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Sheep and Goat, Wool and Mohair, 1994

Texas Agricultural Experiment Station
Edward A. Hiler, Director
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College Station, Texas

Sheep and Goat, Wool and Mohair, 1994

Foreword

The 1994 Sheep and Goat/Wool and Mohair Consolidated Progress Report has been prepared by Texas Agricultural Experiment Station and Extension Service 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. More detailed information on any subject in this report may be obtained by contacting the responsible scientist(s) directly.

Sheep and goat research in Texas is a consolidated effort involving the scientists working at College Station, San Angelo, Sonora, Uvalde, and other research sites. These scientists maintain close communication with scientists at other Texas universities and 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 that may be useful in Texas. The research program maintains relationships with sheep and goat commodity groups and other 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 that may be useful in sheep and goat production.

Research is carefully targeted to address priority needs. The Texas Agricultural Experiment Station maintains a 5-year research plan in coordination with the sheep and goat industry. This research plan is reviewed annually with representatives of the Texas Sheep and Goat Raisers Association, the Mohair Council, and others. This provides an organized approach and still allows for attention to new needs or shifts in priorities in the industry. For example, in response to the current industry situation TAMUS scientists are increasing research to improve productivity of meat goats. The current plan focuses on the following research needs:

1. Develop management schemes for optimal productivity.
2. Improve consumer acceptance of meat and fiber products.
3. Improve ways to reduce predator losses.
4. Develop better quality measurements for meat and fiber to improve producer returns.
5. Improve animal health by controlling parasites, infectious diseases, and toxic and harmful plants.

Texas leads the nation in both sheep and goats and needs to maintain a viable sheep and goat industry in order to efficiently utilize and manage a sustainable range resource. The impending loss of USDA wool and mohair incentive payments removes a stabilizing factor and will drastically impact the industry. There are limited alternative uses for most of the lands where sheep and goats are raised. Cattle numbers can be increased slightly but can not replace these small ruminants on most of the land area. There is also considerable opportunity to expand this industry in farming areas where sheep and goats can make efficient use of waste lands, glean cropland, and provide additional returns for the agricultural sector in the Texas economy.

The primary objective of the TAES research program is to provide new technology to maintain a productive and profitable Texas sheep and goat industry. We are pleased to provide this overview of research and related studies conducted by Research and Extension staff. Please contact any of us if we can be of assistance.

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Contents

Explanation of (P<.05)

Dan Waldron

Much of the research in this report has an aim of making a comparison between different animals or animal products (wool and mohair). Some experiments have the objective of comparing different breeds of animals, while some experiments are comparing the same type of animals that are given different treatments. These treatments are often different feed and(or) management. A brief explanation of the implications of the statistical meaning of (P<.05) is given here in order to make this progress report more useful to all readers.

Significant differences when comparing groups or treatments

Several reports will show the differences among groups and include statements such as 'Group A was heavier (P<.05) than Group B' or 'Group A was significantly (P<.05) heavier than Group B' or 'Group A was not significantly (P>.05) heavier than Group B.' The word significantly, as used in this context, refers to the confidence the researcher has in the observed result. The (P<.05) is read: probability less than .05. This indicates that there is less than a 5% probability that the advantage of A over B was not due to the treatment, A vs B, but was due to chance. If P>.05, probability greater than .05, is used, it indicates that there is greater than a 5% chance that the difference between the averages of the two groups is due to chance. In general, a researcher will consider differences between two groups to be not significant if the probability of the difference being due to chance, rather than the treatment used in the experiment, is greater than 10%. The p-value in P<.05 is a measure of the confidence that a researcher has in the result of the experiment. Smaller values indicate a greater confidence.

As a simplified example, assume that a research project was conducted to measure weight gain of two groups of lambs, A and B, in a 30-d period. The average gain of Group A was 14 lb and the average gain of Group B was 12 lb. This would be a significant difference if each of the lambs in Group A gained 14 lb and each of the lambs in Group B gained 12 lb. However, if the Group A lambs' gains ranged from 8 to 20 lb and the Group B lambs ranged from 6 to 18 lb, the difference between the treatments (14 - 12 = 2) might not be significant. Therefore, the variation within a group is considered when determining how much confidence one should have in a difference between groups. A research report may include a statement such as "the higher average gain of Group A over Group B was not statistically significant." This could be restated as "because the variation of gain within each group of lambs was so high, the fact that the average for Group A was greater than the average for Group B may not be repeated if this experiment were conducted again."

