambs fed *ad libitum* than for those fed restricted intakes. Overall, lambs fed *ad libitum* gained 37.1 percent more ($P < .01$) than lambs fed a restricted intake. Although it was intended that lambs receiving the restricted level of intake be fed at a rate equivalent to 92.5 percent of the *ad libitum* intake, the actual feed consumed by the restricted group was only 87.7 percent of the amount of feed consumed by the group fed *ad libitum*. Feed conversion was not affected by level of feeding during the period 1 to 28 days. Subsequently, however, during the 29 to 56-day period feed requirements for gain was increased by 55.2 percent ($P < .01$) for the animals fed the restricted intake. Overall, for the 56-day study, feed conversion was increased 16.4 percent ($P < .01$) for animals fed the restricted diet compared with those fed *ad libitum* (Table 5).

Table 1. Percent ingredient composition of experimental diets (as fed basis).

	Adaptation rations (Roughage)				Milo		Corn	
Ingredient, percent	45%	35%	25%	15%	ad libitum	Restricted	ad libitum	Restricted
Alfalfa, dehydrated	22.50	17.50	12.50	7.50	7.5	7.5	7.5	7.5
Gin trash	22.50	17.50	12.50	7.50	7.5	7.5	7.5	7.5
Milo, ground	24.25	30.25	36.25	41.25	82.5	80.0	--	--
Corn, ground	24.25	30.25	36.25	41.25	--	--	78.8	76.4
Cottonseed meal	4.00	2.00	--	--	--	2.5	3.7	6.1
Trace mineral, vitamin and antibiotic premix[a]	2.50	2.50	2.50	2.50	2.5	2.5	2.5	2.5

[a]The percentage ingredient composition of the vitamin-mineral premix was as follows: ammonium chloride, 29.70; calcium carbonate, 47.13; salt, 20.64; manganese sulfate, 0.40; zinc oxide, 0.25; vitamin A (13.6×10^6 IU/lb), 0.30; vitamin D (13.6×10^6 IU/lb), 0.10; and cottonseed oil, 1.49.

Results

The nutrient composition of the experimental diets expressed on an as-fed basis are presented in Table 2. The values presented for total digestible nutrients and net energy for gain were calculated by Livestock Nutrition Laboratory Services. The crude protein content of the diet was similar for the milo- and corn-based rations. Crude fiber, acid detergent fiber and neutral detergent fiber values were slightly higher for the milo diets than the corn

The simple effects of milo- and corn-based diets fed at *ad libitum* and restricted intakes on carcass characteristics of the crossbred lambs are summarized in Table 6. Since there were no significant grain source x feeding level interactions, the data are presented and discussed for the main effects of grain source and intake levels in Tables 7 and 8, respectively. Dressing percentages ($P < .10$) and estimated percentages of kidney and pelvic fat ($P < .10$) were slightly

[3]Swift Independent Packing Co., Bell Street, San Angelo, Texas 76904.

[4]Yield grade = 1.66 - (.05 x leg conformation score) + (.25 x percentage kidney and pelvic fat) + (6.66 x adjusted twelfth rib fat thickness in hundredths of inches).

Table 2. Nutrient composition of experimental diets (as fed basis)[a].

	Milo				Corn			
Item	ad libitum	SD[b]	Restricted	SD	ad libitum	SD	Restricted	SD
Dry matter, percent	89.2	0.37	89.5	0.18	89.0	0.13	89.3	0.39
Total digestible nutrients, percent[c]	82.8	0.30	82.1	1.10	84.3	0.79	83.8	0.23
Net energy for gain, Mcal/pound[c]	0.27	0.00	0.26	0.01	0.28	0.00	0.27	0.00
Crude protein, percent	12.2	1.02	13.5	0.34	12.0	0.51	13.3	0.14
Crude fiber, percent	8.4	0.21	8.9	0.74	7.4	0.54	7.7	0.15
A.D. fiber, percent[d]	10.5	0.26	11.1	0.93	9.2	0.67	9.7	0.19
N.D. fiber, percent[e]	28.4	1.77	28.9	2.08	24.5	1.79	24.6	0.79
Calcium, percent	0.66	0.13	0.69	0.04	0.69	0.07	0.74	0.08
Phosphorus, percent	0.22	0.02	0.24	0.02	0.27	0.01	0.31	0.01
Magnesium, percent	0.13	0.01	0.14	0.01	0.13	0.01	0.15	0.01
Potassium, percent	0.55	0.02	0.64	0.02	0.63	0.06	0.74	0.02
Zinc, ppm	52.6	10.7	54.9	3.62	50.1	5.22	54.7	5.3
Manganese, ppm	41.4	7.9	43.2	3.52	36.2	5.22	39.7	0.6
Copper, ppm	5.6	0.01	5.3	1.33	6.4	1.74	6.4	1.28

[a]Mean of three analyses.
[b]Standard deviation.
[c]Calculated by Livestock Nutrition Laboratory Services.
[d]Acid detergent fiber.
[e]Neutral detergent fiber.

greater for lambs fed the milo diets compared with lambs fed the corn diets. None of the other carcass characteristics were affected by grain source. Organ weights (liver, heart and kidney) expressed as a percentage of live weight were unaffected by grain source (Table 7).

Dressing percent was higher ($P < .05$) and estimated percent kidney and pelvic fat were lower ($P < .10$) for lambs fed the restricted diet compared with lambs fed *ad libitum*. None of the other carcass characteristics were affected by level of feed intake. Liver weight, expressed as a percentage of live weight, was higher ($P < .10$) for lambs fed the restricted diet compared with those fed *ad libitum*. Heart and kidney weights were unaffected by level of feed intake (Table 8).

Table 3. Effect of corn- and milo-based diets fed at ad libitum and restricted intakes on performance of lambs.

	Milo		Corn		
Item	ad libitum	Restricted	ad libitum	Restricted	SEM[a]
Feeding period, days	56	56	56	56	
Lambs, number	20	20	20	20	
Initial live weight, pound	76.05	78.5	76.5	79.6	1.52
1-28 days					
ADG, pound/day	0.633	0.531	0.620	0.516	0.04
Feed intake, pound/day	3.66	3.20	3.42	3.02	0.09
Feed conversion, pound feed/pound gain	5.9	6.0	5.5	5.8	0.14
29-56 days					
ADG, pound/day	0.359	0.220	0.403	0.207	0.04
Feed intake, pound/day	3.66	3.24	3.62	3.13	0.09
Feed conversion, pound feed/pound gain	10.2	14.7	9.0	15.1	0.51
1-56 days					
ADG, pound/day	0.496	0.375	0.511	0.362	0.03
Feed intake, pound/day	3.66	3.22	3.50	3.06	0.08
Feed conversion, pound feed/pound gain	7.4	8.6	6.8	8.5	0.18

[a]Standard error of the mean.

Table 4. Performance of growing lambs fed high grain diets based on milo and corn

Item	Milo	Corn	SEM[a]	Level of significance[b]
Feeding period, days	56	56		
Lambs, number	40	40		
Initial live weight, pounds	7.6	78.3	1.08	NS
1-28 days				
ADG, pound/day	0.582	0.569	0.02	NS
Feed intake, pound/day	3.44	3.22	0.07	P<.05
Feed conversion, pound feed/pound gain	5.9	5.7	0.10	NS
29-56 days				
ADG, pound/day	0.291	0.306	0.02	NS
Feed intake, pound/day	3.46	3.44	0.07	NS
Feed conversion, pound feed/pound gain	12.4	12.0	0.36	NS
1-56 days				
ADG, pound/day	0.430	0.436	0.02	NS
Feed intake, pound/day	3.44	3.15	0.07	P<.10
Feed conversion, pound feed/pound gain	8.0	7.7	0.13	NS

[a]Standard error of the mean.
[b]NS = not significant.

Discussion

The higher fiber values for diets based on milo compared with diets based on corn resulted in slightly higher values for total digestible nutrients and net energy for gain for the corn diets. This difference in calculated or estimated energy values for these diets probably accounts for the significant increase in feed intake of lambs fed the milo diets. However, average daily live weight gains and feed conversions were not significantly different for lambs fed the milo and corn diets. These results are similar to those of Hart and Doyle (4) who reported that lambs fed corn or milo *ad libitum* had similar rates of gain and feed efficiency when a high quality milo, similar to corn in starch content, was fed. Also, Harpster et al. (3) showed no significant differences in average daily gain between corn and milo diets. Other earlier studies also support the conclusion that certain milo varieties are equal to corn in lamb finishing diets (8, 12). However, in one conflicting report (9), Jordan reported that corn was 10 percent higher in nutritive value than Norghum sorghum when used to finish lambs (9).

In this study, feed intake restriction decreased average daily gains and increased feed requirements for gain. These

Table 5. Performance of growing lambs fed high grain diets at ad libitum and restricted intakes.

Item	ad libitum	Restricted	SEM[a]	Level of significance[b]
Feeding period, days	56	56		
Lambs, number	40	40		
Initial live weight, pounds	76.7	81.4	1.52	NS
1-28 days				
ADG, pound/day	0.626	0.525	0.04	P<.05
Feed intake, pound/day	3.55	3.11	0.09	P<.01
Feed conversion, pound feed/pound gain	5.6	5.9	0.14	NS
29-56 days				
ADG, pound/day	0.381	0.214	0.04	P<.01
Feed intake, pound/day	3.64	3.20	0.09	P<.01
Feed conversion, pound feed/pound gain	9.6	14.9	0.51	P<.01
1-56 days				
ADG, pound/day	0.505	0.368	0.03	P<.01
Feed intake, pound/day	3.59	3.15	0.08	P<.01
Feed conversion, pound feed/pound gain	7.1	8.5	0.18	P<.01

[a]Standard error of the mean.
[b] NS = not significant.

Table 6. Effects of corn and milo based diets fed at ad libitum and restricted intakes on carcass characteristics of lambs.

	Milo		Corn		
Item	ad libitum	Restricted	ad libitum	Restricted	SEM[a]
Feeding period, days	56	56	56	56	
Lambs, number	6	6	7	5	
Carcass weight, pound	59.3	57.8	57.5	57.3	0.88
Dressing percent	56.0	57.1	54.9	56.1	0.25
USDA final grade[b]	11.5	11.0	11.0	11.0	0.13
Fat thickness, inches	0.13	0.11	0.10	0.10	0.01
Kidney and pelvic fat, estimated percent	3.6	2.6	2.6	2.0	0.20
Leg conformation score[b]	11.7	11.7	11.3	11.8	0.47
USDA yield grade	3.2	2.9	2.9	2.5	0.10
Liver weight, percent of live weight	1.4	1.7	1.4	1.5	0.03
Heart weight, percent of live weight	0.43	0.43	0.42	0.40	0.01
Kidney weight, percent of live weight	0.12	0.12	0.12	0.12	0.002

[a]Standard error of the mean.
[b]Prime = 14; choice = 11.

results are in contrast to a number of studies with cattle and sheep demonstrating improved performance when feed was restsricted to 92.5 percent of *ad libitum* intake (1, 2, 5, 6, 7, 10, 13). For example, in a lamb study by Glimp et al. (1), feed efficiency was improved 28.8 percent by restriction to 92.5 percent of *ad libitum* intake as compared to *ad libitum*. Also, the reduction of feed intake to 92.5 percent in the study by Glimp et al., increased daily gains slightly. However, further restriction beyond 92.5 percent of *ad libitum* resulted in no significant difference in feed efficiency when compared to *ad libitum* diets and daily gain was reduced by 8 percent. One reason for the different results in this study may be that feed intake was restricted to 87.7 percent of the *ad libitum* fed group, instead of the desired 92.5 percent. It is difficult to believe the level of feed intake restriction is that critical. If so, it would be very difficult for a producer to benefit from the practice of feed intake restriction on a practical basis.

Table 7. Comparison of the carcass characteristics of growing lambs fed high grain diets based on corn and milo.

Item	Milo	Corn	SEM[a]	Level of significance[c]
Feeding period, days	56	56		
Lambs, number	12	12		
Carcass weight, pound	58.6	57.3	0.88	NS
Dressing percent	56.6	55.5	0.25	P<.10
USDA final grade[b]	11.3	11.0	0.13	NS
Fat thickness, inches	0.12	0.10	0.01	NS
Kidney and pelvic fat, estimated percent	3.1	2.3	0.20	P<.10
Leg conformation score[b]	11.7	11.6	0.47	NS
USDA yield grade	3.1	2.7	0.10	NS
Liver weight, percent of live weight	1.5	1.5	0.03	NS
Heart weight, percent of live weight	0.43	0.41	0.01	NS
Kidney weight, percent of live weight	0.12	0.12	0.002	NS

[a]Standard error of the mean.
[b]Prime = 14; choice = 11.
[c]NS = not significant.

Table 8. Comparison of the carcass characteristics of growing lambs fed high grain diets at ad libitum and restricted intakes.

Item	Ad libitum	Restricted	SEM[a]	Level of significance[c]
Feeding period, days	56	56		
Lambs, number	13	11		
Carcass weight, pound	58.4	57.5	0.88	NS
Dressing percent	55.5	56.6	0.27	P<.05
USDA final grade[b]	11.3	11.0	0.13	NS
Fat thickness, inches	0.12	0.10	0.01	NS
Kidney and pelvic fat, estimated percent	3.0	2.0	0.003	P<.10
Leg conformation score[b]	11.5	11.7	0.47	NS
USDA yield grade	3.1	2.7	0.10	NS
Liver weight, percent of live weight	1.4	1.6	0.03	P<.10
Heart weight, percent of live weight	0.42	0.42	0.01	NS
Kidney weight, percent of live weight	0.12	0.12	0.002	NS

[a]Standard error of the mean.
[b]Prime = 14; choice = 11.
[c]NS = not significant.

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Performance of Early-weaned Lambs Fed Diets Containing Cottonseed Meal or Soybean Meal Alone or in Combination with Fishmeal

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Summary

Three experiments were conducted to evaluate cottonseed meal (CSM), soybean meal (SOM) and Menhaden fishmeal (FM) as sources of supplemental protein in diets for early-weaned lambs. In Experiment 1, 48 early-weaned lambs were fed high-energy diets based on sorghum grain, alfalfa meal and peanut hulls. Cottonseed meal, SOM and combinations of 3 percent FM with CSM and SOM were used to give four diets containing 15.5 percent crude protein. Three pens with four lambs per pen were fed each diet for 84 days. Daily gains, feed intake and feed requirements for gain were similar for the CSM and SOM diets, however, the addition of 3 percent FM tended to increase gains and reduce feed requirements for gain when added to the CSM and SOM meal diets. In a second experiment, 48 Rambouillet and Suffolk x Rambouillet crossbred ewe lambs were fed the same diets as for Experiment 1 for 59 days. In this experiment, performance of lambs fed the CSM and SOM diets were similar and were not improved with 3 percent FM. In Experiment 3, 36 Rambouillet and Suffolk x Rambouillet crossbred wether lambs were randomly assigned to one of three diets containing the following protein sources: 15.8 percent CSM; 11 percent CSM + 3 percent FM; and 6.2 percent CSM + 6 percent FM. The duration of the experiment was 104 days and lambs were slaughtered upon completion of the study. There was a linear increase in average daily gain and a linear decrease in feed requirements for gain with the substitution of FM for CSM in the diet. Three percent FM increased gains 10.8 percent, and 6 percent FM increased gains 17.4 percent compared to the 15.8 percent CSM diet. The feed to gain ratio was decreased 13.5 percent with 3 percent FM and 18.4 percent with 6 percent FM in the diet. There were no consistent effects of level of FM on any of the carcass characteristics measured. These results indicate a need for high quality protein that is slowly degraded in the rumen. Menhaden fishmeal is an excellent source of the essential amino acid lysine; thus, lysine may be a limiting amino acid for young, rapidly growing lambs fed high-energy diets.

Introduction

Soybean meal (SOM) and cottonseed meal (CSM) are widely used in the United States as protein sources in creep feeds for young lambs and in complete diets for growing and finishing lambs. In the southwestern states, use of CSM predominates, as it is generally the cheapest source of supplemental protein in areas where cotton is raised. However, SOM is generally considered to be slightly superior to CSM as a feed ingredient because of its higher crude protein and energy contents compared with CSM. Occasionally the price of SOM is competitive with CSM in the Southwest and it can be used economically in lamb diets. An additional advantage of SOM is that it does not contain the toxic compound gossypol. There have been reports of gossypol poisoning in young lambs (1, 7) when CSM containing high levels of gossypol was included in the diet.

Newer methods of expressing the protein value of feeds and the protein requirements of ruminants involve partitioning protein into a portion that is degradable in the rumen (rumen degradable protein) and a portion that escapes rumen degradation (rumen undegradable protein) (8). This approach appears to have merit, particularly for young, rapidly growing ruminants with high dietary protein requirements. A number of studies have shown a positive response to the inclusion of high quality protein that is slowly degraded in the rumen, such as FM, in the diets of young sheep (3, 4, 5). Therefore, these experiments were conducted to evaluate CSM, SOM and FM as sources of protein in the diets of early-weaned lambs.

Experimental Procedure

Three experiments were conducted during the spring and summer of 1989 to achieve the objectives of this research.

Experiment 1.

Forty-eight early-weaned lambs were fed high energy diets based on sorghum grain, alfalfa meal and peanut hulls. Cottonseed meal, SOM and combinations of 3 percent FM with CSM and SOM were used to provide four diets containing 15.5 percent crude protein (Table 1). Three pens with four lambs per pen were fed each diet for 84 days. Upon completion of the study, the lambs were slaughtered in a commercial lamb plant and carcass information was obtained with the assistance of a USDA grader.

Experiment 2.

Thirty-two Rambouillet and 16 Suffolk x Rambouillet crossbred ewe lambs were placed in pens containing four Rambouillet and two crossbred lambs per pen. Two pens

Table 1. Percentage ingredient and nutrient composition of diets fed to early-weaned lambs.

	Experiments 1 and 2				Experiment 3		
	Protein Source				Protein Source		
Ingredient	**CSM**	**SOM**	**CSM+FM**	**SOM+FM**	**CSM**	**CSM+FM**	**CSM+FM**
Sorghum grain, milo	62.00	64.65	64.25	66.25	61.50	63.75	65.50
Dehydrated alfalfa meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Peanut hulls	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Cottonseed meal	15.85	--	11.00	--	15.85	11.00	6.15
Fish meal, Menhaden	--	--	3.00	3.00	--	3.00	6.00
Soybean meal	--	13.00	--	9.00	--	--	--
Molasses	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ammonium chloride	--	--	--	--	0.50	0.50	0.50
Calcium carbonate	1.40	1.10	1.00	1.00	1.40	1.00	1.10
Mono-dicalcium phosphate	--	0.50	--	--	--	--	--
Vitamin-mineral premix[a]	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Nutritional values[b]							
Dry matter	88.7	88.5	88.6	88.4	88.7	88.7	88.6
Total digestible nutrients	71.8	73.9	72.4	74.0	71.4	71.9	72.0
Crude protein	15.5	15.5	15.5	15.6	16.3	16.4	16.4
Crude fiber	11.2	9.7	10.7	9.6	11.2	10.7	10.1
Calcium	0.79	0.80	0.79	0.80	0.79	0.79	1.01
Phosphorus	0.42	0.43	0.46	0.40	0.42	0.46	0.51

[a]The percentage ingredient composition of the premix was as follows: sodium chloride, 64.7; potassium chloride, 19.0; sulfur, 10.0; zinc oxide, 0.274; vitamin A (13.6×10^6 IU/pound), 0.73; vitamin D (13.6×10^6 IU/pound), 0.093; vitamin E (12.5×10^4 IU/pound), 0.72; chlortetracycline (49.9 g/pound), 3.0 and molasses, 1.5.
[b]Dry matter basis.

of lambs were fed each of the four rations used in Experiment 1 for 59 days. Lambs were not slaughtered upon completion of the experiment.

Experiment 3.

Eighteen Rambouillet and 18 Suffolk x Rambouillet crossbred wether lambs were randomly assigned to one of three diets containing the following protein sources: 15.8 percent CSM; 11 percent CSM + 3 percent FM; and 6.2 percent CSM + 6 percent FM. The duration of this experiment was 104 days and lambs were slaughtered upon completion of the study in a commercial lamb plant. Carcass information was obtained with the assistance of a USDA grader.

Results and Discussion

Experiment 1.

The performance data presented in Table 2 are for the periods 1 to 28, 1 to 56 and overall for the 84-day study. In general, performance was excellent throughout the study. Daily live weight gains, feed intake and feed requirements for gain (F/G) were not statistically different for the CSM and SOM diets. The addition of 3 percent FM tended to increase average daily gain and reduce feed/gain when added to the CSM and SOM diets; however, the only significant difference was for feed/gain during the first 28 days. During this period, feed/gain was 11.9 percent lower ($P < .05$) for lambs receiving FM.

Final USDA quality grades were higher ($P < .05$) for lambs fed diets containing SOM than for those fed diets containing CSM. Fat thickness measured over the *longissimus* muscle, estimated percent kidney and pelvic fat and USDA yield grade were unaffected by dietary treatments.

The CSM used contained 0.185 percent free gossypol. Thus, the diet containing 15.8 percent CSM had a calculated free gossypol content of 399 ppm. The free gossypol intake of lambs consuming this diet averaged 9.2 mg/pound LW/day for the 84-day study. Performance was not depressed and there were no signs of gossypol poisoning in any of the lambs receiving this level of gossypol for this period of time. These results agree with the previous study of Calhoun et al. in which 12- to 16-week-old lambs were safely fed a diet containing 400 ppm of free gossypol for 98 days (1). In contrast, Morgan et al. (7) reported lambs receiving 9.1 mg gossypol/pound LW/day died from gossypol poisoning in less than 30 days. The difference in response appears related to the source of free gossypol. Morgan et al. administered gossypol acetic acid daily in a gelatin capsule; whereas, direct solvent CSM provided the free gossypol in this study. Equivalent amounts of free gossypol in cottonseed products such as direct solvent CSM and cottonseed have been shown to be much less toxic than gossypol acetic acid (2).

Experiment 2.

The performance of lambs fed diets containing either CSM or SOM were not different. These results are consistent with those obtained in Experiment 1; however, in Experiment 2 there was no response when 3 percent FM was added to either the CSM or SOM diets (Table 4).

Table 2. Performance of early-weaned lambs fed diets containing different protein sources in experiment 1.

	Protein Source[a]				
Criterion	**CSM**	**SOM**	**CSM + FM**	**SOM + FM**	**SEM[b]**
Lamb, number	12	12	12	12	
Initial live weight, pound	47.5	49.7	47.1	50.4	2.8
28-day summary					
Live weight gain, pound/day	0.677	0.681	0.710	0.775	0.035
Feed intake, pound/day	2.99	2.99	2.78	3.00	0.10
Feed/gain	4.4[c]	4.4[c]	3.9[d]	3.9[d]	0.14
56-day summary					
Live weight gain, pound/day	0.682	0.643	0.670	0.742	0.123
Feed intake, pound/day	3.55	3.36	3.30	3.48	0.13
Feed/gain	5.2	5.2	4.9	4.7	0.18
84-day summary					
Live weight gain, pound/day	0.636	0.643	0.673	0.722	0.034
Feed intake, pound/day	3.79	3.53	3.56	3.72	0.12
Feed/gain	6.0	5.6	5.3	5.2	0.28

[a]CSM = cottonseed meal; SOM = soybean meal; CSM + FM = cottonseed meal + fishmeal; SOM + FM = soybean meal + fishmeal.
[b]Standard error of the mean.
[c,d]Means in the same row without a common superscript are significantly different ($P < .05$).

Table 3. Carcass summary of early-weaned lambs fed diets containing different protein sources in experiment 1.

	Protein Source[a]				
Criterion	**CSM**	**SOM**	**CSM + FM**	**SOM + FM**	**SEM[b]**
Carcass weight, pound	53.1	53.9	54.9	60.0	3.0
Dressing percent	52.2	52.3	52.9	54.1	0.61
USDA final grade	10.9[c]	12.1[d]	11.3[c]	11.9[d]	0.17
Fat thickness, inches	0.23	0.25	0.26	0.27	0.03
Kidney fat, percent	1.6	1.9	2.0	2.4	0.38
Leg conformation score	10.9[c]	11.2[cd]	11.6[cd]	12.1[d]	0.30
USDA yield grade	3.2	3.2	3.4	3.4	0.09

[a]CSM = cottonseed meal; SOM = soybean meal; CSM + FM = cottonseed meal + fishmeal; SOM + FM = soybean meal + fishmeal.
[b]Standard error of the mean.
[c,d]Means in the same row without a common superscript are significantly different ($P < .05$).

Table 4. Performance of early-weaned lambs fed diets containing different protein sources in experiment 2.

	Protein Source[a]				
Criterion	**CSM**	**SOM**	**CSM + FM**	**SOM + FM**	**SEM[b]**
Lambs, number	12	12	11	12	
Initial live weight, pound	35.3	35.3	34.2	35.3	1.9
Live weight gain, pound/day	0.507	0.527	0.523	0.524	0.026
Feed intake, pound/day	2.38	2.27	2.24	2.41	
Feed/gain	4.7	4.3	4.3	4.6	0.30

[a]CSM = cottonseed meal; SOM = soybean meal; CSM + FM = cottonseed meal + fishmeal; SOM + FM = soybean meal + fishmeal.
[b]Standard error of the mean.

Experiment 3.

There was a linear increase in average daily gain and a linear decrease in feed requirements for gain with the addition of FM to the diet (Table 5). Three percent FM increased gains 10.8 percent and 6 percent FM increased gains 17.4 percent. The feed/gain ratio was decreased 13.5 percent with 3 percent FM and 18.4 percent with 6 percent FM. There were no consistent effects of level of FM on any of the carcass characteristics measured (Table 6).

Although the differences were not significant for either Experiments 1 or 2, lambs fed the SOM diet without FM were slightly more efficient in converting feed to live weight

Table 5. Performance of early-weaned lambs fed diets containing different levels of fishmeal (experiment 3).

	Treatment[a]			
Criterion	CSM	CSM + 3 percent FM	CSM + 6 percent FM	SEM[b]
Lambs, Number	12	11	12	
Initial live weight, pound	38.0^c	38.0^c	37.0^c	2.1
Live weight gain, pound/day	0.465^c	0.515^{cd}	0.546^d	0.021
Feed intake, pound/day[e]	3.02	2.88	2.89	
Feed/gain[e]	6.5	5.6	5.3	

[a]CSM = cottonseed meal; FM = fishmeal.
[b]Standard error of the mean.
[c,d]Means in the same row without a common superscript are significantly different (P<.05).
[e]It was not possible to test treatment means for feed intake and feed/gain because all lambs on each treatment were fed in a single pen.

Table 6. Carcass characteristics of early-weaned lambs fed diets containing different levels of fishmeal (experiment 3).

	Treatment[a]			
Criterion	CSM	CSM + 3 percent FM	CSM + 6 percent FM	SEM[b]
Lambs, Number	10	11	11	
Carcass weight, pound	48.9	49.1	52.4	1.4
Dressing percent	52.9	52.4	52.9	0.69
USDA final grade	11.2^{cd}	10.6^c	11.5^d	0.26
Leg conformation score	11.2	11.3	11.9	0.26
Fat thickness, inches	0.17	0.22	0.22	0.02
Kidney and pelvic fat, percent	2.2	1.8	2.1	0.25
USDA yield grade	2.8	3.0	3.0	0.18

[a]CSM = cottonseed meal; FM = fishmeal.
[b]Standard error of the mean.
[c,d]Means in the same row with different superscripts are significantly different (P<.05).

gain than lambs fed the CSM diet without FM. Hogue (6) also reported a slight, but nonsignificant, reduction in feed requirements for live weight gain when the protein source in lamb diets was SOM instead of CSM. Compared with CSM, SOM reduced feed requirements an average of 7.9 percent for Experiments 1 and 2 and the study of Hogue (6).