A group of animals of similar breeding will not all gain the same or have fleeces with the same fiber diameter. This variation among animals has to be taken into account when describing differences seen in research trials. Using the concept of statistical significance is the accepted way to take into account the biological variation. The variation may be due to genetics (unless animals are identical litter mates or clones they will have some differences in their genetic makeup), health, nutrition, behavior, environment, or a combination of these factors.

The Economic Impact of the Curtailment of Incentive Payments to the Wool and Mohair Industry of Texas

L.L. Jones and A.J. Wyse

Summary

In the summer of 1993, policy makers began discussing amendments to the 1990 farm legislation that would eliminate price incentive payments to wool and mohair growers. Concerns on the part of producers prompted a request to review the economic impacts of that policy alternative.

This study was initiated to estimate the economic impacts of eliminating wool and mohair payments on 1) Tom Green County and seven contiguous counties, 2) a 41 county area of west and central west Texas, and 3) the state of Texas. The study was limited in scope to consider only the initial loss of revenue in each region. It was not designed to estimate the effects of business exits from or entrants to the industry, or other longer term business adjustments.

The 41 county region receives almost 94% of the incentive payments paid to Texas wool and mohair producers. In 1992, incentive payments amounted to over 50% of cash receipts to the wool, mohair, sheep, goat, and lamb industry. This study revealed that the total of the payments represented less than one half of one percent of the total agricultural and industrial sales for the region. However, the multiplier effect of the wool and mohair industry could reduce jobs by 3,000 and personal income by $75 million in the 41 county region if the price support payments are eliminated.

Wool and mohair production is a primary industry that uses local resources, adds value in production and marketing, and provides basic income within the production region and the state. This analysis indicates that the elimination of price incentive payments would have an immediate negative impact on the economies of the sheep and goat producing regions of Texas.

Introduction

Early in the summer of 1993, discussions by national policy makers had begun to include the possibility of an immediate curtailment of incentive payments to wool and mohair producers. Producers in the western Texas area surrounding San Angelo were concerned that such a policy initiative might adversely impact their economic region, since that region produces much of the state's wool and mohair. These producers contacted Texas A&M University and requested information that might promote an understanding of the economic impacts of such a curtailment. This document is a cursory, non-exhaustive look at some of the economic impacts to sales, income, employment, and taxation-supported infrastructures. The study was designed to provide insight into the impacts surrounding the policy alternative.

Materials and Methods

For purposes of comparison, several regions of Texas were considered. The first was a 41 county region of West Texas that accounts for most of the wool, mohair, sheep, goat, and lamb industry in Texas. In 1992, those counties received 94% of the value of incentive payments for wool and mohair paid to Texas (USDA, 1993). Based on 1990 data from the IMPLAN modeling program for impact analysis, the industry in those counties had total sales of approximately $448.7 million. The industry contributed an estimated $75 million to personal income in 1990 and $224 million to the total income of the region. The industry directly employed approximately 8,880 full-time equivalent workers. Physical observation indicates that a significant percentage of those employed would be defined as low wage, minority workers. The city of San Angelo lies within the 41 county region (Table 1). It is located in Tom Green County and is a marketing center for the industry. A second region was modeled that included the seven counties that were contiguous to Tom Green County. Third, economic impacts at the state level were estimated as well.

All three regions were modeled to analyze the impact of a loss of incentive payments at the 1992 wool and mohair payment level. IMPLAN, a well-known computer program that describes the linkages between the industries in an economy through input-output estimating techniques and generates multipliers for industries in the regions, was the program of choice for the modeling efforts. The assumption was made that the loss of revenue from government incentive payments to the wool and mohair industry would occur in one year. This was represented by a loss of sales from the region for that industry.

Research is underway that suggests that if the reduction is phased over a five year period and ranchers exit from the industry and(or) reduce flock sizes, prices

Table 1. Incentive payments to primary wool and mohair producing counties of Central and West Texas.[a]