The positive effects of FM on live weight gains and feed conversions observed with lambs in Experiments 1 and 3 are consistent with responses previously obtained when FM was fed to young lambs (3, 4, 5, 6). These results indicate a need for high quality protein that is slowly degraded in the rumen. Menhaden fishmeal is an excellent source of the essential amino acid lysine, thus lysine may be a limiting amino acid for young, rapidly growing lambs fed high-energy diets.

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Acid Detergent Fiber, Crude Protein and Ether Extract Digestibility and Crude Protein and Mineral Balance in Lambs Implanted with Ralgro

G. D. Hufstedler, L. W. Greene, G. E. Carstens and F. M. Byers

Summary

Fourteen crossbred wether lambs (average weight 62 pounds) were used in a metabolism trial to determine the effect of Ralgro® implants on apparent crude protein (CP), ether extract (EE), acid detergent fiber (ADF) digestibility and CP and mineral balance. Lambs were blocked by weight and randomly assigned to control or implant treatment groups. Lambs were housed in a single pen and fed a high concentrate diet (Table 1) for a 21-day diet adjustment period and thereafter were housed in metabolism stalls and fed 0.88 pounds twice daily, for a 10-day adjustment followed by a 7-day collection period. Treated lambs received a 12 mg zeranol implant 21 days prior to the initiation of the collection period. During the 7-day collection period, total feces and urine were collected. Feed samples were collected beginning 2 days before the collection period and continued for 7 days. Composites of feed and feces were analyzed for ADF, CP, EE, Ca, P, Mg, Zn, Fe, Mn and Cu and urine was analyzed for CP, Ca, Mg, Zn, Fe, Mn and Cu. Apparent digestibility of ADF, CP, EE and absorption of Fe, Mn and Cu were similar for implanted and non-implanted lambs. Implanting lambs did not affect the retention of CP, Fe, Mn or Cu compared to the non-implanted controls. Fecal excretion of Ca, P, Mg and Zn was decreased 22 ($P < .01$), 27 ($P < .05$), 11 ($P < .03$) and 9 percent ($P < .10$), respectively, in implanted lambs compared to non-implanted controls. This resulted in an increased apparent absorption of Ca, P, Mg and Zn in lambs treated with zeranol. Urinary excretion of all the nutrients analyzed was similar for implanted and control lambs. The amount of Ca, Mg and Zn retained increased 98 ($P < .01$), 138 ($P < .03$) and 60 percent ($P < .10$), respectively, in implanted lambs compared to non-implanted controls. These results indicate that anabolic agents such as Ralgro® enhance the ability of lambs to absorb and retain Ca, P, Mg and Zn, thus providing a level of these minerals that could alter bone ossification. These metabolic changes may also prove beneficial in production situations where lambs are exposed to mineral deficient diets or incidences of requiring enhanced mineral availability.

Introduction

It has been well documented that anabolic agents such as Ralgro® increase the performance (8) as well as the overall leanness of implanted animals (6, 7). Producers currently face a no-win situation, since the use of Ralgro® is discouraged because of the increased incidence of spooling that occurs in implanted lambs. Increased spooling is postulated to be associated with greater calcium retention and increased rate of ossification in implanted lambs (4). Such results are in agreement with studies conducted with post-menopausal women suggesting that estrogen treatment increases Ca absorption and retention, thereby decreasing osteoporosis (2). Recent studies conducted at Texas A&M revealed significant alterations in the serum mineral concentrations and bone breaking strengths of steers treated with anabolic agents (5, 10), indicating that anabolic agents do alter mineral metabolism and bone characteristics. Because of the increased incidence of spooling in lambs implanted with an anabolic agent, producers are penalized by the pricing differential between lamb and mutton even though the leaner carcass would be a more acceptable product to the public (4).

The objectives of this experiment were to identify the changes in mineral status that result from the use of Ralgro® in lambs and to establish evidence that spooling

Table 1. Diet composition.

Composition	Percent
Ingredient[a]	
Cracked corn	63.8
Soybean meal	12.4
Alfalfa pellets	10.8
Sugarcane molasses	7.8
Cottonseed hulls	3.6
Trace mineralized salt	0.6
Ground limestone	0.6
Ammonium sulfate	0.4
Chemical analysis[a]	
Dry matter	86.7
Acid detergent fiber	15.5
Crude protein	12.8
Ether extract	2.8
Calcium	0.6
Phosphorus	0.3
Magnesium	0.2
Iron, ppm	109.0
Zinc, ppm	69.0
Manganese, ppm	38.0
Copper, ppm	6.0

[a] Data are presented on an as fed basis.

is not necessarily a function of age alone but one related to calcium elevations that might account for a more rapid ossification of the bone matrix.

Experimental Procedures

Fourteen crossbred wether lambs (average weight 62 pounds) were fed in a single pen and adjusted to a high concentrate diet (Table 1) for 21 days followed by a 10-day metabolism stall adjustment and a 7-day collection period. Lambs received a 12 mg zeranol implant 21 days prior to initiation of the 7-day feces and urine collection period. During the stall adjustment and collection periods, lambs were fed 0.88 pound twice daily with unlimited access to demineralized water. Feed samples were collected beginning 2 days before the collection and continuing for 7 days. Feed samples, feces and urine collections were composited, and feed and feces analyzed for acid detergent fiber (ADF), crude protein (CP), ether extract (EE; 1) and minerals. Wet digested feed and fecal samples, as well as centrifuged urine samples, were diluted prior to mineral analyses. An inductively coupled plasma emission system (ICP) was used to analyze feed, fecal and urine samples for Ca, P, Mg, Zn, Fe, Mn and Cu (3). Urinary P concentrations were not obtained due to an error in ICP programming. Data were statistically analyzed using the general linear models procedure of SAS (9).

Results and Discussion

The digestibility of ADF was 71 percent and was not affected by implant treatment (Table 2). Lambs implanted with Ralgro® excreted similar quantities of CP in the feces but tended to excrete less CP in the urine compared to the non-implanted controls. Ether extract absorption was similar regardless of implant treatment group (Table 2).

Table 2. Acid detergent fiber, crude protein and ether extract intake, excretion, apparent absorption and retention values in lambs.

	Control	Ralgro®
Acid detergent fiber		
Intake, gram/day	22.20	22.20
Fecal excretion, gram/day	6.83	5.94
Absorption, gram/day	15.37	16.26
percent of intake	69.22	73.27
Crude protein		
Intake, gram/day	97.22	97.22
Excretion, feces, gram/day	39.08	37.69
urine, gram/day	53.40	47.50
Absorption, gram/day	58.14	59.53
percent of intake	59.80	61.24
Retention, gram/day	4.74	12.04
percent of intake	4.88	12.38
percent of absorbed	6.781	8.02
Ether extract		
Intake, gram/day	17.44	17.44
Fecal excretion, gram/day	21.26	22.68
Absorption, gram/day	−3.82	−5.24
percent of intake	−21.88	−30.06

Calcium, phosphorus and magnesium balance data are presented in Table 3. Lambs implanted with Ralgro® excreted less ($P < .01$) Ca in the feces compared to control lambs, which resulted in an 87 percent increase ($P < .01$) in apparent Ca absorption. Because similar quantities of Ca were excreted in the urine, Ca retention values were similar to apparent absorption when comparing implanted lambs to non-implanted controls. Apparent P absorption followed the same pattern as apparent Ca absorption. Fecal excretion of P decreased ($P < .05$) 27 percent when lambs were implanted, which resulted in a 193 percent increase ($P < .05$) in apparent P absorption. Urinary P was not analyzed in this data set; therefore, P retention is not presented. Magnesium fecal excretion decreased 11 percent ($P < .03$), which increased ($P < .03$) apparent absorption of Mg by 9 percent in implanted lambs compared to non-implanted lambs. Since urinary excretion of Mg was similar between the two treatment groups, retention of Mg was increased ($P < .03$) 138 percent for implanted lambs compared to controls. The previously reported increased bone hardness and incidence of spooling in implanted lambs are probably directly related to the increased absorption and retention of these minerals.

Micro-mineral balance data are shown in Table 4. The fecal excretion, apparent absorption and retention of Zn were similar to that observed for Ca and Mg in implanted lambs versus controls. Implanting lambs decreased ($P < .10$) fecal excretion of Zn by 9 percent and apparent absorption increased ($P < .10$) 45 percent. The apparent

Table 3. Calcium, phosphorus and magnesium balance in lambs implanted with Ralgro®.

	Control	Ralgro®
Calcium		
Intake, gram/day	5.11	5.11
Excretion, feces, gram/day[a]	4.08	3.17
urine, gram/day	0.09	0.07
Absorption, gram/day[a]	1.03	1.94
percent of intake[a]	20.30	38.03
Retention, gram/day[a]	0.95	1.88
percent of intake[a]	18.57	36.68
percent of absorbed[c]	90.64	96.60
Phosphorus		
Intake, gram/day	2.19	2.19
Excretion, feces, gram/day[c]	1.92	1.41
Absorption, gram/day[c]	0.27	0.79
percent of intake[c]	12.42	35.93
Magnesium		
Intake, gram/day	1.22	1.22
Excretion, feces, gram/day[b]	0.56	0.50
urine, gram/day	0.58	0.53
Absorption, gram/day b	0.66	0.72
percent of intake[b]	53.92	59.25
Retention, gram/day[d]	0.08	0.19
percent of intake[d]	6.621	5.72
percent of absorbed[d]	11.97	26.02

[a]Affected by implant treatment ($P < .01$).
[b]Affected by implant treatment ($P < .03$).
[c]Affected by implant treatment ($P < .05$).
[d]Affected by implant treatment ($P < .10$).

availability of Zn (absorption expressed as a percent of intake) increased from 17.7 to 25.0 percent when lambs were implanted, compared to controls. The retention of Zn was 60 percent greater ($P < .10$) when lambs were implanted. The apparent absorption of Fe, Mn and Cu were similar between treatment groups.

The precise mechanisms of Ralgro's® action on increasing Ca, P, Mg and Zn apparent absorption and Ca, Mg and Zn retention are not known. Our laboratory recently summarized data that suggest Ralgro® may increase the circulating levels of parathyroid hormone (a proteolytic hormone responsible for Ca absorption from the intestine and resorption from bone) in certain dietary regimens. Two possible scenerio's could exist, based upon the data collected in the present study: Ralgro® may alter metabolic mechanisms to increase the efficiency of Ca, P, Mg and Zn absorption and/or Ralgro® decreases the endogenous loss of these minerals resulting in an increased apparent absorption and retention. Regardless of the precise mechanism, it is obvious that implantation with Ralgro® alters the mineral status of treated lambs, perhaps even enabling them to escape production losses that occur in mineral deficient animals as well as diseases and other abnormalities which mineral deficiencies may precipitate. Most importantly, this study has shown that Ca is available in large enough quantities to stimulate increased calcification which may be linked to premature spool joint formation.

Table 4. Zinc, iron, manganese and copper balance in lambs implanted with Ralgro®.

	Control	Ralgro®
Zinc		
Intake, mg/day	55.0	55.0
Excretion, feces, mg/day	45.4	41.4
urine, mg/day	2.9	2.7
Absorption, mg/day[d]	9.6	13.9
percent of intake[d]	17.7	25.0
Retention, mg/day[d]	6.9	11.0
percent of intake[d]	12.4	20.4
percent of absorbed[b]	61.8	75.9
Iron		
Intake, mg/day	87.0	87.0
Excretion, feces, mg/day	137.7	123.3
urine, mg/day	0.9	0.6
Absorption, mg/day	-50.7	-36.3
percent of intake	-58.3	-42.0
Retention, mg/day	-51.4	-37.0
percent of intake	-59.0	-42.5
percent of absorbed	-	-
Manganese		
Intake, mg/day	30.0	30.0
Excretion, feces, mg/day	29.7	28.7
urine, mg/day	0.0	0.0
Absorption, mg/day	0.4	1.4
percent of intake	1.4	4.8
Retention, mg/day	0.3	1.4
percent of intake	1.3	4.7
percent of absorbed	96.7	106.2
Copper		
Intake, mg/day	6.0	6.0
Excretion, feces, mg/day	5.1	4.7
urine, mg/day	0.0	0.0
Absorption, mg/day	0.7	1.1
percent of intake	13.8	17.6
Retention, mg/day	0.7	1.1
percent of intake	13.3	17.0
percent of absorbed	108.5	95.5

[a]Affected by implant treatment ($P < .01$).
[b]Affected by implant treatment ($P < .03$).
[c]Affected by implant treatment ($P < .05$).
[d]Affected by implant treatment ($P < .10$).

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Performance, Carcass Characteristics and Serum Parathyroid Hormone and Calcium Concentrations in Lambs Implanted with Ralgro® and Fed Two Levels of Calcium and Phosphorus.

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Summary

Seventy-two crossbred wether lambs (average weight 55.3 pounds.) were used to determine the effects of Ralgro® and two dietary levels of calcium and phosphorus on performance, carcass characteristics and serum parathyroid hormone (PTH) and Ca concentrations. Lambs were assigned to either an implant or non-implant treatment group, and either a high dietary Ca (0.8 percent) and P (0.6 percent) or low dietary Ca (0.4 percent) and P (0.3 percent) in a 2 x 2 factorial arrangement of treatments. Lambs were implanted on day 0 and 56 with 12 mg Ralgro®. Lambs were housed by treatment (nine lambs/pen), and fed *ad libitum* for 105 days. Twenty-four lambs, three-lambs/pen, were moved to individual pens on day 84 to determine serum concentration of PTH and Ca. Lambs were bled via jugular puncture prior to feeding (time 0) and 1 hour post feeding (time 1) on day 98. Concentrations of PTH was greater (P) in lambs receiving 0.8 percent Ca and 0.6 percent P than those receiving 0.4 percent Ca and 0.3 percent P (27.0 and 18.6 pmol/dayl). Concentration of PTH in serum pooled across treatments was greater ($P < .10$) at time 0 than at time 1. Serum Ca concentration tended to be greater in lambs receiving the 0.8 percent Ca and 0.6 percent P diet than those receiving the 0.4 percent Ca and 0.3 percent P diet. Serum Ca concentrations pooled across treatments were greater ($P < .05$) at time 0 than at time 1. Overall, implanted lambs had greater ($P < .01$) daily feed intakes, 26 percent faster average daily gains ($P < .10$) and a 12 percent improved ($P < .10$) feed efficiency than non-implanted lambs. Implanted lambs had greater ($P < .01$) backfat thickness over the 12th rib which reflects the greater ($P < .01$) carcass weights in implanted versus non-implanted lambs. Implanted lambs had greater ($P < .01$) leg conformation scores and yield grades than non-implanted lambs. Implants increased gain 26 percent and feed efficiency by 12 percent showing that implants are advantageous in lamb production.

Introduction

Ralgro® has been used extensively throughout the livestock industry to improve average daily gain and feed efficiency. Several studies have shown that average daily gain was greater for Ralgro® implanted lambs than non-implanted controls (3, 4). In another study, it was demonstrated that Ralgro® increased the rate and efficiency of gain of implanted lambs (5). In cattle, in addition to increasing growth, anabolic agents increase the rate of protein deposition and decrease fat deposition (1). The sheep industry is at a point where it must maximize growth and feed efficiency as well as reduce fat to produce a product for the health conscious consumer. The use of anabolic agents such as Ralgro® may allow producers to produce a quality product on a more economical basis. The objective of this trial was to evaluate the effects of Ralgro® and two dietary levels of Ca and P on performance, carcass characteristics, serum concentrations of PTH and Ca in growing wether lambs.

Experimental Procedure

Growth trial. Seventy-two crossbred wether lambs (average weight 55.3 pounds) were used in the 105-day trial. Lambs were randomly assigned to either an implant or non-implant treatment group, and either a high dietary Ca (0.8 percent) and P (0.6 percent) or normal dietary Ca (0.4 percent) and P (0.3 percent) in a 2 x 2 factorial arrangement of treatments. Lambs were penned by treatment (nine lambs/pen) and fed *ad libitum* their respective diets (Table 1) for 105 days. Lambs were implanted on day 0 and 56 with 12 mg of Ralgro® into the middle third of the ear. During this period, lambs were weighed and feed intake measured every 28 days. All lambs were slaughtered at a commercial slaughter plant and carcass characteristics were determined.

Table 1. Diet composition.

Ingredients	High Ca and P	Low Ca and P
	percent as fed	
Cracked corn	59.20	60.80
Dehydrated alfalfa	25.00	25.00
Soybean meal	9.40	9.40
Molasses	4.00	4.00
Dicalcium phosphate	1.70	-
Trace mineral salt[a]	0.45	0.44
Ammonium chloride	0.36	0.36

[a]Trace mineral salt: 93 percent NaCl, 0.30 percent Mn, 0.25 percent Zn, 0.15 percent Fe, 0.015 percent Cu, 0.009 percent I, 0.005 percent Co

Serum parathyroid hormone (PTH) and calcium measurements. Twenty-four crossbred wether lambs (average weight 110 pounds), six lambs per treatment, three lambs/pen, were moved to individual pens on day 84 and allowed to adjust to the new environment for 14 days. Lambs were fed *ad libitum* the same diet they received in their respective outside pens. On day 98, lambs were bled via jugular puncture prior to feeding (time 0) and 1 hour post feeding (time 1). Serum samples were frozen for later analysis. Serum PTH was assayed by a radioimmunoassay procedure (Immuno Nuclear Corp., Stillwater, MN.), and serum Ca concentration was analyzed by atomic absorption spectrophotometry. Statistical analysis of the data was performed using the general linear models procedure of SAS (2).

Results and Discussion

Lambs that received Ralgro® implants gained faster (P <.05) from day 0 to 28, day 28 to 56, day 56 to 84 and day 0 to 105 than those not implanted (Table 2). Over the trial, rate of gain averaged 26 percent faster for implanted lambs over controls. Level of dietary Ca and P did not affect ADG. Feed efficiency for implanted lambs was improved (P <.10) from day 28 to 56, day 56 to 84 and day 0 to 105 compared to non-implanted lambs (Table 2). Daily feed intake was greater (P <.05) for implanted lambs than for non-implanted lambs from day 28 to 56, day 56 to 84, day 84 to 105 and day 0 to 105 (Table 2).

Carcass characteristic data are presented in Table 3. Lambs implanted with Ralgro® had greater (P <.01) final live weights and carcass weights than non-implanted controls. There were no differences (P <.10) for kidney pelvic fat and dressing percent between implant treatment groups. Backfat thickness, measured at the 12th rib, was greater (P <.01) in implanted lambs compared to non-implanted lambs. This difference was largely due to the fact that the implanted lambs grew 26 percent faster (P <.01) and were heavier than non-implanted lambs when slaughtered. Leg conformation scores were greater (P) in implanted lambs than in non implanted lambs (12.1 versus 11.5; where 12 = High Choice and 11 = Average Choice). Yield grades were greater (P <.01) for implanted lambs than non-implanted, and this can be attributed to the fact that the implanted lambs were not marketed at an optimum slaughter endpoint. The incidence of spool joints was numerically greater in implanted lambs (2 spools) than in non-implanted lambs (0 spools).

Dietary levels of calcium and phosphorus did not have any effect on performance or carcass characteristics in these lambs.

Serum concentrations of PTH and Ca are presented in Table 4. Concentrations of PTH were greater (P <.10) in lambs receiving high dietary Ca and P than those receiving low dietary Ca and P (27.0 versus 18.6 pmol/dl). Concentrations of PTH in serum pooled across treatments was greater (P <.01) at time 0 than at time 1 (30.0 and 15.1

Table 2. Ralgro® and Ca and P levels on average daily gain, feed efficiency and feed intake.

	Implant		Control	
	0.8 percent Ca 0.6 percent P	0.4 percent Ca 0.3 percent P	0.8 percent Ca 0.6 percent P	0.4 percent Ca 0.3 percent P
ADG, pound				
Days				
0-28[b]	0.64	0.58	0.56	0.53
28-56[a]	0.65	0.59	0.43	0.48
56-84[a]	0.62	0.67	0.44	0.44
84-105	0.44	0.51	0.39	0.44
0-105[a]	0.59	0.59	0.46	0.47
Feed intake, pound/day				
Days				
0-28	2.56	2.56	2.47	2.29
28-56[a]	3.09	2.94	2.53	2.64
56-84[a]	3.21	3.29	2.72	2.68
84-105[b]	3.52	3.58	3.12	3.13
0-105[a]	3.07	2.92	2.68	2.66
Feed/gain				
Days				
0-28	3.99	4.43	4.43	4.43
28-56[c]	4.80	4.92	5.93	5.54
56-84[b]	5.15	4.95	6.13	6.18
84-105	8.03	6.83	7.81	7.07
0-105[c]	5.12	4.93	5.81	5.63

[a]Affected by implant treatment (P <.01).
[b]Affected by implant treatment (P <.05).
[c]Affected by implant treatment (P <.10).

Table 3. Effects of Ralgro® and Ca and P levels on carcass characteristics.

	Implant		Control	
	0.8 percent Ca 0.6 percent P	0.4 percent Ca 0.3 percent P	0.8 percent Ca 0.6 percent P	0.4 percent Ca 0.3 percent P
Initial live weight, pounds	55.8	56.2	54.9	54.2
Final live weight, pounds[a]	118.6	118.1	103.3	104.0
Carcass weight, pounds[a]	59.5	59.5	53.1	52.8
Dressing percent	50.1	50.4	51.4	50.7
Kidney pelvic fat, percent	2.6	2.4	2.3	2.6
Fat thickness 12th rib, in[a]	0.24	0.21	0.16	0.18
Leg conformation score[a,b]	12.2	12.1	11.6	11.5
Yield grade[a]	3.4	3.1	2.8	3.0
Number spools	1	1	0	0

[a]Affected by implant treatment ($P < .01$).
[b]Leg conformation score: High Choice = 12 and Average Choice = 11.

Table 4. Effects of Ralgro® and Ca and P levels on serum PTH and CA concentrations.

	Implant		Control	
	0.8 percent Ca 0.6 percent P	0.4 percent Ca 0.3 percent P	0.8 percent Ca 0.6 percent P	0.4 percent Ca 0.3 percent P
PTH, pmol/dl[a]				
Time 0[b]	45.9	17.2	29.4	14.1
Time 1	18.3	14.1	11.9	15.6
Serum Ca, mg/dl				
Time 0[b]	9.4	9.2	9.6	9.0
Time 1	9.3	9.0	8.7	8.9

[a] Affected by level of Ca and P ($P < .10$).
[b] Affected by time of sampling ($P < .01$).

pmol/dl). Serum Ca concentrations tended to be greater ($P > .10$) in lambs receiving high dietary Ca and P than those receiving low dietary Ca and P (9.26 and 9.04 mg/dl, respectively). Serum Ca concentrations pooled across treatments were greater ($P < .05$) at time 0 than at time 1 (9.28 and 8.99 mg/dl, respectively). There tended to be an interaction between dietary levels of Ca and P and implant for serum PTH concentrations. Implanted lambs had greater concentrations of PTH when high dietary Ca and P was fed (32.1 versus 21.4 pmol/dl) but lower concentrations of PTH when low dietary Ca and P was fed (15.6 versus 21.5 pmol/dl) compared to non-implanted controls. Parathyroid hormone concentrations were affected by dietary levels of Ca and time due to PTH's role in regulating Ca metabolism in the body. Parathyroid hormone concentrations were not altered by implant treatments.

In conclusion, Ralgro® increased average daily gain, feed efficiency and feed intake compared to non-implanted lambs. Implanted lambs were heavier at slaughter and had greater backfat thickness and yield grades, but this is probably due to their heavier weights at slaughter. Parathyroid hormone is responsible for Ca homeostasis in the body and results in bone resorption activity in times of hypocalcemia. If implanted lambs are absorbing more Ca there would be more Ca available for bone growth, which could be a reason for the increased incidence of spools in implanted lambs.

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Prediction of Variation of Fiber Diameter in Wool Fleeces

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

Summary

Distribution of fiber diameter was determined for side, britch and core samples taken from 100 yearling, fine-wool rams participating in the 1989 Texas Ram Performance Test. The coefficient of variation of diameter of the whole (140 days) fleece was shown to be only poorly correlated (r = 0.15) with the difference in mean diameters between side and britch staples and moderately correlated (r = 0.48) with the coefficient of variation of diameter of the side sample. In contrast, both side diameter and britch diameter were highly correlated with core diameter (r = 0.89 and 0.76, respectively). An implication for ram testing and selection of fine-wool stud rams is that the coefficient of variation of diameter of the whole fleece is not a sensitive indicator of objectionable coarse britch wool. If or when this information is required, wool from the britch should be measured directly.

Introduction

Fiber diameter is an important price-determining characteristic of raw wool. For constant length distribution, diameter and variation in diameter govern the size (linear density) of yarn that can be spun from wool fibers (12, 13, 14, 15). High levels of diameter variability reduce spinning performance, yarn uniformity and tensile properties through the influence on number of fibers in the yarn cross section (17). Consequently, fiber diameter and its variation play major roles in processing and marketing of wool.

Variation of wool fiber diameter may be expressed as the standard deviation of the mean fiber diameter. However, coefficient of variation (CV) provides a more useful statistic for comparing fiber diameter variance of wool differing in mean diameter because it accounts for the increase in standard deviation which generally occurs with an increase in fiber diameter (4, 18). Sources of within-fleece fiber diameter variability include: diameter differences along the length of individual fibers and mean diameter differences between fibers.

The variation of fiber diameter between body regions has been estimated in previous studies. Dunlop and McMahon (5) found the variation in fiber diameter between sites on the bodies of sheep accounted for only 6 to 12 percent of total variation in five Australian Merino strains. Stobart et al. (11) found the variation in fiber diameter attributable to body region accounted for 2 to 15 percent of the total variation.

The variation of wool fiber diameter measured on properly drawn and processed cores would appear to be the best sample for establishing the overall distribution of fiber diameter in a fleece since the cores contain fibers from all regions of the fleece and in the correct proportions. Core samples are considered to be more representative than discrete samples taken from other parts of the fleece, such as side samples and britch samples, for describing mean fiber diameter and associated variability. However, side and britch samples are easier to obtain.

It is hypothesized that overall variation of fiber diameter in the fleece of a fine-wool ram can be estimated by the difference in diameter between side and britch samples. The belief is that the greater the difference in diameter between these two locations, the higher will be the variation.

The britch wool of fine-wool, Rambouillet type of sheep represents only a small portion of the whole fleece. Willingham et al. (16) found that britch wool composed only 5.7 percent of the entire fleece, and although removal of the britch decreased the fiber diameter of the remaining fleece as compared to intact fleeces, this difference was negligible by the time the wool was converted to top. Because the britch constitutes only a small portion of the fleece, its contribution to variability of diameter of the whole fleece is expected to be proportionately low. However, britch wool can contain some exceptionally coarse, hairy fibers and can make a major contribution (together with lower leg wool) to the so-called "coarse edge" of a fleece. Whiteley and Thompson (19) studied ways of establishing the "coarse edge" statistics in grease wool sale lots and concluded that standard deviation and CV are sufficient for establishing "coarse edge" statistics. Other authors are not in agreement with this view (7) particularly when applied to single fleeces.

Although relatively few in number, rams play the major role in the genetic selection process in a flock (2). Because of its importance in establishing price and value, mean fiber diameter is one of the several variables that have been routinely and objectively measured in ram performance tests (8).

The objective of the study was to determine if the CV of the side sample diameter (CVSD) or the difference in diameter between wool from the side and britch (BD-SD) regions could be used to accurately predict the core CV (CVCD) which is frequently used as a measure of overall variation of wool fiber diameter in fleeces. The relationships of mean fiber diameter and CV between side, britch and core samples were also studied.

Experimental Procedure

Wool samples from the mid-side and britch areas of 100 yearling fine-wool rams on the 1989 Texas Ram Performance Test were removed on day 100 of the 140-day test. The staples were subsequently characterized in terms of diameter distribution. Whole fleeces were shorn at the end of the test and core-sampled (32 x 0.5-inch cores) using a technique described by Johnson and Larsen (6). Mid-side and britch staples were subsampled using a two-bladed cutting device (3) producing snippets having a length of 1.8 mm. The staples were sampled at a point 3/10 of their length from the base corresponding to the mid-point of the 140-day staple. The degreased snippets were measured using a Peyer Texlab FDA 200 System (9). In each case, 1,000 fibers were measured providing a mean diameter value having a confidence limit of $\pm$ 0.4 um at the 95 percent probability level.

Core samples removed from whole fleeces were washed and dried in accordance with ASTM standard test method D584 (ASTM, 1989). The cleansed cores were carded (using a Haigh-Chadwick mini-carding machine) prior to subsampling for diameter measurement. Snippets sampled from the card web were thus considered to be representative of the whole fleece in terms of average fiber diameter and variability.

Simple linear regression analysis (10) was used to establish relationships between the mean fiber diameters and variabilities measured on the samples taken from two body locations and the whole fleece core samples.

Results and Discussion

A summary of the mean fiber diameter and CV data is presented in Table 1. The mean values of SD and CD are similar, while the BD is approximately 2.5 um coarser. Mean CVCD is higher than CVSD and CVBD while the side samples are the most uniform (CV = 19.3 percent). Core samples are expected to be the most variable because they contain fibers from all parts of the fleece and from all points along the staples which, under the conditions of a performance test, vary significantly in diameter from tip to base (i.e., 2 μm on average [8]).

Table 1. Fiber diameter distribution for different body areas and in whole fleeces.

Test animals	Sample description	Mean fiber diameter (microns)	Coefficient variation (percent)
	Side	22.98(SD)	19.28(CVSD)
100 rams	Britch	25.82(BD)	21.69(CVBD)
	Core	23.37(CD)	24.43(CVCD)

Table 2 shows correlation coefficients (r values) between the three measures of fiber diameter and also for the mean value of side and britch diameter versus core diameter and the difference between side and britch diameter and core diameter. All coefficients are significant (P<.01) except BD-SD versus CD, suggesting that SD, BD and mean SD/BD are all good indicators of CD. However, SD produced the highest correlation with CD.

Table 2. Correlation coefficients between various measures of fiber diameter.

Correlation	r value
SD versus BD	0.80**
SD versus CD	0.89**
BD versus CD	0.76**
Mean SD/BD versus CD	0.86**
BD - SD versus CD	0.20

**Significant correlation (P<.01)

Correlation coefficients between side, britch and core CV's of diameter are shown in Table 3. The correlation between CVSD and CVCD is significant (P<.01) and moderately high (r = 0.48) while the correlations between BD-SD and CVCD were low (r = 0.15). These results suggest that the CVSD provides a better indication of CVCD than BD-SD. However, the correlation is only moderate, indicating that a mere 23 percent of the variability in CVCD can be accounted for by the variability in CVSD. Thus, it appears that an *accurate* measure of CVCD can be obtained only by measuring it directly. Further, CVCD cannot be relied upon as an accurate indicator of excessively coarse britch wool. When this information is required, it too should be measured directly.

Table 3. Correlation coefficients between various measures of CV and mean diameter

Correlation	r value
CVSD versus CVBD	0.43**
CVSD versus CVCD	0.48**
CVBD versus CVCD	0.21*
Mean CVSD/CVBD versus CVCD	0.37**
CVBD - CVSD versus CVCD	0.12
BD - SD versus CVCD	0.15
BD - SD versus CVSD	0.08

**Significant correlation (P<0.01)
* Significant correlation (P<0.05)

Conclusions

1. Neither side and britch fiber diameter differences nor side and britch coefficients of variations or their differences can be used to accurately predict the variability of diameter of a whole fleece (i.e., coefficient of variation of diameter of a core sample).
2. Variability of fiber diameter in a fleece can be accurately measured using representative carded wool samples. When this is not possible, a side sample may be measured to provide a moderately accurate estimate (r for CVSD versus CVCD = 0.48) of the diameter variability of the whole fleece.
3. The fiber diameter of a side sample provides a good estimate (r = 0.89) of the mean diameter of a core sample from the same whole fleece. Predicting core diameter using britch diameter provides only a slightly inferior estimate (r = 0.76).
4. The coefficient of variation of fiber diameter of a whole fleece is too insensitive a statistic for indicating the presence of excessively coarse britch wool. Direct ac-

cess to the fiber diameter histogram can reveal this objectionable trait. Alternatively, when a more accurate estimate is required (e.g. in the selection of a fine-wool stud ram) wool from the britch area should be measured directly.

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PR 4796

Staple Strength and Resistance to Compression of U.S. Wools

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

Summary

A selected sample of the 1988 U.S. wool clip (600 fleeces) was characterized in terms of staple strength and resistance to compression. Mean fiber diameter, staple length and yield of individual fleeces were also measured. A high proportion (72.7 percent) of the fleeces were determined to be sound (stronger than 30 N/ktex) and a majority (59.7 percent) of the fleeces exhibited resistance to compression greater than 11 kPa and were regarded as being highly resistant to compression.

Introduction

Staple strength of wool is customarily measured as either the maximum load (newtons, N) or the energy (joules, J) needed to break a staple. To correct for differences in the size of the staple being tested, these measures are standardized by the amount (mass in g) or linear density (g/m = ktex) of clean wool.

Staple strength is of practical importance because it is significantly related to processing performance (card waste, noilage, machine speeds and efficiency). Wool with low strength will generally suffer more breaks in processing and produce a top with lower mean fiber length than a higher strength wool. Routine measurements of staple strength would provide producers with important information on the performance of their sheep. Since staple strength is affected by changes in sheep health due to age, environment, nutrition, pregnancy, lactation, stress and disease, including parasite load, its measurement quantifies these influences and provides another management tool (8). The force applied to staples in manual or subjective strength appraisals is approximately 30 N, ranging from 15-50 N. It is physically difficult to apply much more force than this to a wool staple. The thinnest staples normally selected for manual strength appraisal would be about 2 ktex. Therefore, the upper limit of staple strength that can be manually determined is about 25 N/ktex. Above this, even the trained hand cannot distinguish different levels of strength. Below 20 N/ktex, these assessments can effectively rank wools of varying staple strength.

Resistance to compression (R to C) is the force per unit area required to compress a fixed mass of wool to a fixed volume. Units of measurement are kilopascals (kPa). Resistance to compression is related to fiber diameter and the form and frequency of crimp. Differences of 2 kPa result in significant processing differences, thus R to C is a useful measurement from a manufacturer's point of view.

As resistance to compression decreases, wool is generally softer and more lustrous. Resistance-to-compression values are useful in assessing suitability for specific end-uses. For example, low R-to-C wools can provide soft, lustrous effects in knitwear.

A literature search failed to reveal comprehensive information concerning staple strength and resistance to compression of U.S. wool. This study, supported by the American Wool Council of the American Sheep Industry Association, was designed to partially fill this void in our knowledge.

Objective

Characterize a broad cross-section of U.S. wools in terms of staple strength and resistance to compression.

Experimental Procedure

Fifty fleeces from each of 12 major wool-producing locations around the U.S. were assembled and tested at the Wool and Mohair Research Lab, Texas Agricultural Experiment Station, San Angelo. Each fleece was weighed, subsampled (5) and tested for lab scoured yield (3), diameter (6), staple length (4), staple strength (1) and resistance to compression (2,7).

Results and Discussion

The original intent was to test three groups of fleeces having average grades of 64s, 58s and 54s. The fleeces used in this study were subjectively appraised for grade prior to selection. The actual grades of the three groups tested were 62s, 56s and 48s. Since some of the fleeces in the 62s group were finer than 64s and some of the fleeces in the 48s group were coarser than 46s, the study incorporated a broader cross section of wool than was originally intended (Figure 1).

Lab scoured yield (LSY) was measured for each fleece to permit calculation of staple strength based on clean wool. The average LSY for the fine fleeces was 53.9 percent, for the intermediate fleeces 58.3 percent and for the coarse fleeces 61.7 percent. Average staple lengths for the fine, medium and coarse groups were 7.61, 8.29 and 8.62 cm, respectively.

For the purpose of this discussion, ranges of staple strength are described as follows: N/ktex = rotten; 10-20 N/ktex = tender; 21-30 N/ktex = part tender; >30 N/ktex = sound. Staple strength data are summarized in Figure 2.

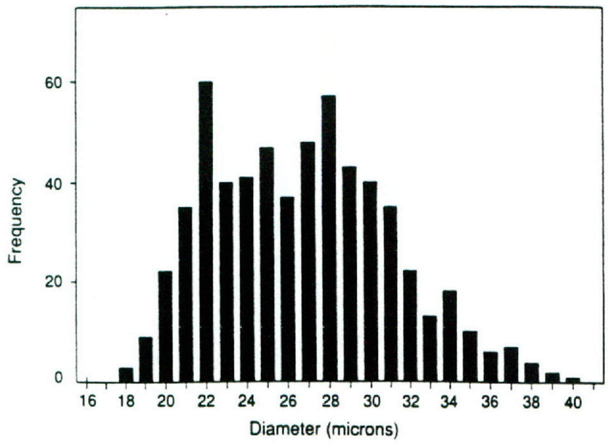

Figure 1. Distribution of fiber diameter.

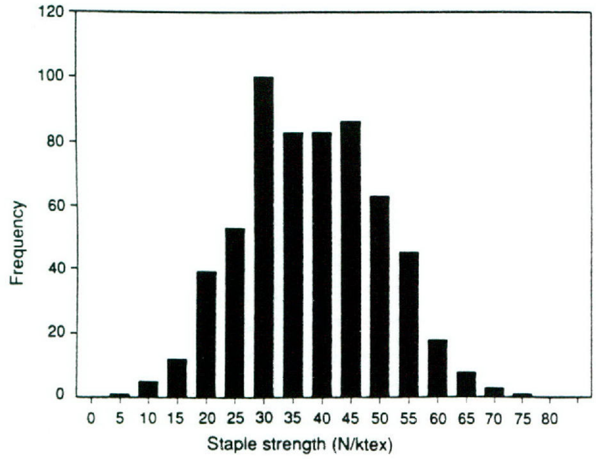

Figure 2. Distribution of staple strength.

The average staple strength of the fine wool group was 35.6 N/ktex. For the medium wool group, the average staple strength was 42.5 N/ktex and for the coarse wool group, 36.7 N/ktex. Overall, 72.8 percent of the 600 fleeces tested were characterized as sound.

In the current context, R-to-C values below 8.0 kPa are designated as low; 8.0 to 10.9 kPa as medium; and 11.0 to 18.0 kPa as high. As a group, the fine wools fell into the low end of the high R-to-C category with a mean of 11.88 kPa. Overall, the medium wools were not as bulky as the fine wools, with a mean R-to-C value of 10.82 kPa. However, the coarse wools were also categorized as high R to C having a mean value of 12.38 kPa. Of the 600 fleeces tested, 358 were classified as having high resistance to compression, 236 medium and six as low. Thus, based on this sample from one production year, a high proportion of U.S. wool is likely to be high R-to-C wool. The R-to-C data are summarized in Figure 3.

Simple linear regression analysis was used to establish mathematical relationships and the degree of correlation between the various characteristics measured in this study.

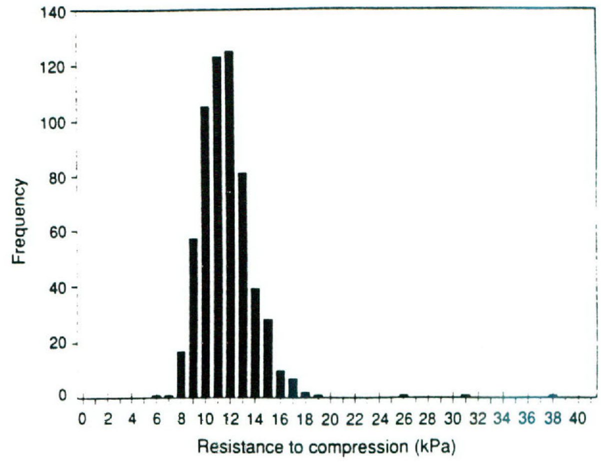

Figure 3. Distribution of resistance to compression.

The results of the analyses of pooled data are presented in Table 1.

Table 1. Correlation coefficients (r values) between fleece characteristics (pooled data).

	Staple length	LSY	Staple strength	R to C
Diameter	0.21*	0.35*	0.03	0.25*
Staple length	–	0.30*	0.00	-0.15*
LSY	–	–	-0.11*	- 0.00
Staple strength	–	–		- .24*

*Significant (P <0.01).

Small but significant (P < .01) positive correlations exist between fiber diameter and lab scoured yield and resistance to compression (r = 0.35 and 0.25 respectively). Equally small correlation coefficients were noted for diameter versus staple length (r = 0.21), staple length versus yield (r = 0.30) and staple strength versus resistance to compression (r = -0.24).

Conclusions

One year's data obtained from a selected sample of U.S. wool permits the following conclusions:

1. A high proportion (72.7 percent) of the fleeces tested in this study were sound (30 N/ktex).
2. The majority (59.7 percent) of the fleeces tested in this study was classified as having a high resistance to compression (> 11.0 kPa). Based on this sampling, a high proportion of U.S. wool is likely to have high resistance to compression. This characteristic (unlike strength) is not expected to change significantly from 1 year to another.

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PR 4797

A Comparison of Core Sampling Techniques (1/2-versus 2-inch Tube) for Wool and Mohair

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

Summary

A study was conducted to determine the effects of coring tube diameter and package type on objectively measured yield, vegetable matter present and fiber diameter of commercial lots of wool and mohair. No significant differences ($P > .05$) were observed between yield values determined from 1/2-inch versus 2-inch core samples taken from identical packages. Similarly, the size of the coring tool and the form of packaging were shown to have no significant effect on the magnitude of average fiber diameter determined from core samples. Despite these findings, 1/2-inch core sampling of lightweight (< 150 pounds) wool bags is not recommended over 2-inch coring since the former is (relatively) slow and laborious.

Introduction

Several physical properties and characteristics of animal fibers determine their value and usefulness as textile fibers. Fineness and yield of clean fibers are two of the major characteristics influencing utility and value. Visual inspection to estimate fineness, yield and length has been the usual basis of evaluating wool and mohair at sale time. However, a more accurate method of establishing value is to measure fiber characteristics using objective measurements. The accuracy of the results of these measurements depends largely upon the sample tested being representative of the entire lot. As early as 1925, Jones and Lush (11) studied the representativeness of a sample composed of 10 percent of the fleeces drawn at fixed numerical intervals at shearing time. Subsequently, core sampling was developed to meet this need for representative samples of bulk lots.

Core testing of greasy wool for yield commenced on a significant scale in the U.S. in 1938, when the Bureau of Customs first started coring wool for assessment of tariff duties (21). Core testing to determine clean content of grease wool was also utilized by the Commodity Credit Corporation (CCC) in price support and wool loan programs (22). Since that time, many articles on the coring of domestic wools and mohair (15) have been published by federal (10, 12, 13, 14, 20, 21, 22, 23), state (4, 6, 7, 8, 9, 18) and private (17) entities. A major study (19) conducted by the United States Department of Agriculture (USDA), Agricultural Marketing Service (AMS), Livestock Division, and reported in 1958 summarized data from core sampling, testing and mill processing 46 lots (607,000 pounds) of CCC wool. It was determined that clean wool yield based on samples drawn with a 1 1/4-inch coring tube most accurately reflected the actual mill top-noil-waste yields of these lots.

Fifty years experience with core testing has resulted in Standard Practice D1060 of the American Society for Testing and Materials (ASTM; 2) which describes a procedure for obtaining samples from lots of grease, pulled or scoured animal fibers in bales or bags for the subsequent determination of clean fiber present and average diameter. The standard practice does not specify size of coring tube but notes that the diameter of sampling tubes in common use ranges from 1/2 to 2 inches. In current U.S. practice, 1/2-inch coring tools are being used to sample tightly packed bags and bales of wool and mohair. Two-inch tools are used for sampling wool in bags and baled bags.

Much of the U.S.-based research also served as a basis for the International Wool Textile Organization (IWTO) Core Test Regulations. As with the ASTM Standard Practice, IWTO Regulations do not specify a particular diameter or length of coring tube. Rather, the regulations state that sampling equipment and the number of cores taken per lot should be adequate to produce a sampling precision of ± 1 percent of IWTO Clean Wool Content for $P = 0.95$. In practice, most Australian bales are sampled with 7/8-inch pressure coring equipment with the coring tubes entering through the cap and/or base of the bale.

This lack of specification of coring tube size in both ASTM and IWTO procedures continues to produce speculation that tube size can affect yield and fineness measurements made on samples. This, in fact, may be the case when core samples are measured directly. However, it is normal commercial practice in the U.S. to subsample 2-inch cores taken from bags and bales using a 1/2-inch subsampler. Thus, actual yield and diameter measurements are actually made on 1/2-inch core samples regardless of the tube size originally used to sample the lot.

The number (and weight) of cores extracted from a lot of wool or mohair for the purpose of characterizing the clip in terms of yield and diameter are dependent upon two factors. First, the number of cores required to ensure adequate representation of the clip (as described in ASTM D1040, for example). This number is independent of core size. Secondly, the requirement of a minimum weight of core sample for actual testing (1.5 pounds in the case of 1/2-inch cores) or further subsampling (in the case of 2-inch cores). In this latter case, the minimum number of cores (40) required to accommodate a commercial subsampler was quite substantial in the past. However, a smaller machine capable of subsampling 20 cores has now been developed (17) so that size of submitted sample should no longer be an issue.

In 1989, the Objective Measurement Task Force (of the American Sheep Producers Council of America) identified core testing for small lots ($< 5{,}000$ pounds) as an area requiring improvement. Researchers were asked to identify procedures for sampling small lots that would provide an unbiased sample, while producing minimal damage to the fibers remaining in the packages. A study was conducted in response to this request, addressing the question of how size of core and package type affects objectively measured characteristics of the core samples. However, this study did not attempt to quantify the relative degrees of fiber damage produced by 1/2- versus 2-inch coring tubes in the sampled packages.

Experimental Procedures

Three small ($< 3{,}500$ pounds) commercial lots of wool and two lots of mohair were identified for this study. The fibers were contained in jute bags (approximate dimensions, when full, 60 inches long x 81 inches circumference) each of which contained about 130 pounds of wool or 260 pounds of mohair. Ten 1/2-inch cores were removed from each wool bag and 8 x 1/2-inch cores from each mohair bag, point of entry of the core tube being chosen to assure uniform sampling within each bag. Core samples from each bag within a lot were combined prior to analysis. This was followed with a similar procedure using a 2-inch coring device with four cores/bag being removed from the wool lots and two cores/bag from the mohair. The number (10) of 1/2-inch cores removed from each wool bag was in excess of the minimum number of cores required to ensure an allowable variation of $< \pm 1$ percent ($P = 0.05$) in clean wool fiber present. The theoretical numbers of cores/bag were calculated for each wool lot using information presented in ASTM Test Method D1060 (2) and are listed in Table 1, together with other pertinent data concerning individual lot composition and package density. The num-

Table 1. Physical characteristics of packages of wool and mohair.

	Number of bags in lot	Net weight of fiber in bags (lb)	Average density of bags (lb/ft^3)	Theoretical number cores/ bag*(**)	Number bales in lot	Net wt fiber in bales (lb)	Average density of bales (lb/ft^3)	Theoretical number cores/ bale*(**)
Wool lot number (and description)								
1. (Texas, 12 mo graded staple)	25	3190	7.04	4	4	3146	14.92	20
2. (Texas, 12 mo graded staple)	10	1405	7.75	8	2	1383	16.27	39
3. (Texas, 12 mo graded staple)	15	1931	7.10	6	2	1484	16.78	39
Mohair lot number (and description)								
A. (Spring, fine young goat)	8	2108	15.5	2	2	2102	19.5	5
B. (Fall, average kid)	9	2298	17.0	2	2	2293	23.4	5

*Minimum number of cores to be taken from each package in the lot to ensure an allowable variation of ± 1 percent clean wool fiber present at a probability level of 95 percent for $s_w = 4.5$ percent and $s_b = 2.0$ percent (2, ASTM D1060).

**Minimum number of cores to be taken from each package in the lot to ensure an allowable variation of ± 1 percent clean mohair fiber present at a probability level of 95 percent for $s_w = 1.56$ percent and $s_b = 2.21$ percent (15, Lineberry et al.).

ber (4) of 2-inch cores removed from each wool bag was equal to or less than the minimum required to achieve the degree of accuracy previously stated. The cored bags were subsequently compressed into bales containing 5 to 8 bags and each bale was resampled. Twenty-four 1/2-inch and 20 2-inch cores were removed from each bale of wool.

The minimum number of cores required from each package of mohair to ensure a variation of $< \pm 1$ percent ($P = 0.05$) in clean mohair fiber present was calculated using the data of Lineberry et al. (15). The theoretical number of cores for each lot are shown in Table 1. The number of 1/2-and 2-inch cores actually taken (8 x 1/2, 2 x 2-inch for bags and 24 x 1/2, 12 x 2-inch for bales) equaled or exceeded the theoretical minimum number.

The 2-inch cores were subsampled prior to measurement with a 1/2-inch coring machine in a manner described by Johnson and Larsen (6). Clean wool (and mohair) fiber present and vegetable matter present were determined in duplicate for each set of core samples using ASTM Test Method D584(1). Subsamples of the scoured wool and mohair were used to determine fineness parameters using a Peyer Texlab FDA 200 System (16) and, in the case of mohair, medullation using ASTM Standard Test Method D2968(3). Analysis of variance (5) was used to test for differences in fiber diameter, yield and vegetable matter present between treatments.

Results and Discussion

The results of analyses for clean wool fiber present (CWFP) and clean mohair fiber present (CMFP) are presented in Table 2. No significant differences ($P > .05$) exist between the four treatments. That is, the size of the coring tool and the type of package sampled did not affect the measured CWFP or CMFP values of the five lots. A similar conclusion applies to measurements of vegetable matter present (Table 3), average fiber diameter (Table 4), standard deviation (Table 5) and medullation (Table 6).

Average diameter of mohair measured on 1/2-inch core samples did show a consistent trend of being coarser than measurements made on 2-inch cores and differences approached significance ($P = 0.10 - 0.25$). This observation warrants further investigation since the 1/2-inch core is used quite extensively in the characterization of mohair clips.

Table 2. CWFP and CMFP values (percent) for wool and mohair in bags and baled bags sampled with 1/2- and 2-inch coring tubes.

Lot number	1/2-inch Bag	2-inch Bag	1/2-inch Bale	2-inch Bale
Wool				
1	58.2	59.2	59.9	59.2
2	55.7	55.1	55.5	55.1
3	61.8	60.6	59.9	60.8
Mean values	58.6	58.3	58.4	58.4
Mohair				
A	75.4	76.2	75.7	76.4
B	76.7	76.5	76.3	76.5
Mean values	76.0	76.4	76.0	76.4

Table 3. VMP values (percent) for wool and mohair in bags and baled bags sampled with 1/2- and 2-inch coring tubes.

Lot number	1/2-inch Bag	2-inch Bag	1/2-inch Bale	2-inch Bale
Wool				
1	4.2	3.1	4.1	3.5
2	1.7	1.9	2.7	2.4
3	2.3	3.2	3.8	2.6
Mean values	2.7	2.7	3.5	2.8
Mohair				
A	1.0	1.2	0.9	0.7
B	0.9	1.1	1.3	0.7
Mean values	0.9	1.2	1.1	0.7

Table 4. Fiber diameter values (microns) for wool and mohair in bags and baled bags sampled with 1/2- and 2-inch coring tubes.

Lot number	1/2-inch Bag	2-inch Bag	1/2-inch Bale	2-inch Bale
Wool				
1	20.5	20.6	20.9	20.8
2	20.9	21.2	21.0	21.1
3	20.5	20.4	20.4	20.3
Mean values	20.6	20.7	20.8	20.7
Mohair				
A	30.9	29.5	30.8	29.0
B	28.9	28.2	29.2	28.5
Mean values	29.9	28.8	30.0	28.8

Table 5. Standard deviation of fiber diameter values (microns) for wool and mohair in bags and baled bags sampled with 1/2- and 2-inch coring tubes.

Lot number	1/2-inch Bag	2-inch Bag	1/2-inch Bale	2-inch Bale
Wool				
1	5.0	4.7	5.0	5.0
2	5.3	5.0	4.8	5.2
3	5.2	5.2	5.0	5.0
Mean values	5.2	5.0	4.9	5.1
Mohair				
A	6.5	7.2	6.7	6.4
B	7.3	6.8	7.4	6.9
Mean values	6.9	7.0	7.0	6.6

Table 6. Medullation values (percent) for mohair in bags and baled bags sampled with 1/2- and 2-inch coring tubes.

Lot number	1/2-inch Bag	2-inch Bag	1/2-inch Bale	2-inch Bale
Kemp (percent)				
A	0.1	0.1	0.2	0.0
B	0.2	0.1	0.0	0.2
Mean values	0.1	0.1	0.1	0.1
Med (percent)				
A	0.2	0.1	0.3	0.0
B	0.3	0.2	0.2	0.1
Mean values	0.2	0.2	0.2	0.1

In conclusion, the size of coring tube (1/2-versus 2-inch) and the type of package (bag versus bale) does not significantly affect the magnitude of the objectively measured characteristics; yield, diameter and medullation for the types of clean, fine wools and mohair examined. However, 1/2-inch core sampling is not recommended for lightweight (< 150 pounds) wool bags since the technique is laborious and slow. In the case of denser mohair bags and wool and mohair bales, the 1/2-inch cores produce results equivalent to 2-inch cores. Although it would appear that the 1/2-inch coring tube would cause less fiber damage than the 2-inch tool, this does not necessarily follow, since to extract enough weight of cores for testing, it is usually necessary to enter the packages more times with the 1/2-inch tube than the 2-inch tube. The question of how much damage (reduction in mean fiber length) results from these two coring procedures requires further study.

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Inter-lab Trials with the Peyer TexLab FDA 200 System

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Summary

The Peyer Texlab FDA 200 System has been extensively evaluated for measuring fiber diameters. Results of two inter-lab (round) trials are presented in which standardized wool and mohair tops were evaluated using this system. Fiber diameter and variability measurements obtained with this instrument were highly correlated with results from standard microprojection and air-flow techniques.

Introduction

The Laser Fibre Fineness Distribution Analyser (FFDA) was developed by Australian researchers in the 1970's (6) and became commercially available in the U.S. in 1983 as the Peyer Texlab FDA 200 System[1] (FDA). The FDA has become a valuable tool in research and industry for rapid and accurate measurements of fiber diameter distribution in wool and mohair. To help facilitate establishment of official test methods (e.g. International Wool Textile Organization [IWTO], American Society for Testing and Materials [ASTM] and International Mohair Association [IMA]), researchers at the Texas Agricultural Experiment Station's Wool and Mohair Research Lab (WMRL) have participated with other labs in inter-lab trials in which wool and mohair were characterized in terms of fiber diameter distribution using standard methods (2, 4 and 5) and the FDA. Results of one of these trials were presented previously (8). Results obtained at the WMRL in two of these round trials are presented in this report.

Experimental Procedures

Since 1985, the WMRL has participated in a continuing inter-lab trial coordinated by Yocom-McColl Testing Laboratories, Inc.[2] For this trial, samples of two different wool tops were sent four times a year to fiber metrology labs (11 ± four labs in each trial) throughout the U.S. Each textile, commercial or university-affiliated lab measured both tops using the standard ASTM technique (2) and reported results to Yocom-McColl. After combining the results from all labs, Yocom-McColl calculated grand means for fiber diameter and distribution of diameter of the tops and reported combined and individual results back to participating labs. In addition to measuring samples using the standard method, the WMRL measured each wool top (28 in all, ranging from 18.7 to 31.7 μm) using the FDA.