County	1990 Population (thous)	Area (mi^2)	Wool '92 Pmts.	Mohair ($1,000)
Bandera	10.6	792	58.7	227.9
Blanco	6.0	711	86.5	375.8
Bosque	4.5	748	0.0	223.5
Brown	34.4	944	140.3	406.2
Burnet	22.7	995	70.5	273.1
Comanche	13.4	938	0.0	244.8
Coke*	3.4	899	908.6	290.3
Coleman	9.7	1273	765.5	71.0
Concho*	3.0	992	1,346.7	1,672.0
Coryell	64.2	1052	0.0	844.8
Crane	4.7	786	57.2	0.0
Crockett	4.1	2808	2,669.4	3,782.8
Edwards	2.3	2120	604.0	4,807.4
Gillespie	17.2	1061	712.6	1,422.8
Glasscock	1.4	901	267.5	0.0
Hamilton	7.7	836	0.0	645.8
Irion*	1.6	1052	937.7	0.0
Kendall	14.6	662	159.2	641.5
Kerr	36.3	1106	357.5	822.8
Kimble	4.1	1251	533.8	1,858.0
Kinney	3.1	1364	984.8	2,735.8
Lampasas	13.5	712	199.8	801.4
Llano	11.6	935	49.7	85.6
Mason	3.4	932	128.9	1,401.3
McCulloch	8.8	1069	563.3	366.0
Menard*	2.3	902	715.6	922.0
Midland	106.6	900	125.4	0.0
Mills	4.5	748	381.9	2,480.0
Pecos	14.7	4764	1,091.9	546.4
Reagan	4.5	1175	404.0	0.0
Real	2.4	700	87.2	912.4
Runnels*	11.3	1055	450.9	78.7
San Saba	5.4	1135	122.9	309.6
Schleicher*	3.0	1311	1,514.0	1,048.3
Sterling*	1.4	923	888.3	0.0
Sutton	4.1	1454	925.6	4,098.6
Terrell	1.4	2358	1,027.2	1,596.2
Tom Green*	98.5	1522	2,231.4	845.0
Upton	4.4	1242	480.8	0.0
Uvalde	23.3	1557	467.8	4,034.1
Val Verde	38.7	3171	2,419.8	6,019.3
Totals	643.6	52097	24,936.9	46,891.6
State Totals			26,467.2	49,867.6

[a]Taken from USDA, ASCS, 1993.
*Represents the Tom Green contiguous area studied.

may rise, thereby increasing sales revenues within the region and offsetting some of the impacts described herein. In this report only the first round of impacts was considered. It is expected that over a period of years, the industry would move to a new equilibrium position in both prices and production levels. Hence the analysis presented here is likely a worst case scenario of regional impacts from incentive payment losses.

Results and Discussion

Larger, more integrated economies tend to have higher industry multipliers. This means that the money generated from agricultural or industrial sales, while it is being passed between individuals and industries, tends to stay longer within that economy before it is lost to other regional economies. Table 2 includes the estimated economic impacts to the various regions of a loss of revenue from wool and mohair incentive payments only. Changes in production levels were not included. For example, based on a regional industry multiplier for business sales of 2.0348, the loss of one dollar in sales in the 41 county region from the wool and mohair industry would initiate an estimated loss of $2.03 in sales across all industries. A loss of incentive payments totalling $71.8 million was estimated to cause regional industrial sales to decline by $146.7 million (Table 2). Whereas this loss of sales would be spread throughout the regional economy, the businesses impacted (in addition to the wool and mohair producers) would be those closely linked to the industry because they provide production inputs, services, and product marketing. Also heavily impacted would be retail stores and businesses and services where ranchers and their employees spend their income.

In addition to regional business sales losses, regional total household income was estimated to decrease by slightly more than $75 million, and employment was estimated to decline by 3,000 jobs. It was estimated that those jobs support the livelihood of 6,293 people, or roughly 1% of the 1990-level population in those 41 counties.

In the Tom Green County area, a drop in incentive payments of about $13.8 million was estimated to decrease overall sales by $24.3 million, lower total regional income by $12.4 million, and decrease regional employment by about 485 full-time-equivalent jobs (Table 2). These impacts are inclusive within those estimated for the 41 county region.

Few alternatives exist in the region for land owners who are interested in applying best management practices (BMP) on their land. The wool and mohair industry utilizes a large portion of the surface land resources in the region. Because there is little rainfall, most of the land surface is best-suited for grazing and foraging by sheep, goats, and cattle, rather than producing crops.

Table 3 presents a comparison of multipliers for an 8 county contiguous area around Tom Green County, the 41 county region of West Texas and the state of Texas. The multipliers presented in Table 3 may be used to estimate regional sales, income and employment impacts from any magnitude of wool and mohair price payment reduction. Table 3 suggests, for example, that at the Texas state level, every dollar in sales from the sheep, goat, wool and mohair industry generates a total of $2.48 in industrial sales in the state economy. Every dollar in sales from that industry in Texas generates $1.26 in income from all sources to individuals. Each million dollars of sales lost from the industry is estimated to remove 48 full-time-equivalent jobs from the state and impact the livelihood of 92 people.