In 1989, the WMRL joined three South African labs in a round trial (8) in which wool and mohair tops were characterized. Six of the wool tops used in the trial were calibration samples provided by IWTO and had been fully quantified in terms of fiber diameter parameters using a projection microscope technique (4). In addition, 49 commercial wool tops (ranging in diameter from 17.0 to 39.7 μm) that had been previously measured using an air-flow apparatus (5) were included in the trial. Projection microscope data for the fiber diameter and distribution of 12 mohair tops used in the trial were provided by the South African Division of Processing and Chemical Manufacturing Technology of the CSIR, Textile and Fibre Programme. Results of FDA measurements made on these tops at the WMRL are presented and compared with the standard measurements.

For the two-round trials, the FDA was calibrated using four different methods. For the Yocom-McColl trial, the instrument was originally calibrated in the recommended manner using eight IWTO (air-flow) calibration wool tops. In later tests, the FDA was calibrated automatically using two specific, standard wool tops (T146 and T147) provided by the manufacturer of the FDA. For the South African round trial, the instrument was calibrated using a quadratic/cubic procedure recommended by Turpie and Steenkamp (7) using eight IWTO calibration tops for the wool and 12 IMA calibration tops for the mohair scales.

Measurements of the diameter and coefficient of variation (CV) of diameter obtained using the FDA were compared with standard measurements using simple linear regression analysis and analysis of variance (3).

Results and Discussion

Results of the Yocom-McColl round trials are presented in Tables 1 and 2. Overall, the FDA diameter results were slightly and consistently higher (0.3 μm) than those obtained using the projection microscope technique. This difference was not significant ($P > .01$). Diameter measurements obtained using the two techniques were very highly correlated and measurements obtained using one technique could be converted to reflect the result of using the other technique using the following equation: FDA μm = 1.0047 x ASTM microscope μm + 0.23 ($r = 0.9961$). CV measurements from the FDA were higher (2.6 percent) than those measured on the microscope. This difference was significant ($P < .01$). CV values obtained using the two

1. A product of Siegfried Peyer AG, CH-8832, Wolleran, Switzerland.
2. Yocom-McColl Testing Laboratories, Inc., 540 West Elk Place, Denver, CO. 80216.

Table 1. Fiber diameter measurements of wool tops (Yocom-McColl round trial, ASTM microscope method versus FDA).

Sample number	Microscope diameter (microns)	FDA 200 diameter (microns)	Sample number	Microscope diameter (microns)	FDA 200 diameter (microns)
1	21.6	21.5	15	21.9	21.9
2	27.5	27.2	16	29.3	30.3
3	18.8	19.1	17	21.5	22.4
4	25.8	26.2	18	29.6	29.7
5	19.6	19.9	19	21.6	21.8
6	25.8	26.1	20	27.6	28.3
7	21.2	21.9	21	18.7	19.2
8	28.6	29.2	22	31.5	31.7
9	21.2	22.1	23	21.8	22.6
10	29.2	29.7	24	27.2	27.8
11	20.9	20.9	25	18.9	19.1
12	26.8	27.0	26	31.7	32.0
13	20.8	20.4	27	23.3	23.7
14	27.5	27.2	28	28.7	29.2
			Mean values	24.6	24.9

Table 2. Coefficients of variation of fiber diameter values of wool tops (Yocom-McColl round trial, ASTM microscope methods versus FDA).

Sample number	Microscope CV (percent)	FDA 200 CV (percent)	Sample number	Microscope CV (percent)	FDA 200 CV (percent)
1	21.2	22.8	15	22.0	27.5
2	23.3	26.4	16	26.9	34.6
3	22.6	21.2	17	21.8	27.1
4	24.0	27.3	18	26.9	33.3
5	20.4	21.6	19	21.0	26.4
6	24.1	26.9	20	23.8	30.9
7	22.9	24.5	21	19.7	22.6
8	27.0	29.8	22	26.5	25.2
9	22.5	24.1	23	21.7	22.5
10	27.4	30.7	24	23.3	24.3
11	21.8	24.0	25	19.4	20.5
12	24.0	27.5	26	27.8	28.7
13	23.3	24.4	27	23.3	24.1
14	23.7	27.6	28	24.7	23.7
			Mean values	23.5	26.1

techniques were also significantly correlated but not to the same high degree as diameter measurements. They were related by the equation: FDA CV = 1.1286 x ASTM projection microscope CV - 0.38 ($r = 0.7431$). High variability values produced by the FDA have been reported previously (7) but instrument modifications have been made to eliminate sources of error. Observed elevated FDA values for fiber diameter and CV in this trial are more likely a result of the method used to calibrate the FDA, i.e., with IWTO air-flow calibration tops, since known biases exist between diameters measured using air-flow techniques (1) versus the projection microscope technique described in ASTM Standard Test Method 2130 (2). The necessity of using a regression equation to convert FDA to ASTM microscope results could presumably be eliminated by calibrating the FDA with ASTM calibration tops. (This has been achieved at the WMRL, data not shown.)

Results obtained at the WMRL as part of the South African round trial are presented in Tables 3 to 7. Differences in FDA-measured fiber diameter and CV versus measurements made on wool and mohair using IWTO projection microscope and air-flow techniques were minute and contained no apparent bias. FDA-generated data were highly correlated with IWTO standard measurements (Table 8). It is noteworthy that correlation coeffi-

Table 3. Fiber diameter measurements of wool tops (South African round trial, IWTO microscope method versus FDA).

Sample number	Microscope diameter (microns)	FDA 200 diameter (microns)
1	17.5	17.6
2	19.7	19.5
3	22.7	22.7
4	23.6	24.1
5	25.4	25.6
6	28.6	27.7
7	33.4	33.1
8	36.3	36.1
Mean value	25.9	25.8

Table 4. Coefficient of variation of diameter values of wool tops (South African round trial, IWTO microscope method versus FDA).

Sample number	Microscope CV (percent)	FDA 200 CV (percent)
1	22.0	22.8
3	22.3	21.5
5	24.0	24.0
6	25.9	25.1
7	24.8	24.9
8	26.9	25.8
Mean value	24.3	24.0

cients (r = 0.9352 [wool], 0.9723 [mohair]) obtained for CV correlations are lower than corresponding values obtained for the diameter correlations (r = 0.9982 [wool], 0.9995 [mohair]). It is possible that further refinement of FDA measurement of CV is required. Alternatively, the anomaly may be a direct result of the standard methodology.

Data generated in these and numerous other round trials have confirmed the reliability and accuracy of the FDA for diameter and distribution measurement. This convincing evidence should assist in acceptance of the FDA instrument as an alternative standard method for measuring fiber diameter and its variability.

Table 5. Fiber diameter measurements of wool tops (South African round trial, IWTO air-flow method versus FDA).

Sample number	Air-flow diameter (microns)	FDA 200 diameter (microns)	Sample number	Air-flow diameter (microns)	FDA 200 diameter (microns)
1	19.6	19.9	25	19.8	20.3
2	29.5	28.7	26	21.4	21.7
3	26.5	26.2	27	25.3	25.5
4	22.0	22.1	28	20.1	20.1
5	24.3	24.3	29	22.0	22.1
6	30.0	29.6	30	21.5	21.2
7	21.8	21.9	31	23.4	23.2
8	39.7	39.7	32	18.8	18.9
9	37.2	37.7	33	23.8	23.9
10	39.5	39.3	34	22.8	22.6
11	30.0	30.2	35	20.9	20.8
12	31.1	30.6	36	28.2	28.3
13	30.0	30.3	37	19.6	20.1
14	27.0	27.1	38	18.7	19.0
15	26.6	26.2	39	21.0	21.2
16	20.3	20.2	40	18.4	18.5
17	27.6	27.2	41	19.5	19.7
18	29.7	27.5	42	17.8	17.2
19	28.1	29.1	43	17.0	17.9
20	26.1	26.0	44	27.4	27.6
21	19.0	19.0	45	24.7	24.9
22	21.1	21.0	46	20.4	20.7
23	23.0	22.9	47	24.0	24.1
24	25.1	24.8	48	25.0	24.8
			49	25.5	25.6
			Mean values	24.5	24.5

Table 6. Fiber diameter measurements of mohair tops (South African round trial, IWTO microscope versus FDA).

Sample number	Microscope diameter (microns)	FDA 200 diameter (microns)	Sample number	Microscope diameter (microns)	FDA 200 diameter (microns)
1	23.1	22.8	7	33.8	33.8
2	23.8	23.9	8	34.7	34.9
3	25.5	25.0	9	35.6	36.0
4	27.1	27.1	10	36.9	37.0
5	30.1	30.2	11	38.9	39.1
6	32.2	32.3	12	43.1	43.1
			Mean values	32.1	32.1

Table 7. Coefficient of variation of diameter values for mohair tops (South African round trial, IWTO microscope method versus FDA).

Sample number	Microscope CV (percent)	FDA 200 CV (percent)	Sample number	Microscope CV (percent)	FDA 200 CV (percent)
1	28.1	30.1	7	21.4	22.8
2	29.7	31.1	8	24.2	25.5
3	28.0	29.4	9	21.9	23.5
4	31.3	32.2	10	27.0	28.1
5	24.1	23.3	11	25.8	26.8
6	23.5	23.5	12	27.0	29.0
			Mean values	26.0	27.1

Table 8. Simple linear regression equations and correlation coefficients for fiber diameter and CV relationships.

Sample measured	Regression equation and correlation coefficient
8 IWTO calibration wool tops (Table 3)	FDA μm = 0.9743 x IWTO microscope μm + 0.5648 r = 0.9982
8 IWTO calibration wool tops (Table 4)	FDA CV = 0.7731 x IWTO microscope CV + 5.2182 r = 0.9352
49 commercial IWTO airflow-measured wool tops (Table 5)	FDA μm = 0.9799 x IWTO Airflow μm +0.4759 r = 0.9962
12 IWTO/CSIR calibration mohair tops (Table 6)	FDA μm = 1.0201 x IWTO microscope μm - 0.6125 r = 0.9995
12 IWTO/CSIR calibration mohair tops (Table 7)	FDA CV = 1.0584 x IWTO microscope μm - 0.4094 r = 0.9723

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Effects of Clip Preparation at Shearing on Quality and Value of Mohair

F.A. Pfeiffer, C.J. Lupton, C.A. Taylor, T.D. Brooks and N.E. Blakeman

Summary

A range flock of Angora goats was divided into three groups by age prior to twice-a-year shearing. The groups consisted of 165 kids (6 or 12 months of age), 130 young goats (18 months) and 305 adults (18 months). Subsequently, half the goats from each age group was shorn and the mohair was bagged without any attempt to improve uniformity of the clip (original bag [OB] category). Hair from the other half of each group was sheared, skirted to remove stained fiber and graded into two categories (fine and average) according to diameter. Over a 2-year period (1987-89), each lot of mohair was objectively characterized. Clean mohair fiber present (CMFP) and vegetable matter present (VMP) values were comparable across age groups in the fine, average and OB categories (73.9, 74.6, 73.7 and 1.6, 0.9 and 1.6 percent, respectively). Fiber diameter was shown to be finest in the fine categories (29.8 um average) as compared to 32.1 in OB, 32.8 in average and 34.3 μm in the stained lots. Kemp, med and colored fiber contents were highest in the stain portions (0.5, 1.4 and 1.8 percent, respectively) as compared to 0.1, 0.3 and 0 percent in average, 0.3, 0.5 and 0 percent in fine and 0.4, 0.5 and 0.3 percent in OB hair. Prices received for mohair during the study were erratic within and between seasons and categories. Inability to sell a single season's clip at one time made valid analysis and interpretation of economic data impossible. In this study, selling mohair that had been graded according to fiber diameter did not result in a significant economic advantage compared to selling comparable hair using the conventional original bag method.

Introduction

Traditionally, U.S. mohair has been sold in original bag (OB) form with a minimal amount of fleece grading, either at the ranch or the warehouse. Typically, animals are separated by age prior to shearing. Thus, hair from kids, young goats and adults is removed and bagged separately. Gate-cutting for this purpose may be regarded as a minimal form of clip preparation. The next level of preparation is removal from individual fleeces of all stained fibers. Mohair fleeces differ in most measurable characteristics; fineness, yield, vegetable matter type and content, length, strength, color, etc. When individual fleeces are subdivided according to any or all of these characteristics, the process is called sorting. Sorting is probably the ultimate form of clip preparation since it results in matchings that are scoured and utilized directly by the textile industry.

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

Mohair grading and sorting have been marketing tools in Texas since at least 1940. However, until recently, only a few warehouses have provided this service. A Texas Agricultural Extension Service report (4) estimated the financial return for grading mohair at the warehouse. The same article attempts to identify conditions under which a clip should not be graded due to fleeces containing no fine and/or a high proportion of stained mohair.

For over 16 years, South African producers have sorted and classed their mohair prior to sale. Cape Mohair Classing Standards incorporate 76 separate classes, mohair being differentiated by such variables as animal source (kid, adult, crossbred, etc.), length, style and character, fineness, kemp content, vegetable contamination and stain. Prior to sale by auction at a central location, small lots are consolidated into larger ones, thus dispensing with the disadvantages associated with marketing small lots. These practices, in conjunction with higher clean yields, have resulted in South African mohair prices being consistently higher than those of similar types in the U.S. This has caused numerous U.S. ranchers and warehousemen to pay more attention to mohair preparation. It has been claimed that such practices have resulted in comparatively higher selling prices. Intuitively, these claims seem reasonable. However, because of the short-term volatility of the mohair market, it is difficult to fully substantiate all claims. Furthermore, because of the extra time or manpower requirement of the intensive preparation methods, it is difficult to demonstrate cost-effectiveness even when superior prices are realized.

With this background, a multi-year experiment was designed to study the technical and economic consequences of ranch-preparing mohair at shearing time. This report contains the results from the first 2-1/2 years of this experiment.

Experimental Procedures

Angora goats from the flock at the Texas A&M University Agricultural Research Station were used for this study. Over the 2 1/2-year study period, the flock was composed of male and female kids, female young goats, adult does and a few mature billie goats. The 600 head were maintained either on the range or in dry lots for the 6-month period prior to shearing. At shearing, the goats were separated by age into the four groups previously identified. Alternate shorn fleeces were packaged in original bag form without any attempt to improve quality. The remaining fleeces were table-graded according to fineness within a particular age group. Graders attempted to remove all stained and fecal-contaminated fibers prior to assigning a fleece to either a fine or average category. Only a minimal effort was expended in sorting or subdividing individual fleeces.

Subsequently, mohair representative of each lot was removed by core sampling (2). Lab analyses of the samples were conducted to establish fineness (5), yield and vegetable matter content (1) and medullation (3) in each lot. The mohair was sold by the Sonora Wool and Mohair Company.

Results and Discussion

Average clip size during the period of the study was 3,000 pounds/season. The average weight and proportion of each category are shown in Table 1. Results of CMFP, VMP, average fiber diameter, kemp, med and colored fiber analyses are contained in Table 1. The reported values represent weighted means of four clips. In addition, actual means and weighted means of prices received for the different categories are also summarized in Table 1. Compared to the fine and average graded mohair, OB hair tended to be marginally lower yielding, slightly higher in vegetable contamination, intermediate in fineness and slightly higher in terms of medullation and colored fiber content. The stained portions of the graded fleeces were lower yielding, higher in plant contamination, coarser, more highly medullated and higher in non-scourable, colored fiber content than either the graded or the OB mohair. Clearly, removing stained fiber at shearing and prior to packaging resulted in technically superior product lines. Grading, in the manner described, resulted in two clearly defined fineness categories per age group.

Mohair from this study was sold in a declining (fall, 1987) and sluggish (1988-89) mohair market. It was not possible to sell all the mohair from a particular clip at one time. Thus, valid analysis and interpretation of the economic data were not possible. Nevertheless, conditions under which this mohair was sold were common to other

Table 1. Laboratory analyses and prices received for graded versus original bag mohair (mean values of 4 clips, 1987-89).

Animal class	Mohair grade	Average weight shorn (lb)	Average proportion (%)	CMFP[1] (%)	VMP[2] (%)	Average fiber diam. (um)	Kemp (%)	Med (%)	Colored fibers (%)	Price $/lb	Weighted price rec'd $/lb
Kids											
	Fine	83	35.3	72.3	2.5	24.6	0.4	0.5	0	5.79	
	Average	130	55.3	73.2	1.5	27.8	0.3	0.5	0	5.01	4.92
	Stain	22	9.4	54.9	6.6	29.2	0.5	2.2	0.9	1.06	
	OB	266	100.0	70.9	1.6	26.1	0.7	1.1	0	5.30	5.30
Young goats											
	Fine	57	17.7	73.9	3.5	28.9	0.1	0.4	0	1.60	
	Average	231	72.0	75.1	3.1	30.8	0.1	0.2	0	1.46	1.45
	Stain	33	10.3	68.8	2.7	35.1	0.6	1.4	2.7	1.17	
	OB	293	100.0	74.5	2.3	30.8	0.3	0.5	1.0	1.34	1.34
Adults											
	Fine	235	27.2	74.4	0.8	31.9	0.3	0.5	0	1.78	
	Average	602	69.8	74.6	1.4	34.7	0.1	0.3	0.1	1.52	1.58
	Stain	26	3.0	61.5	4.4	37.5	0.3	0.7	1.3	1.06	
	OB	990	100.0	74.2	1.4	34.1	0.4	0.4	0.2	1.52	1.52
All age groups (adj. by weight)											
	Fine			73.9	1.6	29.8	0.3	0.5	0	2.64	
	Average			74.6	0.9	32.8	0.1	0.3	0	1.98	2.10
	Stain			62.7	4.3	34.3	0.5	1.4	1.8	1.10	
	OB			73.7	1.6	32.1	0.4	0.5	0.3	2.13	2.13

[1]Clean mohair fiber present.
[2]Vegetable matter present.

mohair producers in Texas during this period, so the data are expected to hold some interest.

Prices received for fine and average graded hair were invariably higher than those paid for OB hair. A major exception was in the kid category, where OB kid sold for a higher price than average kid. However, the higher prices paid for graded mohair were offset by the significantly lower prices paid for the stained hair removed from those fleeces. This is accounted for in the last column of Table 1, where weighted prices received for graded hair versus OB are presented. With the exception of kid hair, prices received for graded hair (including the stained portions) were higher ($0.11/pound for young goat and $0.06/pound for adult) than the OB counterparts. However, when the weighted prices received for kid, young goat and adult hair were combined, OB was marginally higher ($0.03/pound) than graded. Thus, the conclusion of this study, conducted during a period when international mohair prices and demand were low, is that clip preparation (removal of stained hair and grading according to fineness) at shearing did not result in an economic advantage compared to packaging and selling comparable hair using the OB method.

This report does not address the questions: how would preparation affect mohair prices when demand is high; what would have been the result of a similar experiment if the grading and sorting had been conducted according to South African standards; what would be the economic effects of removing stain and grading mohair if all U.S. producers used such a system as a marketing tool? Obviously, answers to the broader questions have yet to be found.

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PR 4800

Comparison of Fiber Traits Between Angora, Angora x Spanish, Cashmere x Spanish and Spanish Goats

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Summary

Twelve doe kids (born spring 1989) from each of two breeds, Spanish (S) and Angora (A) and two crossbreeds, Angora x Spanish (A x S) and Cashmere x Spanish (C x S) were combined into one flock and maintained under range conditions close to San Angelo, Texas. Mid-side fiber samples were taken from each animal starting in June, at 1-month intervals for the C x S goats and at 3-month intervals for the other groups. Mean fiber diameter and distribution of diameter were determined for all samples. Additionally, percentage of down and diameter of down were measured for the S and C x S samples. Two C x S goats and three S goats had significant amounts of down in June. By September, all C x S and all but two S goats were producing significant amounts of down. Percentage of down (by number) present in the C x S and S samples peaked in December. All animals were shorn in February 1990. Mean fleece weights were 3.72, 0.90, 0.33 and 0.25 pounds for A, A x S, C x S and S groups, respectively. Clean yield and medullation were determined for the A and the A x S fleeces. Clean yield averaged 74.2 percent for A and 91.5 percent for A x S fleeces. Mean kemp level in the A x S hair was four times that in the A fleeces (1.3 versus 0.3 percent) while med fiber percentages were double in the A x S compared to the A group (1.64 versus 0.85 percent). Average fiber diameter for the A x S group decreased an average of 10.9 um (32.0 to 22.1) between June and February, while fibers from A goats increased an average of 1.1 μm (23.9 to 25.0) in the same time period. For S goats, mean down diameters were 22.9, 15.9, 16.9 and 15.8 μm in June, September, December and February, compared to 20.9, 15.3, 16.5 and 15.8 μm for the C x S animals.

Introduction

Much interest has been generated in the past 2 years in the production of cashmere in the United States (4). A cashmere goat characteristically produces a double-hair coat consisting of coarse, outer guard hairs and fine down. It has long been realized that some Texas meat-goats (so-called Spanish goats) produce a limited amount of down (5). In contrast, Angora goats produce a single-component fleece composed of a distinctly different type of fiber called mohair. This study compares fiber production traits of four types of kid goats; Angora (A), Angora x Spanish (A x S), Cashmere x Spanish (C x S) and Spanish (S) maintained on rangeland.

Experimental Procedure

Doe kids born between March and May 1989 were randomly selected from flocks of the Texas Agricultural Experiment Station, San Angelo, Texas. Twelve doe kids each of Angora, Angora x Spanish, Cashmere x Spanish and Spanish breeding were combined into one flock and maintained under range conditions from June 9, 1989, to February 9, 1990. A salt-limited feed supplement was available during late fall and winter.

Fiber samples were removed from the left mid-side of C x S goats at 1-month intervals in an attempt to identify the onset of down production. Samples from the other three groups were taken at 3-month intervals. All goats were shorn in February 1990 and grease fleece weights were obtained for each animal. Since Angora goats are traditionally shorn twice a year to obtain desirable staple lengths, the A group was also shorn in September 1989 and these fleece weights were added to those obtained in February 1990 to compare total fiber production across groups from birth to February. Prior to shearing, the C x S and S goats were given a visual "cashmere score" from 0 to 5 with 0 = no cashmere and 5 = plentiful cashmere, this score being equivalent to about a 60 percent (by weight) yield of down. After shearing, cashmere yield (percent by weight) was visually estimated for the C x S and S fleeces. Additionally, clean yield (1) and medullation (3) were measured for the A and A x S fleeces. Clean yield was not measured for the C x S and S fleeces because these types of animals produce very little grease in the hair. Other fiber characteristics measured were mean fiber diameter and distribution of diameter (2, 6). In addition, mean down diameter, distribution of down diameter and percentage of down (by number) were obtained for all C x S and S samples (2). Medullated fibers are regarded as a defect in mohair and were measured primarily to compare the quality of hair produced by A versus A x S Animals.

Results and Discussion

Fiber production and quality characteristics for the four groups of goats are summarized in Table 1. Mean grease fleece weights from birth to February 1990 (approximately

10-month production) were 3.72, 0.90, 0.33 and 0.25 pound for the A, A x S, C x S and S does, respectively. On a clean basis, this corresponded to 2.72 pounds mohair and 0.82 pounds cashgora for the A and A x S groups. Down production was 0.083 and 0.036 pound for the C x S and S does, respectively. Thus, crossing native Spanish stock with improved cashmere billies doubled cashmere production at first shearing. The high yielding (91.5 percent) cashgora fleeces were the finest overall (22.1 μm) compared to 25.0 (A), 34.0 (C x S) and 30.8 (S) μm. However, dehaired fleeces produced by C x S goats were slightly finer (15.2 μm) than the down of Spanish does (15.6 um). Medullation in A was lower than in A x S fleeces (0.82 versus 1.64 percent for med fibers and 0.33 versus 1.31 percent for kemp fibers). This experiment reconfirms that crossing Angora and Spanish goats results in an animal capable of producing less weight but finer fibers than Angoras, but A x S fleeces contain relatively high quantities of medullated fibers, a most undesirable characteristic in mohair.

Table 1. Fleece characteristics of Angora, Angora x Spanish, Cashmere x Spanish and Spanish yearling does

Group	A	AXS	CXS	S
Number animals/group	14	9	11	11
Grease fleece weight (pound)	3.72	0.90	0.33	0.25
Lab scoured yield (percent)	74.2	91.5	–	–
Clean fleece weight (pound)	2.76	0.82	–	–
Estimated cashmere yield (by weight, percent)	–	–	25.0	14.5
Estimated cashmere weight (pound)	–	–	0.083	0.036
Average fiber diameter (μm)	25.0	22.1	34.0 (15.2, down)	30.8 (15.6, down)
Std. dev. of diameter (μm)	7.0	7.2	25.3 (3.2, down)	21.4 (3.6, down)
Med fiber (percent)	0.82	1.64	–	–
Kemp fiber (percent)	0.33	1.31	–	–
Cashmere score	–	–	2.30	1.86

Removal and measurement of side samples on a regular basis throughout the growing season facilitated the monitoring of change in mean fiber diameter with time (Figure 1) for all four types of goats. In addition, diameter of down and percent down (number basis) versus time (Figures 2 and 3) were measured for C x S and S goats. Figure 1 clearly shows the seasonal fluctuation in fiber diameters of C x S goats with means decreasing significantly at the onset of down production in July and increasing again after December, as down fibers began to shed (and were later sheared). The A x S and S goats showed a similar but less pronounced trend while the A goats showed a small but steady increase in fiber diameter with time. Figure 2 shows that the average diameter of down fibers on C x S and S goats decreased from 22 to 16 μm from the beginning of the season through September.

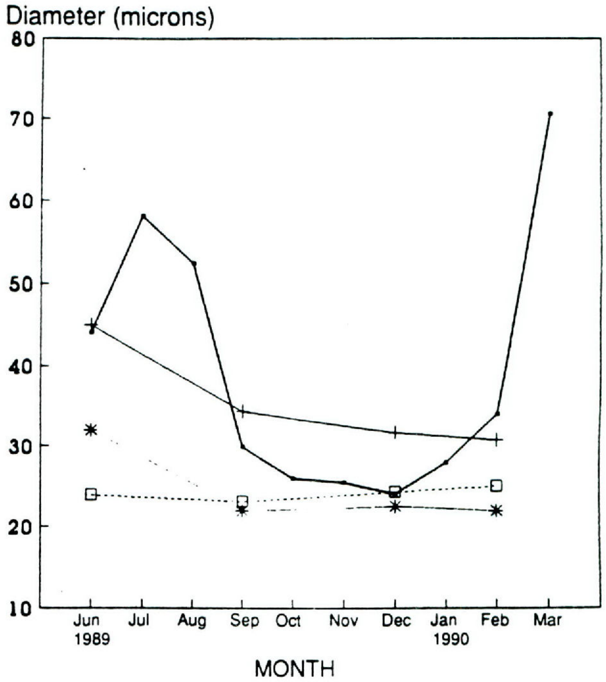

Figure 1. Changes in mean fiber diameter with time for A, A x S, C x S and S goats.

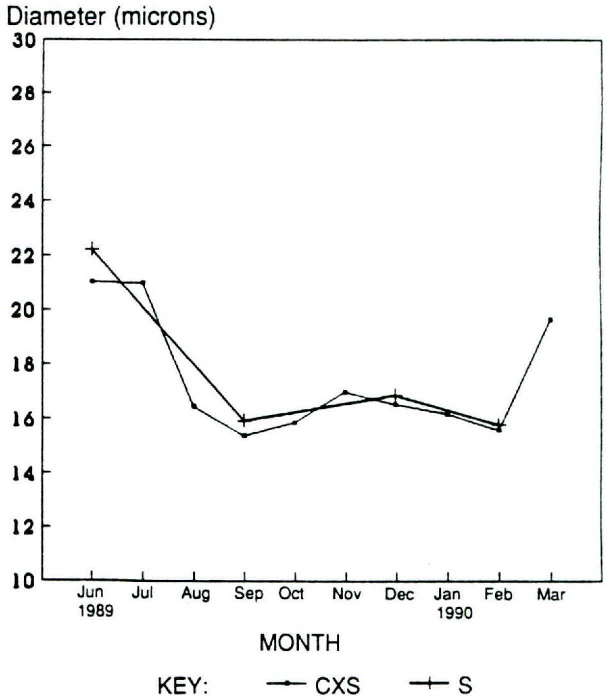

Figure 2. Average fiber diameter of down component versus time for C x S and S goats.

Figure 3 shows that down was detected in C x S and S goats throughout the experimental period. Proportions of down fibers to guard hair were at a maximum in December, indicating that this was probably the optimum time for shearing. Subsequently, the ratio of down to guard hair decreased, indicating some cashmere had been shed. The C x S goats consistently produced hair containing a greater

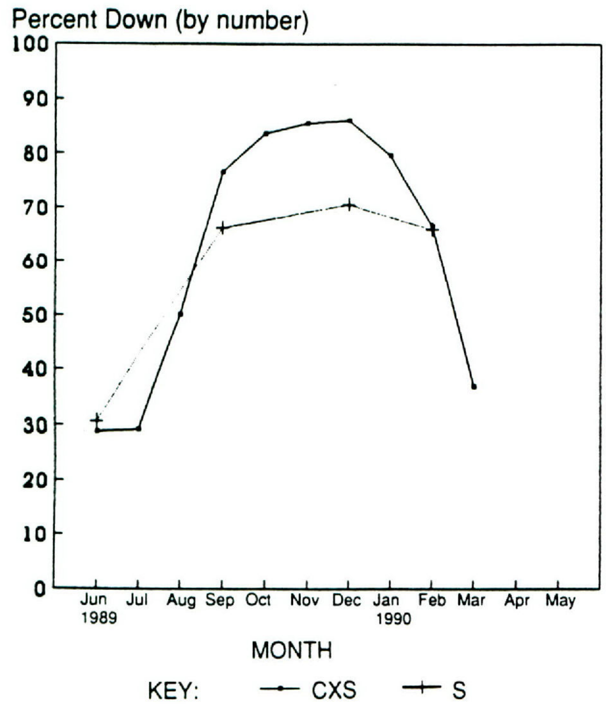

Figure 3. Percentage (by number) of fibers classed as cashmere down versus time for C X S and S goats.

percentage of down fiber than S goats between August and February, this being consistent with the observation that C x S goats produced twice as much cashmere as S goats.

For the S group, high percentages (by number) of down (69, 59 and 49 percent) were detected in three individual animals in June. Similar amounts (52 and 64 percent) were also measured for two C x S goats. This compared with group means for the remaining does of 23 and 21 percent for the C x S and S groups, respectively. Throughout the growing season, these percentages increased even further. The presence of relatively high proportions of down in some individuals throughout the year suggests that it should be possible to select for goats that produce cashmere all the year round.

Due to the high possibility of inclement weather, shearing the C x S and S goats in December in West Texas is not practicable, particularly in the absence of structures in which the goats can be sheltered after being shorn. During this experiment, the observation was made that some cashmere-bearing goats had not begun to shed even in February, while the average onset of shedding was late December. Of course, nutrition and health factors are certainly other considerations, but it appears that onset of shedding may also be genetically controlled. This being the case, the helpful prospect of selecting for later shedding of cashmere also becomes a possibility.

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PR 4801

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

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Three series of experiments were conducted to study the effects of spraying range flocks of adult Angora goats for reduction of plant defect levels in mohair. The first study utilized multiple oils and multiple plant types at three locations in Texas. Oleic acid was identified as the most effective agent tested and was subsequently evaluated at a single level prior to and after plant contamination of Angora goat fleeces. Since significant reductions in defect were not achieved in this second experiment, a third trial was designed to test higher application levels of oleic acid. With the exception of the control groups, animals were sprayed 1 month prior to shearing and returned to the range. One group of animals was sprayed with an aqueous solution (0.14 percent body weight) of a non-ionic detergent (Triton N101[1]). Animals in group two were sprayed with a similar volume of an emulsion containing oleic acid and Triton N101 (0.14 percent each of body weight). Animals in a third group were sprayed with an emulsion composed of oleic acid (0.42 percent body weight) and Triton N101 (0.42 percent body weight). Subsequently, individual fleeces were sampled and tested for clean mohair fiber present (CMFP) and vegetable matter present (VMP). Generally, treatments resulted in small (0 to 2.4 percent) statistically insignificant increases in CMFP. Fleeces from all three locations were contaminated with plant material at low levels (0.87 to 1.32 percent). Any effects on VMP from spraying the goats with non-ionic detergent or oleic acid/detergent emulsions at the levels described were negligible.

Acknowledgment

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[1]Rohm and Haas Co.

PR 4802

Effects of Skirting Technique on the Quality and Value of Wool

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Summary

Seventy-seven registered Rambouillet ewes were assigned to three treatment groups to study the effects of skirting technique on the quality and value of wool from fine-wool sheep. Two fleece skirting techniques were compared with a method of wool packaging in which fleeces were not skirted (original bag, OB procedure). Objective measurements showed that belly wool, tags and sweepings were lower yielding and contained higher proportions of vegetable matter than skirted fleeces and OB wool. Differences in average fiber diameter between skirted wool, skirts and OB wool were negligible. The two methods of skirting resulted in 12.7 to 15.0 percent of wool being removed as skirts in the two shearings. In both years of the study, the average combined prices received for skirts and skirted wools exceeded the prices received for comparable OB wool. Gross returns attributable to skirting ranged from $1.03 to $3.33 / ewe.

Introduction

A review conducted in 1989 (3) concluded that the value of all types of wool clips can be increased by careful preparation. For fine wool, tags and clippings normally comprise between 5 and 10 percent of the whole clip. For skirting to be profitable, the proportion of other skirts should be less than 10 percent. A study (4) initiated in 1987 also indicated that gross return can be increased by skirting fine wool prior to marketing. Conversely, excessive skirting was shown to reduce the value of the clip. To study the effects of fine-wool skirting in different marketing years and under varying environmental conditions, this experiment was extended to include the 1988 and 1989 clips.

Experimental Procedure

A flock of registered, mixed-age, Rambouillet ewes conventionally managed on rangeland at the Texas Range Station in Crockett County was used for this long-term skirting experiment. All ewes were tagged in January prior to lambing in February/March/April and shearing in late April or early May. Belly and some leg wool was removed from one-third of the ewes (Group 1) when tagged. At shearing, the belly wool on these ewes was not reshorn. The remainder of the fleece was shorn from each animal and skirted to remove stained, exceptionally greasy and tag wool. Skirted wool, belly wool, tags and sweepings were packaged separately. Wool from another third of the flock (Group 2) was skirted using a combination of "floor skirting" and "table skirting". In this method, the shearers dropped the leg and belly wool onto the shearing floor so that it could be readily removed and placed into a designated bag while the remainder of the fleece was being sheared. The shorn fleece was subsequently placed flesh-down on a slatted table where all remaining skirts were removed prior to rolling and packaging the skirted fleece. Wool from the third group of sheep (Group 3) was shorn and packaged without removal of any skirts (original bag, OB procedure).

Average fiber diameter (2), yield and vegetable matter present (1) were determined from core samples representing each lot of wool. All wool lots were sold by the Sonora Wool and Mohair Company, thus permitting simple economic comparisons between the two skirting methods and OB procedures.

Results and Discussion

The fleece, fiber and selling price data for the 1988 and 1989 clips are summarized in Tables 1 and 2. Differences in average fiber diameter between skirted wool, skirts and OB wool were negligible, illustrating the high fleece uniformity of this ewe flock. Belly wool, tags and sweepings were consistently lower yielding than skirted and OB wool and contained larger proportions of vegetable material. The differences between OB and skirted wool yields were insignificant, most likely reflecting the limitations of the sampling and/or measuring methods. In 1987, the technique used to skirt fleeces in Group 1 (bellies shorn in January) resulted in 22.6 percent total skirts (4). Recognizing this amount to be excessive, care was taken during 1988 and 1989 to minimize removal of fleece wool when tag and belly wool was being sheared in January. This resulted in 15.0 and 13.7 percent total skirts in 1988 and 1989, respectively, values that were only slightly higher than the Group 2 amounts, 12.7 and 13.1 percent, respectively.

Clips shorn in 1988 and 1989 were produced during years of different environmental conditions. This is

Table 1. 1988 clip-wool and price data.

	Number of sheep	Fiber diameter (μm)	CWFP[1] (%)	VMP[2] (%)	Grease weight (lb)	Fraction of total (%)	Price rec'd ($/lb) and date sold
Group 1	28						
(Bellies and tags shorn 1/29/88, sheared 5/4/88)							
Skirted wool		19.8	60.0	1.1	157.1	85.0	3.09(6/28/88)
Bellies		19.9	50.6	3.4	13.4	7.2	1.235(6/13/88)
Reclips/tags (January)		20.0	54.8	2.7	12.9	7.0	1.10(6/13/88)
Tags/sweepings (May)		20.0	43.0	3.0	1.4	0.8	0.76(6/28/88)
						Weighted average price	2.80
Group 2	26						
(Tagged 1/29/88, sheared 5/4/88)							
Skirted wool		20.0	58.2	1.3	166.9	87.3	2.84(6/28/88)
Bellies		19.9	51.0	2.8	10.9	5.7	1.38(6/28/88)
Reclips/tags (January)		20.0	54.8	2.7	12.0	6.3	1.10(6/13/88)
Tags/sweepings (May)		20.0	43.0	3.0	1.4	0.7	0.76(6/28/88)
						Weighted average price	2.63
Group 3	27						
(Tagged 1/29/88, sheared 5/4/88)							
OB Wool		19.7	59.6	1.2	178.2	92.8	2.60(6/28/88)
Reclips/tags (January)		20.0	54.8	2.7	12.4	6.5	1.10(6/13/88)
Tags/sweepings (May)		20.0	43.0	3.0	1.4	0.7	0.76(6/28/88)
						Weighted average price	2.49

Increased return compared to original bag:
Group 1 $0.31/pound (6.60 pound/sheep) = $2.05/sheep
Group 2 $0.14/pound (7.35 pound/sheep) = $1.03/sheep

[1]Clean wool fiber present
[2]Vegetable matter present

Table 2. 1989 clip-wool and price data.

	Number of sheep	Fiber diameter (μm)	CWFP[1] (%)	VMP[2] (%)	Grease weight (lb)	Fraction of total (%)	Price rec'd ($/lb) and date sold
Group 1	25						
(Bellies and tags shorn 1/27/89, sheared 4/25/89)							
Skirted wool		20.8	57.8	0.6	202	86.3	2.53(10/3/89)[3]
Bellies		20.8	49.7	1.7	13	5.6	1.52(6/23/89)
Reclips/tags (January)		21.4	38.7	1.2	16	6.8	0.80(6/23/89)
Tags/sweepings (April)		20.5	42.0	2.3	3	1.3	0.80(6/23/89)
						Weighted average price	2.33
Group 2	25						
(Tagged 1/27/89, sheared 4/25/89)							
Skirted wool		20.7	58.0	1.0	219	86.9	2.53(10/3/89)[3]
Bellies		20.8	49.7	1.7	15	5.9	1.52(6/23/89)
Reclip/tags (January)		21.4	38.7	1.2	15	6.0	0.80(6/23/89)
Tags/sweepings (April)		20.5	42.0	2.3	3	1.2	0.80(6/23/89)
						Weighted average price	2.35
Group 3	23						
(Tagged 1/27/89, sheared 4/25/89)							
OB Wool		18.9	57.5	1.2	205	90.9	2.15(6/23/89)
Reclips/tags (January)		21.4	38.7	1.2	18	8.0	0.80(6/23/89)
Tags/sweepings (April)		20.5	42.0	2.3	2.5	1.1	0.80(6/23/89)
						Weighted average price	2.02

Increased return compared to original bag:
Group 1 $0.31/pound (9.36 pound/sheep) = $2.90/sheep
Group 2 $0.33/pound (10.08 pound/sheep) = $3.33/sheep

[1]Clean wool fiber present.
[2]Vegetable matter present.
[3]Contracted early in 1989.

reflected in the average grease fleece weights for the 2 years (7.0 and 9.7 pound for 1988 and 1989, respectively) and the slightly coarser fibers produced in 1989. Similarly, wool marketing conditions were substantially different, with record high prices being received in 1988 with somewhat lower prices being received in 1989. Average combined prices received for skirts and skirted wools in June 1988 exceeded the OB price of comparable wool by $0.31 (Group 1) and $0.14 (Group 2) /pound. This was equivalent to an extra return from skirting of $2.05 and $1.03/ewe (Table 1). Despite the lower prices received for the 1989 wool clip, increased returns attributable to skirting (Groups 1 and 2) averaged $0.32/pound which was equivalent to $3.11/ewe (Table 2).

In conclusion, both methods of skirting resulted in about 13.5 percent of the clip being removed as skirts. For both 1988 and 1989 marketing years, the average combined prices received for skirts and skirted wools exceeded the OB price for comparable wool. It is recognized that the quantities of wool generated in this study were small. Every effort was made by the cooperating warehouseman to obtain realistic prices and we believe that lot size did not affect prices received. It is also recognized that a producer would need to consider the extra labor requirement of skirting and grading versus OB packaging when attempting to apply results of this experiment to his specific circumstances. Finally, in order for a producer to reap the economic advantages of selling a skirted product, he should sell his wool through a warehouse with experience and knowledge of marketing this value-added product.

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Evaluation of the Shelf-Life of Lamb Retail Cuts Differing in External Fatness and Fabrication Techniques

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Summary

Twelve lamb carcasses were selected from a commercial packing facility based upon the 12th-rib fat thickness measure and were divided into two fat thickness groups (0.10 and 0.20 inch). Two lambs from each fatness group were fabricated by one of three fabrication styles (carcass, three-way, block-ready). The lamb carcasses were stored for 4 or 18 days, postmortem. At the end of the storage period, one lamb from each treatment group was cut into retail cuts. The cuts were trayed, overwrapped and placed in a retail case for 1, 3 or 5 days. Three evaluators scored the retail cuts for lean color, percentage discoloration, overall acceptability and off-odor. Regardless of treatment group, percent discoloration and off-odor increased ($P < 0.05$) while acceptability decreased ($P < 0.05$) with increased days in the retail case. The deterioration increased at a faster rate in the retail cuts stored for 18 days compared to those stored for 4 days. Retail cuts from lambs with 0.20 inch of external fat at the 12th rib did not differ ($P > 0.05$) in the lean storage/display characteristics when compared to the cuts from the lambs with 0.10 inch of fat.

Introduction

The United States lamb industry has realized that alternate marketing methods for lamb retail cuts are needed to maintain or increase the market share of retail lamb. The lamb packing industry is addressing alternative marketing methods with the use of a "block-ready" program where retail lamb cuts would be merchandised with 0.10 inch of external fat. However, the average fat thickness of lamb carcasses in the U.S. is in excess of 0.25 inch. Therefore, the majority of the carcasses will require extensive trimming before merchandising. The effect of external fatness on the shelf-life on lamb retail cuts is in question. Lamb carcasses with less than 0.10 inch of external fat have been shown to possess shorter shelf-life and greater carcass shrink during storage than fatter lamb carcasses (1, 5). In fact, the USDA Quality Grade Standards for lamb carcasses indicate that carcasses with less than 0.10 inch of external fat are not eligible for the USDA Choice grade (7). However, an increasing percentage of lamb is being shipped as boxed lamb in vacuum packaged containers rather than as carcass lamb. As these changes continue and the industry moves toward tray-ready, brand-identified products, the question of how retail cuts from lamb carcasses with 0.10 inch of external fat perform in the retail case must be addressed. This study was designed to investigate the shelf-life of retail cuts fabricated from lamb carcasses possessing either 0.10 or 0.20 inch of external fat at the 12th rib and with different fabrication styles (carcass, vacuum packaged three-way cuts or vacuum packaged block-ready primals).

Materials and Methods

Twelve lamb carcasses were selected from a commercial slaughter and fabrication plant based upon the 12th-rib fat thickness measure. Six lambs were selected with approximately 0.10 inch of external fat at the 12th rib and six with 0.20 inch. USDA lamb carcass grade data were collected (7). Two carcasses from each fatness group were cut into three sections (leg, middle, shoulder), vacuum packaged and boxed (three-way). Two carcasses from each fatness group were fabricated into block-ready primals (leg, loin, rack and shoulder) vacuum packaged and boxed. The remaining four carcasses (two from each fatness group) were left intact as carcass lamb. All carcasses were transported to the Rosenthal Meat Science and Technology Center at Texas A&M University for storage at 35° F. On days 4 and 18 postmortem, one carcass, three-way and block-ready lamb was fabricated into retail cuts. The retail cuts included, leg roasts (shank and sirloin halves), 0.75 inch thick center cut leg slices and 1.0 inch thick chops from the shoulder, rack and loin. The retail cuts were placed on plastic foam trays and over-wrapped with oxygen permeable film and placed in a refrigerated (35° F) retail case under fluorescent lights for 1, 3 or 5 days.

All retail cuts were evaluated immediately after fabrication (day 0). For each retail cut type, the retail cuts then were assigned randomly to one of three display periods (1, 3 or 5 days) and were subsequently evaluated at the end of each period. Three experienced evaluators scored the retail cuts for lean color (8 = pinkish red; 1 = dark brown or green), percentage discoloration (7 = no discoloration; 1 = total discoloration), overall acceptability (8 = extremely acceptable; 1 = extremely unacceptable) and off-odor intensity (8 = most intense and 1 = least intense).

Data were analyzed using analysis of variance and mean separation analyses were performed using the Student-Newman-Keuls multiple range test (4).

Results and Discussion

Means for the carcass grade traits by fatness group indicated that traits related to changes in carcass fat thickness differed ($P < 0.05$) (Table 1). Kidney and pelvic fat percentages, USDA yield grades and the USDA quality grades were higher for the lambs in the 0.20-inch fatness group.

Table 1. Carcass grade traits by fatness group.

Trait	Fatness group, inch 0.10	0.20
Number	6	6
12th rib fat thickness, inch	0.09^{c}	0.20^{d}
Adjusted fat thickness, inch	0.11^{c}	0.23^{d}
Kidney and pelvic fat, percent	1.36^{c}	3.39^{d}
Leg conformation score[a]	13.6^{c}	12.4^{d}
USDA quality grade[b]	10.2^{c}	10.8^{d}
USDA yield grade	2.0^{c}	3.4^{d}
Hot carcass weight, pounds	55.7^{c}	57.5^{c}

[a]Leg conformation score: 15 = Prime +; 13 = Prime −; 12 = Choice +; 10 = Choice −; 9 = Good +.
[b]USDA Quality Grades: 15 = Prime +; 13 = Prime; 12 = Choice +; 10 = Choice −; 9 = Good +.
[cd]Means in the same row with a common superscript do not differ ($P > 0.05$).

Mean color scores for the 4-day storage period are shown in Table 2. Regardless of fatness group or cutting style, the color scores for the retail cuts tended to decrease with increased days in the display case. Retail cuts from carcass lamb with 0.20 inch had lower ($P < 0.05$) mean color values at all display days as compared to the other treatment groups. With the exception of the retail cuts from the carcass lamb with 0.20 inch, undesirable color scores (> 4) were not reached until the retail cuts were in the retail case for 5 days. At storage day 18, the color scores for the retail cuts again tended to decrease with increased days in the retail case (Table 3). Carcass lambs, regardless of fatness group, possessed lower ($P < 0.05$) initial (0 day) color scores. The retail cuts from the carcass lamb with 0.20 inch had the lowest lean color score after 5 days in the display case. However, cuts from all treatment groups possessed scores below four by the 3rd day in the retail case.

At storage day 4, the percentage discoloration scores indicated an increase ($P < 0.05$) in discoloration across display time for the retail cuts within each treatment group (Table 4). All the retail cuts possessed at least 60 percent discoloration by day 5. Cuts from the carcass lamb with 0.20 inch had a higher ($P < 0.05$) percentage of discoloration than the other treatment groups across all display days. The initial discoloration on the carcass treatment may be the

Table 2. Mean values for lean color scores for each treatment group at storage day 4[a].

Fatness group, inch	Cutting style	Retail display time, days 0	1	3	5	Days in retail case comparison[b]
0.10	Carcass	6.4^{c}	6.1^{c}	4.2^{de}	3.8^{c}	0 1 3 5
	Three-way	5.4^{e}	5.1^{d}	4.9^{c}	3.4^{cd}	0 1 3 5
	Block	5.6^{de}	4.9^{de}	4.0^{ef}	2.9^{d}	0 1 3 5
0.20	Carcass	5.1^{f}	4.6^{f}	3.6^{f}	2.1^{e}	0 1 3 5
	Three-way	5.7^{de}	5.3^{d}	4.8^{c}	3.8^{c}	0 1 3 5
	Block	5.8^{de}	5.1^{d}	4.6^{cd}	3.3^{cd}	0 1 3 5

[a]Lean color: 8 = pinkish red; 5 = red; 1 = dark brown or green.
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cdef]Means within the same column with common superscripts do not differ ($P > 0.05$).

Table 3. Mean values for lean color scores for each treatment group at storage day 18[a].

Fatness group, inch	Cutting style	Retail display time, days 0	1	3	5	Days in retail case comparison[b]
0.10	Carcass	5.0^{e}	4.8^{de}	2.5^{d}	3.0^{c}	0 1 3 5
	Three-way	5.3^{d}	4.8^{de}	3.5^{c}	2.3^{d}	0 1 3 5
	Block	6.1^{c}	5.4^{c}	2.5^{d}	2.4^{d}	0 1 3 5
0.20	Carcass	5.0^{e}	4.6^{e}	2.3^{d}	1.8^{e}	0 1 3 5
	Three-way	5.5^{d}	5.3^{d}	3.5^{c}	2.3^{d}	0 1 3 5
	Block	5.5^{d}	5.0^{e}	2.6^{d}	2.2^{d}	0 1 3 5

[a]Lean color: 8 = pinkish red; 5 = red; 1 = dark brown or green.
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cde]Means within the same column with common superscripts do not differ ($P > 0.05$).

Table 4. Mean values for percentage discoloration scores for each treatment group at storage day 4[a].

Fatness group, inch	Cutting style	Retail display time, days: 0	1	3	5	Days inches retail case comparison[b]
0.10	Carcass	7.0^{c}	6.5^{c}	4.1^{de}	3.2^{cd}	0 1 3 5
	Three-way	6.9^{c}	6.3^{cd}	5.1^{c}	3.0^{cd}	0 1 3 5
	Block	6.9^{c}	5.9^{d}	3.7^{e}	2.5^{d}	0 1 3 5
0.20	Carcass	6.5^{d}	5.5^{e}	3.0^{f}	1.9^{e}	0 1 3 5
	Three-way	7.0^{c}	6.1^{cd}	4.7^{cd}	3.7^{c}	0 1 3 5
	Block	6.9^{c}	6.1^{cd}	4.5^{de}	3.0^{cd}	0 1 3 5

[a]Percentage discoloration: 7 = no discoloration (0 percent); 4 = modest discoloration (40-59 percent); 1 = total discloration (100 percent).
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cdef]Means within the same column with common superscripts do not differ ($P > 0.05$).

result of dehydration of the unprotected carcass. At storage period 18 (Table 5), the retail cuts from the carcass lamb treatment groups had lower day 0 values when compared to the vacuum packaged block-ready lamb. All retail cuts showed a dramatic decrease in discoloration scores (higher percent discoloration) by day 3.

Overall acceptability is a subjective score which provided a measure for examining the retail cuts for a combination of lean color, discoloration percentage and overall appearance. Overall acceptability scores below five are considered unacceptable. At storage day 4 (Table 6), all retail cuts, regardless of treatment group, decreased in acceptability with increased display time with all cuts receiving unacceptable scores by day 5. At storage period 18, the retail cuts from all treatment groups received unacceptable scores by day 3 (Table 7).

Off-odor intensity, at storage period 4 (Table 8), tended to increase with days in the retail case for all treatment groups, particularly for the retail cuts at day 5. At storage period 18 (Table 9), there was a significant increase in off-odor intensity between days 1 and 3 for all treatment groups. However, cuts from lambs that had 0.20 inch of external fat were assigned lower off-odor intensity scores, except for the cuts from the three-way, 0.20-inch treatment group. The lower carcass off-odor scores correspond with findings from other studies which indicated that retail cuts

Table 5. Mean values for percentage discoloration scores for each treatment group at storage day 18[a].

Fatness group, inch	Cutting style	Retail display time, days: 0	1	3	5	Days in retail case comparison[b]
0.10	Carcass	6.4^{e}	5.8^{d}	2.3^{d}	2.0^{c}	0 1 3 5
	Three-way	6.6^{de}	6.0^{d}	3.4^{c}	1.5^{c}	0 1 3 5
	Block	6.8^{c}	6.2^{cd}	2.4^{d}	1.5^{c}	0 1 3 5
0.20	Carcass	6.5^{e}	5.9^{d}	2.0^{d}	1.6^{c}	0 1 3 5
	Three-way	6.7^{cd}	6.3^{c}	3.3^{c}	1.5^{c}	0 1 3 5
	Block	6.7^{cd}	6.4^{c}	2.2^{d}	1.5^{c}	0 1 3 5

[a]Percentage discoloration: 7 = no discoloration (0 percent); 4 = modest discoloration (40-59 percent); l = total discoloration (100 percent).
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cde]Means within the same column with common superscripts do not differ ($P > 0.05$).

Table 6. Mean values for overall acceptability scores for each treatment group at storage day 4[a].

Fatness group, inch	Cutting style	Retail Display Time, days: 0	1	3	5	Days in retail case comparison[b]
0.10	Carcass	7.5^{c}	6.8^{c}	4.6^{de}	3.1^{c}	0 1 3 5
	Three-way	7.1^{d}	6.4^{d}	5.4^{c}	3.2^{c}	0 1 3 5
	Block	7.1^{d}	6.2^{d}	4.3^{e}	3.0^{c}	0 1 3 5
0.20	Carcass	6.6^{e}	5.9^{e}	3.6^{f}	2.0^{d}	0 1 3 5
	Three-way	7.1^{d}	6.5^{d}	5.1^{cd}	4.0^{c}	0 1 3 5
	Block	7.3^{d}	6.4^{d}	4.8^{cde}	3.5^{c}	0 1 3 5

[a]Overall acceptability: 8 = extremely acceptable; 5 = slightly acceptable; 1 = extremely unacceptable.
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cdef]Means within the same column with common superscripts do not differ ($P > 0.05$).

from carcass lambs tended to have lower off-odor scores and less spoilage bacteria than those retail cuts from vacuum packaged lamb (2, 3, 6).

In general, with increased days in the retail case, retail cuts from all treatment groups tended to have lower color scores, a higher percentage of discoloration and increased occurrence of off-odor. This usually occurred at a faster rate in storage period 18 than in period 4. Retail cuts from carcass lamb with 0.20 inch rather than 0.10 inch tended to have more adverse characteristics.

Table 7. Mean values for overall acceptability scores for each treatment group at storage day 18[a].

Fatness group, inch	Cutting style	Retail display time, days				Days in retail case comparison[b]
		0	1	3	5	
0.10	Carcass	6.7^{e}	6.0^{d}	2.2^{d}	2.0^{c}	0 1 3 5
	Three-way	6.8^{e}	6.2^{d}	3.3^{c}	1.7^{c}	0 1 3 5
	Block	7.3^{c}	6.6^{c}	2.2^{d}	1.8^{c}	0 1 3 5
0.20	Carcass	6.7^{e}	6.1^{d}	2.2^{d}	1.5^{c}	0 1 3 5
	Three-way	7.0^{d}	6.5^{c}	3.0^{c}	1.7^{c}	0 1 3 5
	Block	7.0^{d}	6.6^{c}	2.4^{d}	1.7^{c}	0 1 3 5

[a]Overall acceptability: 8 = extremely acceptable; 5 = slightly acceptable; 1 = extremely unacceptable.
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cde]Means within the same column with common superscripts do not differ ($P > 0.05$).

Table 8. Mean values for off-odor scores for each treatment group at storage day 4[a].

Fatness group, inch	Cutting style	Retail display time, days				Days in retail case comparisonb
		0	1	3	5	
0.10	Carcass	1.0^{c}	1.0^{c}	2.5^{c}	4.1^{c}	0 1 3 5
	Three-way	1.0^{c}	1.1^{c}	1.8^{de}	4.2^{c}	0 1 3 5
	Block	1.0^{c}	1.0^{c}	2.3^{cd}	4.2^{c}	0 1 3 5
0.20	Carcass	1.0^{c}	1.1^{c}	1.4^{e}	2.8^{c}	0 1 3 5
	Three-way	1.0^{c}	1.1^{c}	1.7^{e}	3.3^{c}	0 1 3 5
	Block	1.0^{c}	1.1^{c}	1.3^{e}	3.6^{c}	0 1 3 5

[a]Off-odor intensity: 8 = most intense; 1 = least intense.
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cde]Means within the same column with common superscripts do not differ ($P > 0.05$).

Table 9. Mean values for off-odor scores for each treatment group at storage day 18[a].

Fatness group, inch	Cutting style	Retail display time, days				Days in retail case comparison[b]
		0	1	3	5	
0.10	Carcass	1.0^{c}	1.6^{c}	5.9^{c}	7.2^{c}	0 1 3 5
	Three-way	1.1^{c}	1.5^{c}	5.6^{c}	7.8^{c}	0 1 3 5
	Block	1.1^{c}	1.5^{c}	6.4^{c}	7.6^{c}	0 1 3 5
0.20	Carcass	1.0^{c}	1.4^{c}	3.4^{e}	7.1^{c}	0 1 3 5
	Three-way	1.0^{c}	1.1^{c}	4.3^{de}	7.6^{c}	0 1 3 5
	Block	1.0^{c}	1.3^{c}	5.2^{cd}	7.7^{c}	0 1 3 5

[a]Off-odor intensity: 8 = most intense; 1 = least intense.
[b]Retail display days underscored by a common line do not differ ($P > 0.05$).
[cde]Means within the same column with common superscripts do not differ ($P > 0.05$).

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PR 4804

A National Market Basket Survey for Lamb

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Summary

Lamb retail cases in six cities across the United States were surveyed. Information gathered included fat thickness measurements, numbers and weights of packages, boneless versus bone-in cuts and other pertinent data. Randomly selected retail cuts (n = 274) were transported to Texas A&M University. Cuts were dissected into knife-separable components and the lean portion was analyzed for chemical fat. Just under 9 percent of all cuts were boneless and almost 6 percent had no external fat. Average fat thickness for retail cuts was 0.14 inch. Average percentage separable lean was 55.64 percent, separable fat was 16.51 percent and bone and connective tissue was 27.67 percent. Of the separable fat, 42.83 percent was external fat, 53.00 percent was seam fat and 4.15 percent was body cavity fat. The average percentage chemical fat (lean tissue only) was 6.05 percent and the average percentage fat in ground lamb was 19.8 percent.

Introduction

The lamb industry is facing changes that are long overdue. Attempts have been made to market live lambs and lamb carcasses based on cutability rather than dressing percentage for more than 20 years. However, most early attempts to do so have met considerable roadblocks. Carpenter (3) concluded that high dressing percentage often corresponded to excess fat and should not be used as an estimator of carcass desirability. Numerous researchers, including Carpenter (3), Smith et al. (7), Smith and Carpenter (8) and Johnson (6) found that lamb carcass fatness had the most influence on yields of retail product. Recently, all segments of the lamb industry have come together with discussions focused on the need to improve cutability. In 1987, the lamb industry conducted a cutability survey (9); the survey found that the average lamb in the United States was quite fat (approaching a yield grade 4). More than 39 percent of the lamb carcasses surveyed were yield grade 4 or 5 (6). When compared to similar surveys conducted in 1968 (4) and 1971 (5), it becomes obvious that lamb carcasses have become much fatter over the last 20 years. Yield grade 4 and 5 lamb carcasses made up only 21.3 percent and 19.8 percent of the population in 1968 and 1971, respectively. It has been believed that this fatness may be carried through to the retail case. However, no information was available to establish how fat lamb is as it is presented to the consumer. Breidenstein and Carpenter (2) found that consumers prefer red meat products with less fat. By obtaining lamb products from across the United States, the lamb industry could avail itself of the opportunity to obtain as much information as possible about lamb products being marketed today. Information obtained in this survey will allow the lamb industry to establish a benchmark for the composition and palatability of lamb retail cuts. This information will complement the industry-led attempts to market lean lambs and lamb products.

Experimental Procedure

The study was conducted during May and June 1989 in six U.S. cities – Houston, Texas; Miami, Florida; Denver, Colorado; Los Angeles, California; Boston, Massachusetts and New York, New York. These cities were selected to allow sampling in various geographic regions of the United States and to represent some of the largest Standard Metropolitan Statistical Areas based on both population and grocery store sales (SN Distribution Study of Grocery Store Sales, 1987, Fairchild Publications, New York). In addition, these cities are large distribution points for lamb. Two to three retail chains per city were selected to represent at least one-third of the total volume of supermarket sales in that city.

Two stores per chain were chosen for sampling so that a total of four to six supermarkets per metropolitan area were reviewed. Supermarkets were selected at random within the metropolitan area. The corporate offices of each retailer were contacted to ensure full cooperation.

Within the lamb portion of the retail case, a representative sample of all chops, steaks, roasts and other appropriate cuts were measured by ruler to determine the average external fat thickness of each. Each cut had at least three fat measurements taken to compute the average. A total of 623 retail cuts were measured during the survey. Retail cuts that had no external fat were recorded as such. Data were recorded on retail cut weight, number of packages, brand name, packaging style and materials, price per pound and price per package.

After measuring each retail cut, two cuts each of various styles were selected randomly for purchase and shipped to Texas A&M University for dissection and chemical studies.

Cuts (n=274) received at Texas A&M University were subjected to knife dissection to determine the percentage subcutaneous (external) fat, intermuscular (seam) fat, perinephric (body cavity) fat, lean, bone (if present) and connective tissue. The separable lean portion and ground lamb we

re extracted with ether to determine the chemical fat content (1). The dissection and chemical analyses data were used to determine the fatness of lamb retail cuts in each city and overall.

Results and Discussion

General findings. Aside from occasional vacuum-packaged wholesale cuts, retail cuts were merchandised in traditional oxygen-permeable-film over-wrapped trays. While most retailers packaged retail lamb cuts in traditional white foam trays, some packaged retail cuts in colored (pink or blue) foam trays while others used clear plastic trays. All retailers surveyed used primarily U.S. Choice lamb; however, a small percentage also offered imported, vacuum-packaged subprimals (leg, loin or shoulder). The percentage distribution, by weight, of bone-in and boneless retail cuts (Table 1) indicated that just under 9 percent of all retail cuts nationwide were merchandised as boneless cuts. The high was in Denver (29 percent) and the low was in Miami (4 percent). The high percentage of boneless cuts in Denver was due, in part, to a high frequency of boneless legs (heavier cuts) that contributed a large percentage of total case weight. Table 2 indicates the percentage distribution of retail packages marketed with and without external fat. Less than 6 percent of the retail cuts surveyed were displayed without external fat. Retailers in Houston offered the highest percentage (12.3 percent) of cuts without external fat; whereas, in Boston, all of the cuts surveyed had some amount of external fat present.

Table 1. Percentage, by weight, of bone-in and boneless retail cuts.

City	Percentage retail cuts (excluding ground lamb).	
	with bone	without bone
	percent	
Houston	99	1
Miami	100	0
Denver	76	24
Los Angeles	94	6
Boston	83	17
New York	94	6
Average	**91.2**	**8.8**

Table 2. Percentage distribution of retail packages with and without external fat.

City	Percentage retail cuts	
	With external fat	Without external fat
	percent	
Houston	87.7	12.3
Miami	93.7	6.3
Denver	92.8	7.2
Los Angeles	98.1	1.9
Boston	100.0	0.0
New York	94.4	5.6
Average	94.4	5.6

The distribution of retail cuts purchased for dissection and chemical analyses is given in Table 3. The number of cuts purchased in each city was a direct reflection of the total number of retail cuts available in that city. There was a total of 274 retail cuts purchased for shipment to Texas A&M University for subsequent dissection and chemical analysis.

Fat thickness measurement information. The fat thickness of retail cuts from specific primals stratified by primal cut origin and city are reported in Table 4. The retail cuts from the loin had the greatest average fat thickness (0.20 inch) and those cuts from the leg and rack had the lowest average fat thickness. The overall weighted average fat thickness for retail cuts from the four major primals was 0.15 inch. Between cities, those cuts from Houston had the smallest average external fat thickness (0.11 inch). Table 5 shows the weighted average external fat thickness for all retail cuts stratified by city. The overall weighted average external fat thickness was 0.14 inch. Those cuts from Houston, again, had the lowest average external fat thickness (0.10 inch) and those from Miami had the highest average external fat thickness (0.19 inch). The trimmest retail cuts externally (<0.10 inch) were neck slices, leg steaks and shanks. The fattest cuts externally (>0.17 inch) were all cuts from the loin, blade chops, square-cut shoulder roasts and shoulder combination packages (composed of blade chops, arm chops and neck slices).

Dissection data. The percentages of separable lean, fat, bone and connective tissue are presented in Table 6. The overall weighted average for total fat was 16.51 percent and slightly over half (55.64 percent) of each retail cut was separable lean. Of the separable fat component, seam fat was the most predominant fat depot. Table 7 indicates the distribution of total separable fat as external, seam or body cavity for retail cuts grouped as to their primal cut origin.

Table 3. Number of individual retail packages purchased for dissection and chemical analysis in each city.

	City						
Cut Name	**Houston**	**Miami**	**Denver**	**Los Angeles**	**Boston**	**New York**	**Total**
Shoulder							
Blade chops	4	6	6		6	11	**33**
Arm chops		5	6	6	2	8	**27**
Neck slices			3		2	1	**6**
Shoulder chops	4		3	8	2		**17**
Square cut roast	1					1	**2**
Shoulder combo					2		**2**
Loin							
Loin chops	6	6	6	8	6	8	**40**
Double chops			2				**2**
Whole loin	2		2				**4**
Rack							
Rib roast			2				**2**
Rib chops	6	4	3	5	7	8	**33**
Leg							
Whole leg	3	1	1	1	1	2	**9**
Shank half		1	1	2	3	4	**11**
Sirloin chop	4			8			**12**
Sirloin half		2	3	4	2	2	**13**
Leg steak			3	2			**5**
Misc.							
Breast	4		2		1	2	**9**
Shank	4	2	2	4	4	4	**20**
Stew meat	2	1	3	6	1	5	**18**
Denver ribs			4				**4**
Riblets				2		1	**3**
Kabobs				2			**2**
Total	**40**	**28**	**52**	**58**	**39**	**57**	**274**

Table 4. Average fat thickness, in inches, for retail cuts from the primals stratified according to primal cut origin.

	Primal cut origin of retail cut				
City	**Leg**	**Loin**	**Rack**	**Shoulder**	**Weighted average**[a]
			inches		
Houston	0.12	0.12	0.09	0.11	0.11
Miami	0.15	0.25	0.13	0.20	0.18
Denver	0.10	0.23	0.12	0.12	0.13
Los Angeles	0.11	0.16	0.13	0.12	0.12
Boston	0.16	0.22	0.13	0.17	0.16
New York	0.15	0.17	0.14	0.16	0.16
Average	0.13	0.20	0.12	0.15	0.15

[a]Average weighted by proportion of total case weight accounted for by retail cuts from each primal.

separable fat was in the form of seam fat. This could imply that excessively fat lamb carcasses are being fabricated and the excess external fat is trimmed, leaving the large deposits of seam fat in the cuts. In the loin cuts, the external fat was the major fat component, much as would be expected because the loin retail cuts are comprised essentially of only two major muscles, thus precluding large deposits of seam fat. In the leg cuts, there was only a slightly higher proportion of external than seam fat. The leg also was the only primal cut in which body cavity fat (primarily pelvic fat) made up a substantial part (6.7 percent) of the total fat.

Chemical fat data. The percentages of chemical fat (lean tissue only) stratified by retail cut (excluding ground lamb) and city are reported in Table 8. There tended to be a large amount of variability between cities for some retail cuts (e.g. leg, shank half); however, the overall averages for all but one of the cities were very similar. The weighted average percentage chemical fat for lamb retail cuts from Los Angeles was much lower than for those from any other city, partially due to the predominance of leg cuts in Los Angeles compared to the other cities. The overall weighted average for percentage chemical fat was 6.05 percent.

The chemical composition of retail ground lamb by city is presented in Table 9. The overall average percentage fat was 19.8 percent with very little variation between cities; however, there was no ground lamb present in any of the supermarkets surveyed in Los Angeles.

Conclusions. Lamb retail cuts as they were presented to the consumer did not have excessive amounts of external fat; however, there was still excessive seam fat in many retail cuts. Because the average lamb carcass today is approaching a yield grade 4, this would indicate that extensive trimming of fat is occurring before presentation at the retail level. Therefore, the lamb industry must continue to strive toward producing and marketing leaner lambs and lamb products if lamb is to keep pace with other protein sources in today's very health conscious society.

Table 5. Average external fat thickness, in inches, for all retail cuts stratified by city.

	City						
Cut Name	Houston	Miami	Denver	Los Angeles	Boston	New York	Wtd Average[a]
	inches						
Shoulder							
Blade chops	0.08	0.21	0.19		0.20	0.17	**0.18**
Arm chops	0.11	0.18	0.13	0.11	0.20	0.15	**0.14**
Neck slices			0.15			0.02	**0.04**
Shoulder chops	0.11		0.00	0.12	0.11		**0.11**
Square cut roast	0.15					0.28	**0.22**
Shoulder combo					0.18		**0.18**
Shoulder roll				0.13			**0.13**
Loin							
Loin chops	0.08	0.25	0.23	0.16	0.22	0.17	**0.18**
Double chops			0.22				**0.22**
Whole loin	0.15		0.23				**0.19**
Rack							
Rib roast			0.08	0.15			**0.11**
Rib chops	0.09	0.13	0.16	0.10	0.13	0.14	**0.12**
Crown roast				0.15			**0.15**
Leg							
Whole leg	0.14	0.16	0.13	0.12	0.20	0.19	**0.16**
Shank half	0.10	0.12	0.10	0.12	0.12	0.14	**0.12**
Sirloin chops				0.13			**0.12**
Sirloin half		0.18	0.10	0.13	0.17	0.14	**0.15**
Leg Steak			0.09	0.06		0.13	**0.08**
Misc.							
Breast			0.23	0.18		0.13	**0.15**
Shank		0.10	0.06		0.16	0.04	**0.07**
HQ combo[b]	0.12						**0.12**
FQ combo[c]	0.13						**0.13**
Weighted average[a]	**0.10**	**0.19**	**0.15**	**0.12**	**0.16**	**0.12**	
National average	**0.14**						

[a]Average weighted by number of retail packages present for each cut.
[b]Hindquarter combination.
[c]Forequarter combination.

Table 6. Separable lean, fat, bone and connective tissue (combined retail cuts) as a percentage of total case weight.

		Percentage separable fat				
City	Separable Lean	Ext.[a]	Seam	Body Cavity	Total[b]	BCT[c]
	percent					
Houston	54.46	3.26	11.37	0.00	14.63	30.91
Miami	52.84	5.47	13.38	0.00	18.85	28.30
Denver	54.94	7.10	12.03	0.02	19.15	25.91
Los Angeles	61.80	5.14	8.22	0.15	13.51	24.64
Boston	53.16	6.05	10.19	0.24	16.48	29.23
New York	53.94	6.33	10.95	0.16	17.44	28.62
Average	**55.64**	**5.65**	**10.76**	**0.10**	**16.51**	**27.67**

[a]External fat.
[b]Total separable fat is the combined percentages of external, seam and body cavity fat.
[c]Bone and connective tissue.

Table 7. Percentage of total separable fat as external, seam and body cavity from retail cuts grouped as to their primal cut origin.

	Total separable fat from retail cuts		
Primal origin	External fat	Seam fat	Body cavity fat
	percent		
Leg	48.0	45.3	6.7
Loin	71.0	27.1	1.9
Rack	30.2	68.2	1.6
Shoulder	30.1	68.3	1.6
Weighted average[a]	**42.83**	**53.00**	**4.15**

[a]Average weighted by proportion of total case weight accounted for by retail cuts from each primal.

Table 8. Total percent chemical fat (lean tissue only) stratified by retail cut and city.

Cut name	City: Houston	Miami	Denver	Los Angeles	Boston	New York	Weighted Average[a]
	percent						
Shoulder							
Blade chops	7.27	9.16	8.04		8.05	7.81	**8.24**
Arm chops	4.02	7.97	4.85	4.66	6.66	5.12	**5.67**
Neck slices			6.39		7.42	5.11	**5.93**
Shoulder chops	7.24		9.78	7.20	5.53		**7.13**
Square cut roast	8.43					6.84	**7.39**
Shoulder combo					6.42		**6.42**
Loin							
Loin chops	4.54	7.09	5.87	5.49	4.62	4.76	**5.87**
Double chops			6.98				**6.98**
Whole loin	5.78		7.32				**6.55**
Rack							
Rib roast			8.52				**8.52**
Rib chops	7.96	8.29	6.54	6.10	6.64	6.98	**7.21**
Leg							
Whole leg	4.21	4.96	4.33	3.77	5.72	4.85	**4.56**
Shank half		6.31	4.86	3.96	3.30	4.06	**4.27**
Sirloin chop	4.07			3.98			**4.00**
Sirloin half		3.52	5.12	3.84	4.28	4.79	**4.34**
Leg steak			4.58	3.87			**4.30**
Misc.							
Breast	10.57		8.60		10.96	10.14	**9.91**
Shank	3.40	3.00	1.96	1.48	3.60	5.32	**3.83**
Stew meat	6.88	5.59	5.83	5.96		5.69	**5.86**
Denver ribs			11.25				**11.25**
Riblets				11.87		6.35	**10.95**
Kabobs				3.71			**3.71**
Weighted average[a]	**5.94**	**6.26**	**5.92**	**5.05**	**5.55**	**5.85**	
National average	**6.05**						

[a]Average weighted by proportion of total case weight accounted for by each retail cut.

Table 9. Fat content of retail ground lamb by city.

City	Number in case	Percentage fat
Houston	22	21.0
Miami	12	18.7
Denver	13	22.3
Los Angeles	0	
Boston	1	17.0
New York	9	20.2
Average	**9.5**	**19.8**

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Evaluation of the Hennessy Grading Probe to Predict Yields of Lamb Carcasses Fabricated to Multiple Endpoints

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Summary

Lamb carcasses (N = 278) were selected immediately after slaughter and fat thickness was measured with the SP2 Hennessy grading probe (HP) at the interface of the 12th and 13th ribs, 1.5 inches from the backbone. Following a 24-hour chilling period, carcasses were graded by a USDA grader and probed to obtain a second fat thickness measure. All carcasses were fabricated into either wholesale cuts (0.25-inch fat trim) or into tray-ready retail cuts (0.10-inch fat trim). All external fat measures of carcass fatness collected with the HP or by the grader as well as kidney and pelvic fat percentage were highly correlated to cutting yield for both fabrication methods. Regression models developed to predict wholesale cut yields utilizing HP or grader measures were similar with respect to predictive accuracy, but fat thickness explained the majority of the variation in yield among the variables collected by the grader. Equations developed utilizing HP or USDA grader carcass measures to predict tray-ready retail cuts were similar in predictive accuracy. Kidney and pelvic fat explained a large percentage of the variation in yield among the carcasses and must be included in equations to maximize predictive accuracy.

Introduction

The sheep industry in the United States must make changes in the composition of lambs. The 1988 survey describing lamb carcass cutability traits (8) revealed that U. S. lamb carcasses are excessively fat. The average fat thickness was 0.29 inches and the average yield grade 3.9. Results of the Lamb Market Basket Survey (3) showed that lamb retail cuts are marketed with 0.14 inches of external fat on retail cuts. This reduction of fat in the retail case results only if fat is trimmed off the subprimals or retail cuts before display. Fatness of lambs must be reduced if the lamb industry is to make advances in marketing lean lamb via a lean lamb certification program or by promotion of lambs with acceptable yield grades.

The move toward leanness must start with the development of an accurate method that can be used to identify lean carcasses. The USDA yield grading system is available to the packing industry; however, few packers utilize it. Also, there is no price reporting system utilizing yield grades. The recent development and implementation of the Lean Lamb Certification Program is a positive move to identify those lamb carcasses that will fit into a progressive marketing program where there is emphasis on fat reduction. The Certification Program and sorting based on cutability would be enhanced by the use of a grading probe to objectively measure carcass fatness at chain speeds of current production systems.

The objectives of this study were to investigate the use of the Hennessy grading probe to identify lean lamb carcasses and to determine the relationships between various carcass measurements taken with the Hennessy grading probe and the composition of lamb carcasses when fabricated to wholesale and retail-ready endpoints. Regression equations were developed to predict yields of carcasses fabricated to wholesale and tray-ready endpoints from measures collected by a USDA grader and the Hennessy grading probe (HP).

Experimental Procedure

Lamb carcasses (N = 278) were selected randomly on the slaughter floor. Lambs were probed with the HP at a point between the 12th and 13th ribs that was perpendicular to the exterior surface of the carcass to determine fat thickness. Probed carcasses were tagged, weighed and chilled following normal procedures. After 24 hours, USDA quality and yield grade factors (9) were collected by USDA personnel. Each carcass was probed with the HP to obtain a fat thickness measurement at a point between 12th and 13th ribs on the chilled carcasses.

One hundred sixty-five of the carcasses were selected and fabricated into wholesale cuts (double legs, loins, racks and shoulders) and trimmed to an external fat thickness of 0.25 inch. Weights were collected on each of the individual wholesale cuts. The remaining 113 carcasses were fabricated into a boxed tray-ready retail endpoint with a maximum fat thickness of 0.10 inch on the exterior surface utilizing procedures described below:

- Legs were fabricated into short-cut, shank-off legs with the aitch bone removed.
- Sirloins were removed from the loin between the last two lumbar vertebra and 0.50 inch anterior to the lobe of the aitch bone on the leg.
- Sirloins were deboned and sliced into chops and trimmed.
- Loins were fabricated into chops after kidney and pelvic fat and loin tails in excess of 1.0 inch were removed.
- Racks were separated from loins between the 12th and 13th ribs and from the shoulder between the 4th and 5th ribs.
- The rib-ends (riblets) were removed in excess of 2.0 inches from the longissimus muscle.
- Racks were frenched and sliced into chops after trimming.
- Shoulders were sliced into arm and blade chops and trimmed.
- The thin cuts which include the loin and rib tails, breasts, shanks and neck were separated into lean trim.
- Weights were recorded on each of the cuts described.

Data Analysis

Because of the different cutting styles employed, data were analyzed by each fabrication endpoint. Means, standard deviations, correlation coefficients and multiple regression equations, including the statistics, R^2, mean squared error and C(p) (5) were calculated using SAS (6). The best subsets of independent variables to predict each carcass endpoint were identified and subsequent regression analyses were performed.

Results and Discussion

Carcass Characteristics

Carcasses fabricated into wholesale cuts were fatter than those fabricated into tray-ready cuts, which was evidenced by greater adjusted fat thickness, a higher percentage of kidney and pelvic fat and a higher USDA Yield Grade (Tables 1 and 2). This was due to the selection procedure incorporated by the packing plant. At the time of the study, heavier and fatter lambs were being fabricated into wholesale cuts, while leaner and lighter lambs were fabricated into tray-ready retail cuts. These data indicate that measures of carcass fatness on unchilled carcasses utilizing the HP underestimated the actual fat thickness taken with a metal ruler. When carcasses were measured cold, the HP produced a mean fat thickness that was greater than the actual thickness measured with a metal ruler.

Table 1. Mean values of carcass measures from carcasses fabricated into wholesale cuts and trimmed to 0.25 inch of fat.

Carcass measure	N	Mean	Std Dev.	Min.	Max.
Fat thickness, inches	165	0.28	0.10	0.07	0.51
Adj. fat thickness, inches	165	0.30	0.10	0.10	0.60
Leg conformation score	165	12.29	0.81	11.00	14.00
Kidney and pelvic fat, percent	165	4.22	1.79	1.00	9.00
Carcass weight, pounds	165	74.62	8.86	52.80	99.19
HP-hot rib, inches	165	0.21	0.08	0.05	0.33
HP-cold rib, inches	164	0.31	0.12	0.04	0.60
Wholesale cut yield, percent	165	71.82	2.51	61.24	85.52
USDA yield grade	165	4.12	1.07	2.15	6.67

Table 2. Mean values of carcass measures from carcasses fabricated into tray-ready cuts and trimmed to 0.10 inch of fat.

Carcass measure	N	Mean	Std Dev.	Min.	Max.
Fat thickness, inches	113	0.21	0.07	0.07	0.41
Adj. fat thickness, inches	113	0.22	0.07	0.07	0.45
Leg conformation score	113	11.93	0.84	10.00	14.00
Kidney and pelvic fat, percent	113	3.21	1.35	1.00	8.00
Carcass weight, pounds	113	63.11	4.62	52.11	79.68
HP-hot rib, inches	113	0.16	0.07	0.05	0.33
HP-cold rib, inches	113	0.23	0.10	0.04	0.60
Tray-ready cut yield, percent	113	49.27	2.42	43.62	54.42
USDA yield grade	113	3.34	0.77	1.89	5.23

Correlation Analysis

Correlation coefficients for those carcasses fabricated into wholesale cuts are presented in Table 3. The variables highly correlated to yields of carcasses fabricated into wholesale cuts trimmed to 0.25 inch were carcass weight, fat thickness, adjusted fat thickness, kidney and pelvic fat percentage, HP hot rib and HP cold rib. Leg conformation was moderately correlated to yield. The HP measures of fatness at the 12th rib were highly correlated to the actual fat measure at the 12th rib. Simple correlation coefficients were 0.79 and 0.82 for the hot and cold probe measures, respectively. These data indicate that the HP can be used to measure carcass fat before chilling. Kirton (4) reported simple correlation coefficients between measures of fat depth with the HP taken on the chilled carcass and hot carcass weight to be 0.59, but in this study the coefficient was 0.40.

There has been no cutability information presented in the literature to indicate which carcass measures taken with the HP are correlated to trimmed retail or wholesale cuts at different fabrication endpoints. Research by Kirton (4) used percentage fat, muscle and bone as their final carcass endpoints. Correlation coefficients for carcass measurements from carcasses fabricated into tray-ready cuts trimmed to 0.10 inch are presented in Table 4. The measures of carcass weight, fat thickness, adjusted fat thickness, kidney and pelvic fat percentage, HP hot rib and HP cold rib were all highly correlated to carcass cut-out percentages. Leg conformation score was uncorrelated to yield, which is in agreement with earlier research (7). The cold measure of fatness taken with the HP had a higher correlation coefficient to actual fat thickness than did the HP hot rib measure. The R-values were 0.70 and 0.83 for hot and cold measures, respectively.

Regression Analysis

Regression analysis was performed utilizing the R-square regression package to determine the "best" subsets of variables to predict yields of carcasses fabricated into wholesale or tray-ready cuts. After selection of the best equations containing 1, 2, 3 and 4 variables, regression analyses were performed. Regression equations for predicting wholesale cut yields are presented in Tables 5 and 6. The measures of fat thickness, kidney and pelvic fat percentage and carcass weight resulted in the most desirable equation for predicting yields of carcasses fabricated into wholesale cuts. The best HP equation for predicting yield of wholesale cuts included in order of importance: kidney and pelvic fat percentage, carcass weight and the cold rib fat measure. There was no difference in the predictive accuracy of regression equations that utilized HP or carcass measures collected by the USDA grader. Therefore, the HP or a grader could be utilized to sort carcasses into groups of different composition with the same degree of accuracy.

Regression equations for predicting tray-ready cut yields are presented in Tables 7 and 8. The results indicate that equations utilizing fat thickness or adjusted fat thickness, kidney and pelvic fat percentage, leg conformation score and carcass weight can be used to predict carcass yields with a relatively high degree of accuracy. The equations utilizing HP measures also are highly accurate at predicting yields of carcasses fabricated into tray-ready cuts. The hot HP measure obtained from unchilled carcasses at the 12th rib explained more of the variation in yield than did the cold HP measure. There was virtually no difference in the predictive accuracy of equations utilizing HP fat measures or USDA grader collected fat measures.

Table 3: Simple correlation coefficients for carcass measures and wholesale cut yields.

Carcass measure	2	3	4	5	6	7	8
Carcass weight (1)	0.50	0.50	0.34	0.42	0.54	0.40	- 0.51
Fat thickness (2)		0.96	0.63	0.27	0.79	0.82	- 0.65
Adjusted fat (3)			0.68	0.32	0.79	0.82	- 0.66
KP[a] fat, percent (4)				0.21	0.50	0.61	- 0.62
Leg Conf.Score (5)					0.33	0.33	- 0.28
HP Hot Rib (6)						0.78	- 0.59
HP Cold Rib (7)							- 0.59
Cutting Yield, percent (8)							

[a]Kidney and pelvic

Table 4: Simple correlation coefficients for carcass measures and tray-ready cut yields.

Carcass measure	2	3	4	5	6	7	8
Carcass weight (1)	0.35	0.39	0.25	0.40	0.46	0.30	- 0.41
Fat thickness (2)		0.96	0.64	0.14	0.70	0.83	- 0.71
Adjusted fat (3)			0.64	0.17	0.71	0.81	- 0.72
KP[a] fat, percent (4)				0.28	0.45	0.56	- 0.67
Leg conf. score (5)					0.14	0.08	- 0.12
HP Hot Rib (6)						0.74	- 0.69
HP Cold Rib (7)							- 0.62
Cutting yield, percent (8)							

[a] Kidney and pelvic

Table 5: Best set of regression equations to predict yields of carcasses fabricated into wholesale cuts trimmed to 0.25 inch of external fat utilizing grader measures.

	Variable[a]								
Model	Int.	FAT	AFAT	KP	LEG	WT	R^2	MSE	C(p)
1	76.44		- 15.71				0.43	3.47	31.50
2	76.79	- 10.28		- 0.49			0.49	3.16	15.10
3	80.94	- 7.61		- 0.47		- 0.06	0.53	2.91	2.73
4	81.49	- 7.56		- 0.47	- 0.10	- 0.06	0.53	2.93	4.40

[a] Int = Intercept, FAT = Fat thickness 12th rib (inches), AFAT = Adjusted fat thickness 12th rib (inches), KP = Kidney and pelvic fat percentage, LEG = Leg conformation score (11 = Average Choice, 12 = High Choice, etc.) and WT = Carcass weight (pound).

Table 6. Best set of regression equations to predict yields of carcasses fabricated into wholesale cuts trimmed to 0.25 inch of external fat utilizing Hennessy probe measures.

	Variable[a]							
Model #	Int	HP5	KP	LEG	WT	R^2	MSE	C(p)
1	75.49		- 0.86			0.38	3.82	46.75
2	81.89		- 0.71		- 0.09	0.48	3.22	14.90
3	81.46	- 4.82	- 0.51		- 0.07	0.52	3.00	4.35
4	91.85	- 4.82	- 0.51	- 0.04	- 0.07	0.52	3.02	6.31

[a] Int = Intercept, HP5 = Hennessy probe cold rib fat measure (inches), KP = Kidney and pelvic fat percentage, LEG = Leg conformation score (11 = Average Choice, 12 = High Choice, etc.) and WT = Carcass weight (pound).

Table 7. Best set of regression equations to predict yields of carcasses fabricated into tray-ready cuts trimmed to 0.10 inch of external fat utilizing grader measures.

	Variable[a]							
Model #	Int	AFAT	KP	LEG	WT	R^2	MSE	C(p)
1	54.23	- 22.39				0.52	2.82	31.04
2	54.72	- 15.13	- 0.65			0.60	2.38	10.16
3	59.24	- 13.31	- 0.65		- 0.07	0.62	2.29	6.64
4	56.35	- 12.56	- 0.72	0.40	- 0.10	0.63	2.21	4.09

[a] Int = Intercept, AFAT = Adjusted fat thickness 12th rib (inches), KP = Kidney and pelvic fat percentage, LEG = Leg conformation score (11 = Average Choice, 12 = High Choice, etc.) and WT = Carcass weight (pound).

Table 8. Best set of regression equations to predict yield of carcasses fabricated into tray-ready cuts trimmed to 0.10 inch of external fat utilizing Hennessy probe measures.

	Variable[a]							
Model #	Int	HP5	KP	LEG	WT	R^2	MSE	C(p)
1	53.71	-27.43				0.48	3.04	58.49
2	55.03	-19.30	- 0.82			0.65	2.07	6.45
3	52.37	-19.30	- 0.86	0.23		0.65	2.05	6.42
4	55.01	-17.01	- 0.87	0.37	- 0.07	0.67	1.99	4.00

[a] Int = Intercept, HP5 = Hennessy probe cold rib fat measure (inches), KP = Kidney and pelvic fat percentage, LEG = Leg conformation score (11 = Average Choice, 12 = High Choice, etc.) and WT = Carcass weight (pound)

Therefore, either method of obtaining the fat measure could be used to estimate the yields of lamb carcasses or to sort carcasses into cutability groups. In comparison to data reported by Kirton (4), residual standard deviations for equations utilizing the HP in this study were lower than those from previously reported equations. Cabassi (1) reported that a fat thickness measure at the 12th and 13th rib interface was accurate at predicting both carcass fat and muscle percentages and that 62 and 42 percent of the variation among carcasses in fat and lean percentages were explained, respectively.

Regression equations developed with HP probe measures coupled with other easily obtainable carcass measures were as accurate as equations developed with USDA grader measurements. The Hennessy grading probe can be used to sort carcasses into groups of different cutability if some measure of kidney and pelvic fat is included and coupled with carcass weight; this is in agreement with results of Edwards (2). This can be accomplished easily through the use of two scales interfaced with a computer and the grading probe. Such a set-up could be arranged with a scale to collect warm carcass weight followed by kidney and pelvic fat removal and the second scale weighing the "KP fat-out" carcass and would allow for the calculation of kidney and pelvic fat percentage. The carcass minus the kidney and pelvic fat could be probed then without the hindrance (interference with the probe which results in erroneous measurements) of the kidney and pelvic fat. The computer then would analyze the two weights and the probe measure to print a tag with the carcass number, original warm carcass weight, weight minus kidney and pelvic fat, the fat thickness at the 12th rib and finally the expected yield. This system could be effected without the need for a USDA grader, who has to estimate kidney and pelvic fat and physically probe each carcass and then adjust fat thickness or estimate fat thickness.

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Breed, Nutrition and Slaughter Weight Effects on Lean Lamb Production

H. D. Blackburn, G. D. Snowder and H. Glimp

Summary

A series of simulations were performed to evaluate the effects of mature size (WMA; 60, 70, 80 and 90 kg), slaughter weight (SW; 55, 60 and 65 kg) and three rations fed to feedlot lambs. Rations included a traditional feedlot ration (C2L), placing weaned lambs on alfalfa for 30 or 60 days and then placing the lambs on C2L (A3O-C2L and A6O-C2L, respectively). Fat content decreased 9.0 to 5.8 percent as WMA increased from 60 to 90 across nutritional treatments. Lambs were leaner when placed on alfalfa before going into the feedlot, A3O-C2L and A6O-C2L treatments. Financial returns increased by placing lambs on A3O-C2L or A6O-C2L ($2.34 and $5.21, respectively, above C2L) and by increasing SW over 55 kg ($4.77 and $7.16 for SW 60 and 65 kg, respectively). Average net returns across ration indicated that no WMA had a clear advantage.

Introduction

The sheep industry has become aware of the need to reduce fat content in slaughter lambs. However, it would be desirable to increase slaughter weights to take advantage of larger primal cuts and processing efficiencies (4). Studies have been conducted to determine how breed, sires within breed and nutrition can be used to reduce fat content and increase slaughter weight (2, 5, 7). Few studies have combined breed, nutrition and management effects to find solutions to the stated problems. The objective of this study was to use computer simulation to examine how combinations of breed, nutrition and management interplay in reducing fat content and how these differences translate into financial returns.

Materials and Methods

The Texas A&M Sheep Simulation Model was used to perform the reported simulations (3). It was used in the present study to evaluate the effects of mature size, nutrition and slaughter weight on carcass composition and net returns. The levels of mature size (WMA) were 60, 70, 80 and 90 kg. Breeds analogous to these WMAs are Rambouillet or Targhee (60 and 70 kg) and Columbia or Suffolk (80 or 90 kg). Selected slaughter weights were 55, 60 and 65 kg (SW55, SW6O and SW65, respectively). Three nutritional levels were tested: a control, which ranged in digestibility from 60 to 75 percent and crude protein of 10 to 15 percent (C2L); and placing weaned lambs on alfalfa pasture for 30 or 60 days; and then placing the lambs on the C2L ration (A3O-C2L and A6O-C2L, respectively). It was realized that a potential flavor problem could occur by using alfalfa pastures. However, in this study lambs would spend at least 2 weeks in a commercial feedlot and it is likely that any flavor problem would subside (4).

Production costs used in the financial analysis were obtained from several feedlots; prices paid and received for lambs were averages for 1987 and 1988 reported by the U. S. Sheep Industry Market Situation Report 88-89 (Table 1). Two slaughter lamb pricing scenarios were evaluated. The first assumed a fixed price per kg of live weight, with no adjustments for slaughter weight. The second provided lamb feeders with a bonus or discount based on the lamb's fat composition. The discounts and incentives were as follows: lambs with less then 23 percent body fat were discounted $0.066 per kg; lambs with fat content ranging from 24 to 28 percent had a $0.11 per kg bonus added to the base purchase price; and lambs with 29 percent or more body fat were discounted $0.11 per kg. Although the market does not follow this type of market incentive, it would appear to be an approach for value-based marketing. The adjustments were based upon two of the criteria of the certified lean lamb program; kidney and pelvic fat of 3.5 percent or less and a yield grade of 2.67 to 3.67 (8). Price discounts and incentives are values currently used to adjust lamb carcasses for weights within or outside market demands.

Table 1. Costs and prices used in financial analysis.

Animal Costs			
WMA	Initial weight(kg)	Price/kg	Purchase Price
60	28.6	$1.93	$55.08
70	31.4	$1.93	$60.48
80	34.0	$1.88	$64.01
90	37.2	$1.82	$67.77

Feedinq and Feedlot Expenses	
Yardage	$0.05/day
Pasture	$0.05/day
Veterinary	$0.06/day
Mineral	$0.0l/day
Feedlot ration	$0.ll/kg
Proloxolene	$0.02/day
Transport	$0.60/hd
Sale Price	$1.59/kg

Base price of $1.926/kg with a $0.88/kg slide for feeder lambs over 3l.8kg.

Prices based on 1987 and 1988 averages.

Results and Discussion

Averaqe Daily Gain

The simulated ADG for the different WMAs are in agreement with those reported in the literature for these breed types (2, 6). Across all rations, an increasing linear trend existed for ADG as WMA increased (Figure 1). However, ADG slowed by approximately 30 gr d^{-1} as length of time on alfalfa increased. The faster growth rate for lambs of larger WMA was a result of them being less mature and therefore at a faster growing stage (an earlier point on their growth curve) of development.

The A3O-C2L ration deviated from the flat plane simulated for C2L. The relatively slower growth rates for 80 and 90 WMA at SW55 were due to less time spent on the C2L ration. When slaughter weight increased to 60 kg, requiring a longer period of time on C2L, faster growth rates were simulated for heavier WMAs.

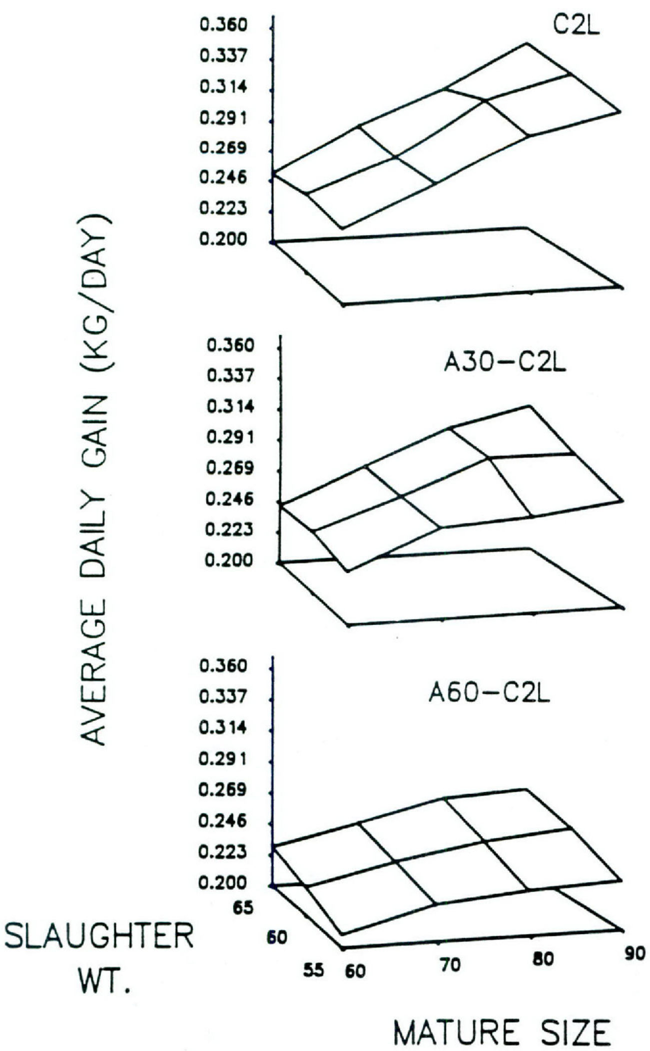

Figure 1. Variation in average daily gain as slaughter weight and mature size were altered within ration C2L, A3O-C2L and A6O-C2L.

Placing the lambs on alfalfa for 60 days decreased ADG for all conbinations tested. Within A6O-C2L ADG increased with heavier slaughter weights. This was a result of interactions between energy content of the diet and length of time lambs were fed the C2L ration.

Fat Percent

In the simulation model lean and fat are simulated separately. For this study we chose to present fat percentage only at slaughter. Figure 2 demonstrates how fat percentage decreases as WMA increases. For example, differences between WMA of 60 and 90 ranged from 5.8 to 9.0 percent. These differences were a result of diet and the degree of maturity simulated lambs obtained. Within nutritional treatment, as length of time on alfalfa increased, fat differs approximately 3 percent between rations. Percent fat increased approximately 2 percent per incremental increase of slaughter weight.

For some combinations of mature size, diet and slaughter weight lambs may not be fat enough to be desirable to the market. This occurred when lambs were placed on A60-C2L. At SW55, lambs with a WMA of 70, 80 and 90 had less than 20 percent fat; at SW60 the 80 and 90 WMAs had less than 20 percent fat, at SW65 the 90 WMA had less than 20 percent fat.

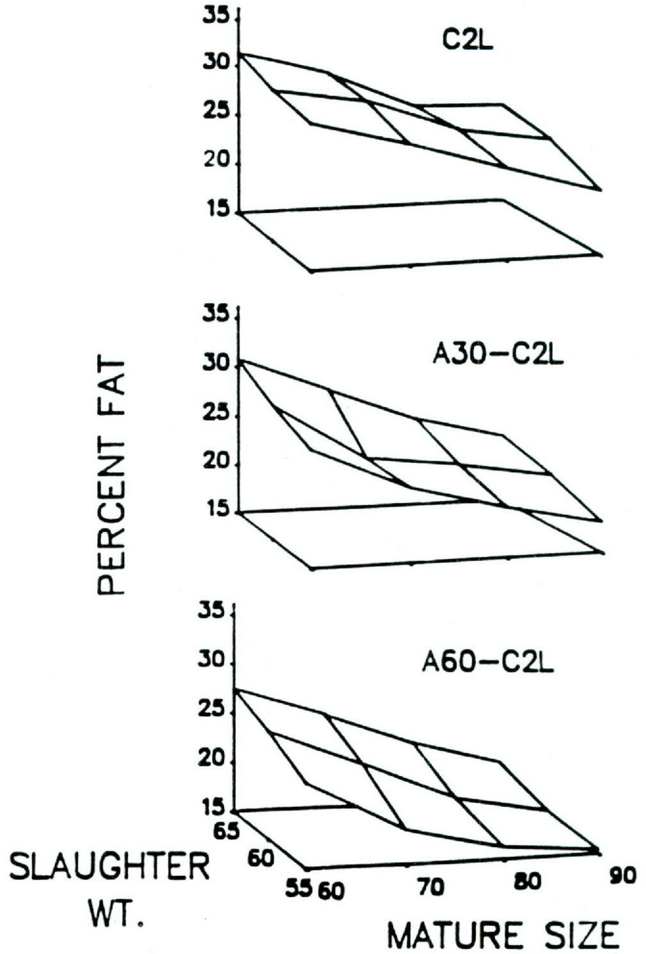

Figure 2. Variation in percent body fat as slaughter weight and mature size were altered within ration C2L, A3O-C2L and A6O-C2L.

As slaughter weight increased it appeared that lambs with WMA of 60 and fed C2L were too fat (Figure 2). This implies that lambs of small mature size should be slaughtered at lighter weights, which is in agreement with Baird, et al. (1). However, if market conditions should not allow lambs of varying mature size to be differentially marketed, rations with lower levels of energy might be used (e.g. A3O-C2L or A6O-C2L).

Economic Evaluation

Economic evaluation of the simulated results are presented in Tables 2 and 3. Table 2 presents net returns for lambs based on sale weight. Within ration and slaughter weight only small differences occur between mature sizes. The uniformity of net returns between genotypes is in part due to increased purchase price with increased WMA. Increasing net returns were realized when time on alfalfa increased. The greatest increases in net returns occur when slaughter weight was increased. However, the rate of increase for net return was not constant; as slaughter weight increased from 60 to 65 kg, net return increased an average of 26.1 percent, but when lambs were slaughtered at 60 instead of 55 kg net returns increased an average of 108.9 percent.

Table 2. Net profit for lambs on various rations slaughtered at three different weights.

WMA	Ration[a] C2L	A3O-C2L	A6O-C2L
		Slaughter weight 55	
60	$2.24	$4.31	$6.76
70	$1.95	$4.52	$6.84
80	$1.48	$4.14	$7.20
90	$1.13	$4.37	$7.61
		Slaughter weight 60	
60	$7.44	$9.12	$11.20
70	$5.65	$8.75	$10.96
80	$6.80	$9.84	$11.93
90	$6.37	$8.99	$12.70
		Slaughter weight 65	
60	$8.91	$10.61	$13.85
70	$9.03	$10.98	$13.48
80	$9.15	$12.49	$14.87
90	$9.87	$10.01	$15.19

[a]C2L = feedlot; A3O-C2L = 30 days alfalfa before feedlot; A6O-C2L = 60 days alfalfa before feedlot.

Table 3 shows the net returns when slaughter lamb prices were adjusted for fat content. The general trends for profitability remain the same, in terms of increasing returns as time on alfalfa increased and as slaughter weight increased. However, Table 3 demonstrates that in such a pricing environment genotype interacting with ration and slaughter weight could be a much more important component of lamb feeding. Based on these results it would appear that a feeder would have to evaluate his options more carefully.

Table 3. Net profit for lambs on various rations slaughtered at three different weights adjusted for body fat.

WMA	Ration[a] C2L	A3O-C2L	A6O-C2L
		Slaughter weight 55	
60	- $3.81	$10.36	$12.81
70	$8.00	$0.89	$3.21
80	$7.53	$0.51	$3.57
90	- $2.50	$0.74	$3.98
		Slaughter weight 60	
60	$0.84	$15.72	$17.80
70	$12.25	$15.35	$7.00
80	$13.40	$5.88	$7.97
90	- $0.23	$5.03	$8.74
		Slaughter weight 65	
60	$1.76	$3.64	$21.00
70	$1.88	$6.69	$20.63
80	$4.86	$8.20	$10.58
90	$5.58	$5.72	$10.90

Fat adjustment: if fat percent ≤ 23 percent, $ – .066/kg; if fat percent 24 to 27 percent, +$.11/kg; if fat percent ≥28 percent, – $.11/kg.

[a]C2L = feedlot; A3O-C2L = 30 days alfalfa before feedlot; A6O-C2L = 60 days alfalfa before feedlot.

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Performance and Carcass Characteristics of Lambs Implanted with Zeranol and Fed at Two Levels of Intake

G. D. Hufstedler, J. T. French, G. E. Carstens, L. W. Greene, T. H. Welsh, Jr. and F. M. Byers

Summary

Forty crossbred wether lambs (average weight 66 pounds) were used to determine the effect of feeding level and Ralgro® implants on performance and carcass characteristics. The lambs were fed a high concentrate diet at two levels: *ad libitum* or restricted intake (to gain 0.5 x the *ad libitum* group). Treated lambs were implanted with 12 mg zeranol at 30-day intervals. *Ad libitum*-fed lambs were slaughtered on day 98 and restricted-fed lambs on day 154. There were no differences in carcass conformation, back fat, yield grade, carcass weight or leg conformation due to feeding level or implant. There was, however, a 16 percent increase in average daily gain due to implantation as well as an improvement in feed efficiency when comparing implanted lambs to controls. Implanted lambs had lower percentages of dry matter and ether extract in concert with an increase in percent protein in the carcass. Dressing percentage was slightly lower in implanted than non-implanted lambs. Ribeye area was increased and kidney pelvic fat was significantly lower in implanted lambs compared to non-implanted controls. Carcass age scores increased due to implantation with Ralgro®. Pituitary gland weight was increased by Ralgro® treatment. In addition, four lambs in the implant-restricted group developed urinary calculi during the trial. These data indicate that implanted and *ad libitum*-fed lambs perform better than controls in average daily gain and feed efficiency as well as selected carcass traits. However, for current marketing systems, these advantages must be evaluated with respect to the economic consequences of increasing the percentage of mutton carcasses produced within any production group.

Introduction

One of the most serious problems facing the American sheep industry today is the production of too much fat. A recent comparison of slaughter lambs indicates that 67 percent of the feedlot lambs marketed have too much external and internal fat (7). The same study found that feedlot lambs produced fatter, lower yielding carcasses than their non-grain fed counterparts, which may partially explain why only 33 percent of the grain-fed carcasses were able to meet the American Sheep Producers Council's lean lamb certification specifications. Obviously, some means of reducing the overall fatness of lambs going to market will have to occur if American sheep producers wish to continue to market their product to a health conscious public (6).

A possible management tool that feeders could employ to decrease fatness of lamb carcasses is more extensive use of an anabolic agent such as Ralgro®. Performance could be increased (4) but, more importantly, the percentage protein gain may be increased and percentage fat gain decreased by implanting with anabolic agents (2, 3). Based on the improvements in performance as well as the alterations in carcass composition of animals implanted with Ralgro®, our study was designed to evaluate the changes that repeated implantation with Ralgro® might exert on the performance and carcass characteristics of lambs fed at two levels of intake.

Experimental Procedures

Forty crossbred wether lambs (average weight 66 pounds) were blocked by weight and placed in 20 pens. Lambs were randomly assigned by pen to either an implant or no-implant treatment group and fed at two levels of intake (*ad libitum* versus restricted) in a 2 x 2 factorial arrangement of treatments. Restriction of intake was incorporated into the experimental design to facilitate the collection of growth hormone and somatomedin-C response data. Restricted-fed lamb intakes were adjusted to produce live weight gains at 0.5 x the rate of their parallel *ad libitum*-fed group using NEg gain prediction equations. Lambs were fed a high concentrate diet as shown in Table 1. Individual weights were taken every 14 days to monitor individual lamb performance. Lambs were implanted every 30 days (alternating left and right ears) with 12 mg Ralgro® (implant-ad libitum and implant-restricted receiving three and five implants respectively) to maintain a sustained anabolic agent release for the duration of the trial. No implants were administered within 40 days of slaughter. *Ad libitum*-fed lambs were slaughtered on day 98 and restricted-fed lambs on day 154. After a 24-hour chill, carcasses were weighed and ribbed, followed by collection of subjective (leg conformation, carcass conformation, flank streaking, kidney and pelvic fat, carcass age and quality grade) and non-subjective (carcass weight, dressing percentage, back fat thickness, rib eye area, spooling and yield grade) carcass traits based on current USDA grading standards (8). Carcasses were divided down the midline and the right side was ground with dry ice. Ground subsamples were analyzed for crude protein and ether extract according to AOAC procedures (1). Statistical analysis of the data was performed using the general linear models procedure of SAS (5). All variables were analyzed using pen effects within block and treatment in the model. A

Table 1. Diet composition.

Composition	percent
Ingredient[a]	
Cracked corn	63.8
Soybean meal	12.4
Alfalfa pellets	10.8
Sugarcane molasses	7.8
Cottonseed hulls	3.6
Trace mineralized salt	0.6
Ground limestone	0.6
Ammonium sulfate	0.4
Chemical analysis[a]	
Dry matter	86.7
Acid detergent fiber	15.5
Crude protein	12.8
Ether extract	2.8
Calcium	0.6
Phosphorus	0.3
Magnesium	0.2
Iron, ppm	109.0
Zinc, ppm	69.0
Manganese, ppm	38.0
Copper, ppm	6.0

[a]Data are presented on an as-fed basis.

pooled error term was used when pen within block and treatment effects were not significant.

Results and Discussion

Average daily gain (ADG) and pen feed-to-gain measurements are presented in Table 2. Average daily gain increased by 114 percent (P <0.10) for ad libitum- versus restricted-fed lambs. Feed efficiency was improved (P <0.05) in *ad libitum*-fed lambs compared to the restricted-fed group. There was an implant by feeding level interaction for feed efficiency. The restricted-fed lambs had a much poorer feed conversion than *ad libitum*-fed lambs if they were not implanted. Because animals were housed indoors without air conditioning, optimal performance may not have been realized.

Table 2. Effects of Ralgro® implants and feeding levels on live weight gains and feed to gain ratios of lambs.

	Ralgro®		Control	
Parameter	ad libitum	Restricted	ad libitum	Restricted
ADG, pound[b,d]	0.48	0.24	0.42	0.18
Feed to gain[a,c,d]	6.1	7.5	6.6	10.9

[a]Implant X feeding level interaction (P <0.05).
[b,c]Affected by implant (P <0.10, 0.01) respectively.
[d]Affected by feeding level (P <0.01).

Subsamples of the ground carcass halves (Table 3) revealed that the percentage dry matter of the carcasses was lower (44 versus 42 percent; P <0.10), percentage ether extract was lower (61 versus 58 percent; P <0.11) and percentage crude protein was higher (32 to 34 percent; P 0.11) in implanted lambs when compared to controls, demonstrating the fact that Ralgro® altered lamb carcass composition.

Table 3. Chemical analysis of ground carcass halves.

	Ralgro®		Control	
Constituent	ad libitum	Restricted	ad libitum	Restricted
Ether extract, percent (DM basis)	59.1	57.7	61.8	60.2
Crude protein, percent (DM basis)	34.1	34.0	31.5	31.9
Dry matter, percent[a]	41.6	43.1	43.3	45.0

[a]Affected by implant (P <0.10).

It was noted upon examination of the carcass variables (Table 4) that there were no differences in chilled carcass weight, leg conformation score, carcass conformation score, flank streaking, back fat thickness or yield grade due to assigned treatments. Quality grades (Ch° versus Ch+), however; were significantly lower (P <0.01) in restricted-fed lambs compared to *ad libitum* groups and dressing percentages were reduced by 3 and 9 percent (P <0.05) in implanted and *ad libitum*-fed lambs, respectively. Rib eye areas (REA) were affected by treatment interactions (P <0.05) but when implanted and control *ad libitum*-fed REA were compared there was a 12 percent increase in

Table 4. Carcass characteristics of lambs implanted with Ralgro® and fed either ad libitum or restricted feed intakes.

	Ralgro®		Control	
Parameter	ad libitum	Restricted	ad libitum	Restricted
Chilled carcass weight, pound	61.8	64.2	59.6	60.1
Dressing, percent[d,h]	55.8	59.8	56.3	62.8
Leg conformation[i]	12.2	12.6	11.9	12.2
Carcass conformation[j]	3.9	4.8	4.4	4.4
Flank streaking[b,k]	6.8	4.8	5.2	6.3
Back fat thickness, inch	0.30	0.34	0.28	0.28
Rib eye area, square inch[b,h]	2.34	1.71	2.08	1.75
Kidney pelvic fat, percent[e,g]	2.3	1.8	3.1	3.0
Carcass age[a,e,f,l]	5.4	7.0	4.6	4.5
Spooling, percent	40.0	100.0	0.0	0.0
Yield grade	3.6	3.8	3.7	3.6
Quality grade[h,j]	4.0	5.1	3.9	4.3

[a,b]Implant X feeding level interaction (P 0.10, 0.05) respectively.
[c,d,e]Affected by implant (P 0.10, 0.05, 0.01) respectively.
[f,g,h]Affected by feeding level (P 0.10, 0.05, 0.01) respectively.
[i]Leg conformation scores based on a scale of 1-15 where 1 = Cull- and 15 = Prime +.
[j]Scores based on a scale of 1-7 where 1 = Prime + and 7 = Select +.
[k]Degree of streaking on a scale of 1-10 where 1 = devoid and 10 = abundant.
[l]Carcass age scores based on a scale of 1-7 where 1 = A + and 7 = mutton.

REA due to implantation. There were also significant implant ($P < 0.01$) and feeding level ($P < 0.05$) effects on percentage kidney pelvic (KP) fat with percent KP decreasing by 33 percent in implanted lambs. Carcass age scores were increased ($P < 0.01$) in implanted lambs compared to controls resulting in more spool joints from carcasses of lambs implanted than those not implanted. Implant-*ad libitum*, implant-restricted, no implant-*ad libitum* and no implant-restricted treated lambs had a 40, 100, 0 and 0 percent incidence of spooling at slaughter, respectively. The combination of repeated implantation and restriction of intake were major contributors to the relatively high incidence of spooling in the implant-restricted and implant-ad libitum groups. The four cases of urinary calculi that occured in the implant-restircted group were most likely linked to the same combination.

Ralgro® treatment increases pituitary gland weights and production of growth hormone (4, 8). In this study anterior pituitary gland weight at slaughter was increased by treatment with Ralgro® (Figure 1).

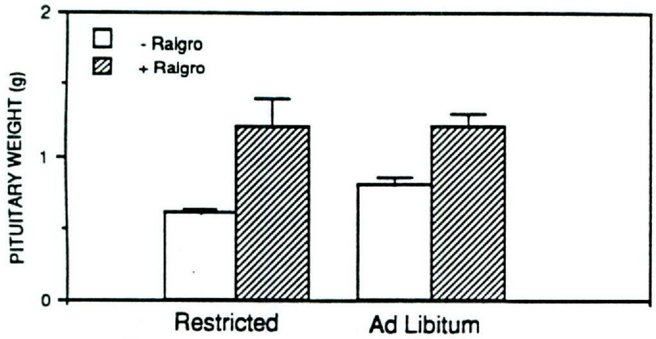

Figure 1. Weight (g) of anterior pituitary glands collected at slaughter from each of the four treatment groups.

There is a definite place for Ralgro® in the lamb production system if the negative aspects of increasing bone hardness can be overcome. Ralgro® implants enhance performance and exhibit the capacity for producing leaner, more acceptable carcasses. Whatever the advantages may be, at present Ralgro® usage must be weighed against the current economic consequences of increasing percentages of mutton carcasses within any production group. Thus, timing of implantation becomes the key if producers wish to maximize their profit potential.

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Effect of Confinement on Physiology and Motivation for Movement in Lambs

C.L. Bowers, T.H. Friend, G.R. Dellmeier, D.C. Lay and M.E. Mal

Summary

The effects of chronic close confinement of sheep on adrenal response, thyroid hormones and motivation for movement were investigated. Seventeen 8-week old Rambouillet wether lambs were habituated to human contact for 2 months and subsequently placed in 16 x 37-inch individual metabolism stalls for 9 days. At 7 days prior to and on day 2 and day 9 of confinement, two basal blood samples were drawn from each lamb, followed by administration of 1 IU/kg ACTH via jugular cannulae. Serial blood samples were then drawn over the next 3 hours. An open-field test was conducted the day before the lambs were placed in the stalls and again on day 9 following the last blood sampling. Adrenal response, as measured by integrating cortisol concentrations in response to the ACTH, was greater when the lambs were housed in stalls than when maintained on pasture ($P = 0.0065$). Lambs in stalls also had higher basal concentrations of thyroxine than lambs on pasture ($P = 0.0004$). Lambs traveled further in open-field tests after 9 days in metabolism stalls than they did before confinement ($P = 0.0011$). Results of this study indicate that chronic close confinement can cause many physiological changes indicative of stress. Such changes in metabolism could complicate the interpretation of experimental data obtained from lambs maintained in metabolism stalls.

Introduction

Sheep are commonly used in agricultural and medical research, in addition to being raised for meat and fiber. The effects of any potential stressors, such as the close confinement typically required to permit the collection of research data, may affect the characters measured and should be considered by researchers when applying their findings to sheep in more conventional conditions. Chronically blocking the expression of a "drive-motivated" behavior, such as locomotion, grooming or social interaction, can adversely affect the animal by the effects of the associated physiological responses (3). Also, the well-being of the animal may be compromised under certain conditions.

Long-term stress is generally associated with an increase in pituitary-adrenal activity (16). Changes in adrenal function can be evaluated by measuring the actual size of the adrenal gland or by administering adrenocorticotropic hormone (ACTH) and measuring the corresponding release of cortisol into the blood of the animal (5, 8, 11). Rats exposed to chronic intermittent stress exhibit adrenal hypertrophy (1). Chronically confined calves had a higher adrenal reactivity to ACTH than calves housed loose in groups (2, 9). Increased adrenal function was also observed in dairy cows at the later stages of lactation (12). The adrenal-pituitary system in even 2-week-old lambs is fully responsive to environmental stresses (14).

Chronic stress also may be associated with a change in the blood concentration of the thyroid hormones, triiodothyronine and thyroxine. Chronically confined calves had higher plasma concentrations of triiodothyronine and thyroxine than less confined calves (9), but similar results have not been found for closely confined gestating gilts (10). Thyroid function in sheep increases in response to some acute stressors, such as restraint (6) and has also been shown to increase during some chronic environmental stressors (7).

One technique for determining the behavioral needs of an animal is through controlled deprivation of a behavior followed by open-field testing (11). A confined animal may have an intensified motivation for movement and therefore exhibit more locomotor behaviors upon release from confinement (3). This movement may be a behavioral indicator that the animal is experiencing some degree of mental or physical stress due to certain environmental conditions placed on it by man (3). These hormonal and behavioral changes can be accentuated by the animal's natural excitability or previous experience (13, 15). Fortunately, responses to certain stimuli, such as handling by man, can be attenuated by training and experience (6, 15).

Experimental Procedure

Seventeen 8-week old Rambouillet wether lambs were obtained from the Texas A&M Research and Extension Center at San Angelo, Texas and taken to Texas A&M University at College Station. These lambs were habituated to human contact for 2 months following their acquisition. The lambs were maintained on a small pasture throughout the habituation period, after which the lambs were placed side by side in individual metabolism stalls for 9 days. The stalls measured 16 x 37 inches and held the lambs' heads in a stanchion. The lambs had visual and auditory contact with one another, but no tactile contact.

Lambs had jugular catheters inserted at least 12 hours prior to blood collection, 7 days before and on day 2 and day 9 of confinement. After two basal blood samples were drawn 15 minutes apart for determination of basal cortisol, triiodothyronine and thyroxine, 1 IU/kg ACTH was administered to each lamb via the cannulae. Blood samples were subsequently drawn at 15, 30, 45, 60, 90, 120 and 180 minutes. Adrenal response was measured for each lamb by integrating the resultant cortisol curve after subtraction of the mean of each animal's basal concentrations (8).

An open-field test was conducted the day before the lambs were placed in stalls and again on day 9, following the last blood sampling. During the open-field tests, each lamb was placed in a 30- x 40-foot fenced outside pen for 5 minutes, while distance traveled was determined and behaviors performed were timed and counted. Blood plasma was assayed for cortisol, triiodothyronine and thyroxine by radioimmunoassay.

Results and Discussion

The results of this study indicate that physiological and behavioral changes took place in the lambs maintained for 9 days in chronic close confinement. Adrenal response was significantly greater in the lambs housed in stalls than in the lambs maintained on pasture (P = 0.0065) (Figure 1). Adrenal response at day 2 was not statistically different from day 9, but the mean response did increase from day 2 to day 9. Similar to adrenal response, plasma concentrations of thyroxine were greater for lambs housed in stalls than in lambs maintained on pasture (P = 0.0004). Plasma concentrations of triiodothyronine did not differ significantly. Adrenal response and thyroxine concentrations are increased after only 2 days in stalls, indicating a change in the physiology of the lamb. This change is considered to be indicative of an animal responding to a stressor (8, 14).

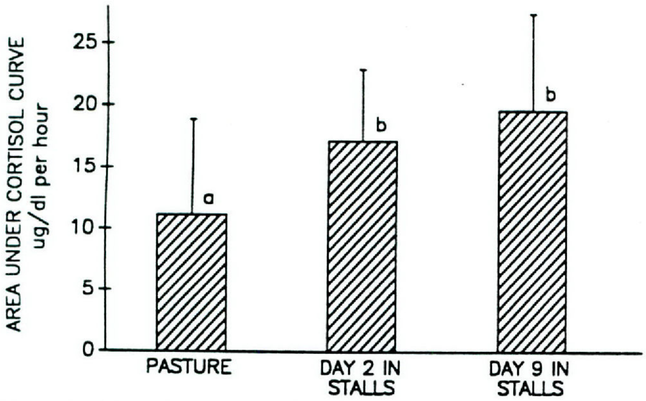

Figure 1. Adrenal response of lambs to housing treatment (bars with different letters differ, P = 0.0065).

Response to the open-field tests also indicate that the lambs were affected by confinement in the stalls. Lambs traveled further in open-field tests after 9 days in metabolism stalls than they did before confinement (61.9 feet/minute ± 27 versus 28.5 feet/minute ± 15, P = 0.0011). This increased "motivation for movement" is a behavioral response to chronic confinement, which may be an indicator of a thwarted behavioral need. An animal deprived of the opportunity to perform certain drive-motivated behaviors may perform other, less desirable, behaviors and is often considered to be in a state of diminished well-being (4).

In conclusion, these results show the need to consider all behavioral and environmental factors when conducting research and when applying the findings to actual production situations. In certain situations, close confinement can produce hormonal changes that affect the animal's overall metabolism and may have possible negative effects on the animal. Further research is being conducted to determine the effect that the lamb's temperament has on its response to close confinement. More research is also needed to determine the exact consequences of close confinement for differing time periods on the total physiological and behavioral make-up of the animal.

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PR 4809

Performance Levels and Fleece Characteristics of Angora Mutton Goats in the Edwards Plateau and South Texas Plains Regions of Texas

J.E. Huston, C.J. Lupton, J.W. Holloway and B.G. Warrington

Summary

Two hundred Angora mutton goats (1 year of age) were divided between research sites in McCulloch (Edwards Plateau) and Zavala (South Texas Plains) counties for a period of 3 years to study effects of location and phenotype of the goats on body weight, mohair production and mohair fiber characteristics. Of the 100 goats sent to each study site, 50 each were classified as small, fine-haired and large, high-yielding goats, respectively. Animal weights, mohair production and fiber characteristics were similar for the two locations during the 3-year period. Generally, the goats were heavier and produced fibers that were coarser and contained a slightly greater percentage of kemp at the fall shearing compared with the spring shearing. The large, high-yielding group maintained higher weights and produced higher-yielding fleeces that contained a greater percentage of med fibers compared with the small, fine-haired group. It was concluded that Angora goats having similar phenotypic characteristics were equally productive in the Edwards Plateau and South Texas Plains regions.

Introduction

Angora goats were introduced into the United States more than 100 years ago because of their capacity to produce large quantities of fiber (mohair). Unique dietary preferences for foliage from trees and shrubs make the goat of greatest value on ranges where these plants are present. Goats in the Edwards Plateau region depend heavily on "oak-type" browse, especially during winter and periods of low-moisture dormancy (4). In the South Texas Plains region, goats rely on "leguminous" browse (mostly species of Acacia) and other "thorny" species (7) which are generally higher in protein than shrubs from the Edwards Plateau region (3, 6). Quality characteristics of mohair are affected by nutrient content of diet (2, 5), age of goat and season of the year (1). A study was initiated during the fall of 1986 to determine the long-term effects of location (therefore, diet and other environmental factors) on weight and fiber characteristics in Angora mutton goats.

Experimental Procedure

Two hundred 1-year-old mutton Angoras were selected from a flock of 600 in Crockett County, Texas, prior to fall shearing, 1986. Two extremes were selected based on subjective, visual classification. Half (100) were characterized as small, fine-haired goats and the other half as large, high-yielding goats. After shearing, half of each type (50 fine-haired and 50 high-yielding) were transported to an experimental ranch in McCulloch County (Edwards Plateau region) and the other half of each type to an experimental ranch in Zavala County (South Texas Plains). The goats were grazed on rangeland typical for the respective regions and given typical management for 3 years. Each year the goats were weighed and sheared in July-August and February. Fleeces were taken individually and transported to the Texas A&M University Agricultural Research and Extension Center at San Angelo, Texas, where fleece characteristics were determined. Statistical comparisons for location, season and phenotype were made for body weights and each fleece characteristic using a randomized block analysis of variance procedure. Only main effects are presented and discussed in this report.

Results and Discussion

Complete data for the 3-year period were collected on 65 and 32 goats at McCulloch and Zavala counties, respectively. Data from animals that died or lost identification or were inadvertently missed at one or more of the data collection periods were not included in the analysis.

Over the 3-year period, the goats gained approximately 30 pounds (Table 1). Initially the goats taken to McCulloch and Zavala counties weighed 72.3 and 69.7 pounds, respectively ($P < 0.10$). The apparent difference in initial weight likely was because weights were taken after they arrived at the respective experimental sites and the groups may have been weighed in different degrees of shrink. At the end of the 3-year period, the goats at the two sites weighed approximately the same. The goats gained approximately 9 pounds ($P < .05$) between the first fall and first spring sampling, reflecting growth of the yearling animals. The difference in weights for fall and spring during the final year of the study (approximately 12 pounds; $P < .05$) reflects the higher overall nutrition level during the 6 months prior to the fall shearing. Differences in weights of the small, fine-haired and the large, high-yielding goats remained rather consistent between the initial (8 pounds; $P < .05$) and the final (9.2 pounds; $P < .05$) sampling periods.

Table 1. Effects of location, season and phenotype of Angora mutton goats on live body weight, mohair production and mohair fiber characteristics.

Composition	Number of goats	Weight (pounds)[a]		Fleece[b]			Fiber[c]		
		Initial	Final	GFW (lb)	Yield (%)	CFW (lb)	Diam. µm)	Med (%)	Kemp (%)
Location									
McCulloch County	65	72.3[d]	98.2	5.9	77	4.5	37.1	1.20	0.61[f]
Zavala County	32	69.7[e]	99.4	5.8	78	4.5	37.8	1.22	0.85[g]
Season									
Fall	97	66.4[f]	105.0[f]	5.7	78	4.4	39.0[f]	1.07	0.80[d]
Spring	97	75.6[g]	92.6[g]	6.0	78	4.6	35.9[g]	1.35	0.66[e]
Phenotype									
Small, fine-haired	50	67.0[f]	94.2[f]	5.8	76[f]	4.5	36.6	0.97[f]	0.71
Large, high-yielding	47	75.0[g]	103.4[g]	5.8	79[g]	4.6	38.3	1.45[g]	0.74

[a]Weights at the first spring and fall and final spring and fall clips, respectively.
[b]Grease fleece weight (GFW) and clean fleece weight (CFW).
[c]Mean diameter of fibers (Diam.), med and kemp percentages.
[d,e]Values in a comparison having different superscript letters differ ($P < 0.10$).
[f,g]Values in a comparison having different superscript letters differ ($P < 0.05$).

Mohair production was almost identical for locations, seasons and phenotypes. Yield, also, was similar for all comparisons. The small difference in yield between the two phenotypes ($P < .05$) reflects the initial, subjective separation considering this characteristic.

Fiber characteristics were similar but some differences were detectable. Fibers grown prior to spring shearing had a smaller average diameter compared with those in the fall fleeces ($P < .05$), possibly as a result of a lower overall level of nutrition. This is consistent with results of previous studies with Angora goats which found that fiber diameter increased with increases of protein (5) and energy (2) in the diet. However, the apparent inconsistency between fiber diameter and total weight of fiber produced (CFW) is not explained by this study but probably is a result of higher fiber (follicle) density and/or greater staple length. In the previous studies, fiber diameter was generally, though not rigidly, related positively with weights of fiber produced (1, 2, 5). The apparent difference in diameter of mohair fibers grown by the small, fine-haired and large, high-yielding phenotypes approached significance at the 0.10 level of probability and again, likely reflects the initial subjective separation of phenotypes. Fleeces from the large, high-yielding goats included a higher percentage of med fibers (medullated animal fibers in which the diameter of the medulla is less than 60 percent of the diameter of the fiber) compared with those from the small, fine-haired goats ($P < .05$). However, kemp fibers (medullated animal fibers in which the diameter of the medulla is 60 percent, or more, of the diameter of the fiber) were present at near the same level for the two groups. Fleeces from the two locations contained similar proportions of med fibers, but kemp percentage was higher in fleeces from Zavala County ($P < .05$). Although this difference in percentage of kemp was statistically detectable indicating a locational effect, the mathematical difference was small (0.61 versus 0.85 percent) and is considered of minor importance. Kemp fibers were present at a higher percentage in fall compared with spring fleeces ($P < .10$). This finding is consistent with the results of Calhoun et al. (2), but contrary to those reported by Bassett (1). Again, the mathematical difference was rather small (0.66 versus 0.80 percent). An interesting difference was noted for the kemp and med fiber contents of the spring and fall fleeces. Although kemp was higher in the fall fleeces ($P < .10$), med fibers appeared higher in the spring fleeces (approached significance at the 0.10 level). However, this apparent inverse relation did not appear in either the location or phenotype comparisons.

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PR 4810

Sacahuista Control with Soil-active Herbicides

J.L. Petersen and D.N. Ueckert

Summary

Sacahuista (*Nolina texana*) is a perennial grass-like plant that occurs on rocky soils in central and western Texas and northern Mexico. Its flower buds, blooms and fruit are toxic to goats, sheep and cattle during winter to early spring. Three field experiments were conducted in the Edwards Plateau of western Texas to evaluate selected soil-active herbicides applied as individual plant treatments at 0.018, 0.035 and 0.07 ounce active ingredient (a.i.)/plant for sacahuista control. Plant mortality and canopy reduction increased linearly with increasing rates of tebuthiuron (Graslan® Brush Bullets), bromacil (Hyvar® X-L) and hexazinone (Velpar® L). Tebuthiuron applied at 0.07 ounce a.i./plant as a 14 percent a.i. briquette killed 87 percent of the treated sacahuista plants, whereas bromacil and hexazinone applied as liquids at the same rate killed 62 and 44 percent, respectively. Treatments applied in June and October 1984 and May 1985 were equally effective. Picloram applied at rates up to 0.07 ounce a.i./plant as a 10 percent a.i. pellet (Grazon® 10K) did not affect sacahuista.

Introduction

Sacahuista (*Nolina texana*), also known as beargrass, is a perennial grass-like plant of the Liliacea family that occurs on rocky soils in central and western Texas and in northern Mexico. Sacahuista flowers are produced from the plant base in late winter-early spring. All parts of the flowering stalks are toxic and readily eaten by sheep, goats and cattle, particularly during periods when the quality and quantity of desirable forages are low (7). The hepato-nephro-toxin produces icterus and liver and kidney damage, and subsequent consumption of green forage and exposure to sunlight produces secondary photosensitization (4). With secondary photosensitization, phylloerythrin is not eliminated via the bile duct due to cholestasis and the compound becomes deposited in the skin, where it absorbs sunlight and induces skin lesions (2). The minimum toxic dose of sacahuista buds and blooms for sheep is about 1.1 percent of the animal's weight (4). Goats are more susceptible to sacahuista poisoning than are sheep. Animals that have eaten sufficient toxic material to produce symptoms of the disease rarely recover. Toxicity to livestock is closely correlated with the abundance of bloom crops, which varies from year to year. A "heavy bloom" crop occurs about every 4 to 5 years in western Texas.

Livestock losses due to sacahuista toxicity can sometimes be minimized through grazing management. Pastures that have only sparse stands of sacahuista are often stocked lightly until sacahuista blooms. Livestock from densely infested pastures are then moved to the sparsely infested pastures until the blooms no longer present a threat (3 to 4 weeks). Using combinations of livestock under continuous, light stocking rates or with a moderately stocked, four-pasture, deferred-rotation system reduced incidence of sacahuista poisoning in long-term grazing studies near Sonora, Texas (5). Control measures for sacahuista are needed to minimize the necessity for special grazing management, reduce the risk of livestock poisoning and to restrict further distribution of plants. There is increasing interest in the use of soil-active herbicides for control of undesirable brush and weeds because timing of herbicide application is less critical than with foliar sprays. The purpose of this study was to evaluate selected soil-active herbicides applied as individual plant treatments for sacahuista control.

Experimental Procedures

The study was conducted on Cho gravelly loam soils about 5 miles east of Barnhart (Irion County), Texas. Redberry juniper (*Juniperus pinchotii*), honey mesquite (*Prosopis glandulosa*) and broom snakeweed (*Xanthocephalum sarothrae*) are the dominant brush species. Dominant grasses include common curlymesquite (*Hilaria belangeri*), buffalograss (*Buchloe dactyloides*) and threeawns (*Aristida* spp.).

Four soil-active herbicides were evaluated as individual plant treatments for control of mature sacahuista plants. The herbicides and their formulations included tebuthiuron as 1 cc briquettes (Graslan® Brush Bullets), picloram as extruded pellets (Grazon® 10K), hexazinone liquid (Velpar® L) and bromacil liquid (Hyvar® X-L). The herbicides were applied at equivalent rates of active ingredient (0.018, 0.035 and 0.07 ounce a.i./individual plant) (see Table 1 for bulk rates). The dry formulations were distributed by hand and the liquids were applied as undiluted spot-sprays with a hand-held drench gun into or underneath the plant canopy near the base of each plant. Treatments were applied to three replications of 10 plants each in separate experiments on June 4 and October 23, 1984 and May 9, 1985.

canopy reduction were similar for all dates of application. Plant response differences to dates of application at the earlier evaluations may be related to the amount of precipitation received during the first few months after herbicide application. Less than half as much precipitation was received during the first 90 days after treatments were applied in June 1984 compared to the other two experiments. Dry conditions following the June 1984 herbicide applications probably delayed effective movement of the herbicides into the plant root zone.

Table 1. Herbicides, formulations and rates of application/plant in sacahuista control experiments.

Herbicide			Rates of application/plant	
Common name	Trade name	Formulation	a.i.[a]	bulk product
			ounce	
Tebuthiuron	Graslan® Brush Bullet	briquette (14 percent a.i.)	0.018	0.13
			0.035	0.25
			0.070	0.50
Picloram	Grazon® 10K	pellets (10 percent a.i.)	0.018	0.18
			0.035	0.35
			0.070	0.70
Hexazinone	Velpar® L	liquid (25 percent a.i.)	0.018	0.07
			0.035	0.14
			0.070	0.28
Bromacil	Hyvar® X-L	liquid (22 percent a.i.)	0.018	0.08
			0.035	0.16
			0.070	0.32

[a]Active ingredient.

Efficacy of the treatments was determined annually for 3 years after application. Percentage live canopy reduction of each treated plant was visually estimated and plants with no live tissue were recorded as dead. Picloram did not affect sacahuista, so data for the picloram treatments were not included in the analyses.

Results and Discussion

Effects of the soil-applied herbicides on sacahuista were not fully manifested for 2 to 3 years (Table 2). Sacahuista mortality and canopy reduction were greater at 1 and 2 years after treatment for treatments applied in October 1984 and May 1985 compared to those in June 1984. However, by 3 years after treatment, sacahuista mortality and canopy reduction were similar for all dates of application.

Table 2. Mortality and live canopy reduction (percent) of sacahuista after herbicidal treatment at three treatment dates near Barnhart, Texas. Data are averaged over herbicides and rates of application.

	Mortality			Canopy reduction		
	Years after treatment					
Treatment dates	1	2	3	1	2	3
	percent					
June 1984	0	17	31	42	59	62
October 1984	3	36	39	47	69	67
May 1985	6	34	35	53	67	67

Mortality and canopy reduction increased as rate of application of tebuthiuron, hexazinone and bromacil increased (Table 3). Bromacil and hexazinone had killed more sacahuista at 1 year after treatment than had tebuthiuron (data not shown). However, tebuthiuron has a long residual that extends its effectiveness (1, 3, 6, 8) and the ultimate efficacy of tebuthiuron was significantly greater than that of hexazinone and bromacil after 3 years (Table 3). Tebuthiuron at 0.07 ounce a.i./plant killed 87 percent of the sacahuista whereas equivalent rates of bromacil and hexazinone killed 62 and 44 percent, respectively.

Table 3. Mortality and live canopy reduction (percent) of sacahuista 3 years after herbicidal treatments near Barnhart, Texas. Data are averaged over three experiments.

	Mortality[a]			Canopy reduction		
	Rate of application (ounce a.i./plant)					
Treatment	0.018	0.035	0.07	0.018	0.035	0.07
	percent					
Tebuthiuron	13 a	49 a	87 a	50 a	84 a	98 a
Hexazinone	1 b	16 b	44 c	20 b	48 b	88 b
Bromacil	7 ab	39 a	62 b	29 b	64 b	93 ab

[a]Means within a column followed by similar lower case letters are not significantly different at the 5 percent probability level.

These data indicate that sacahuista can be effectively controlled with tebuthiuron applied at 0.07 ounce a.i./plant. The tebuthiuron formulation evaluated in this experiment (Graslan® Brush Bullets) is no longer available, but tebuthiuron is commercially available as a 20 percent a.i. pelleted formulation (Spike® 20P).

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