Table 3 may also be used to compare the multipliers for each category across the regions. This comparison provides an understanding of the contribution of each region to the other regions from the perspective of a trade area. The difference between the sales multiplier for the Tom Green area (1.7533) and the 41 county area of Texas (2.0348) is equal to 0.2815. This is commonly referred to as economic leakages from the Tom Green area. These impacts result when money from sales of goods produced within the Tom Green area is spent in the 41 county region around the Tom Green contiguous county area. Similarly when comparing the 41 county area sales multiplier for the sector (2.0348) and the Texas sales multiplier (2.4767), it can be seen that leakages of 0.4419 occurred from that region to the state.

Table 2. Economic impacts to the wool and mohair industry from loss of incentive payments across various regions.[a]

	Subsidy ($MM)	Sales ($MM)	Income ($MM)	Jobs (#)	People (#)
Economic Region	1992	Economic Impacts			
Tom Green Contiguous	13.8	-24.3	-12.4	-485	-885
41 County West Texas	71.8	-146.7	-75.0	-3,000	-6,293
State of Texas	74.8	-185.9	-94.8	-3,597	-6,873

[a]Output generated by IMPLAN using data taken from USDA, ASCS, 1993.

Trade among regions is an essential part of any economy. Nevertheless, the economic impact of the sheep and goat industry on the West Texas region could be increased by developmental efforts to supplant imports with local processing and services. Putting it another way, if the region had controlled all of the production, manufacturing, processing, distribution, and equipment manufacturing for the industry, the regional multiplier would have been similar to the state multiplier. That would indicate that the regional economy could possibly benefit from additional industry input suppliers, processors, services, etc., being located within the region.

The impact of a loss of incentive payments for the sheep, goat, wool and mohair industry on federal, state, and local tax generation was estimated for the three regions. Information was used from IMPLAN and the Texas State Comptroller of Public Accounts. The results indicate that for every dollar of payments lost in the 41 county region, almost $0.15 in taxes (state, local, federal) or tax allowances are lost within the region. If the region were to lose the $71.8 million in incentive payments, it would imply that almost $11 million in taxes or tax allowances would fail to be generated in the region (Sharp, 1992). About two thirds, or $7 million, of these impacts would be to taxes and tax allowances at the federal level. The remainder are taxes to the state and local jurisdictions in the amount of about $4 million. When the model for the state is considered, this would imply a loss of tax revenue to Texas of approximately $5 million.

Implications

The wool and mohair industry is a basic industry for Texas and in particular, the west central counties of Texas. The industry adds employment, profits, taxes, and income to the region. However, the industry represents a relatively small segment of the area's economic structure. The study suggests that additional industries that supply the wool and mohair industry could be beneficial to the region.

The study also suggests that the structure of the economic impacts of the aggregate sheep, lamb, goat, wool, and mohair industries are similar for Texas, Colorado, and Wyoming. However, there is some dif-

Table 3. Economic multipliers for the wool and mohair industry for various regions.[a]

	Sales	Income	Jobs	People
Economic Region	Economic Impacts Relative to Sales			
Tom Green Contiguous	1.7533	.8946	35.0315	64.1374
41 County West Texas	2.0348	1.0401	41.6047	87.6452
State of Texas	2.4767	1.2625	47.9344	91.8850

[a]Output generated with IMPLAN.

ference in the enterprise mix within the aggregate industry structure of the sector in Texas. Texas has a somewhat higher amount of goat and mohair production included in the sector than does Wyoming or Colorado. It may be beneficial to consider a further study that breaks out the wool and mohair industries from the aggregated sector.

Addendum

When producers were given the initial results from the study, they requested that the analysis be re-evaluated for the 41 county area with the exception of Midland County. They also requested that Edwards County be evaluated by itself. The multipliers in Table 4 can be used to estimate regional sales, income and employment impacts from any magnitude of wool and mohair price payment reduction. Table 4 suggests that, with an employment and income multiplier of nearly one half of the same multipliers for the 40 county region, Edwards county could benefit from more supporting industries for the wool and mohair industry. The results for Colorado and Wyoming in Table 4 also suggest that there is not a substantial difference in the overall economic impacts of the combined sheep, goat, wool and mohair industry in those states as compared to Texas.

Table 4. Economic multipliers for the wool and mohair industry for (Midland excluded) regions.[a]

	Sales	Income	Jobs
Economic Region	Economic Impacts Relative to Sales		
Edwards County	1.2501	.6195	25.8268
40 County West Texas	1.9961	1.0094	41.3985
State of Texas	2.4767	1.2625	47.9344
State of Colorado	2.2022	1.1759	42.4055
State of Wyoming	2.1145	.7573	49.7427

[a]Output generated with IMPLAN.

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A Target Price Income Support Program for Wool

D.P. Anderson, J.W. Miller, E.G. Smith, R.D. Knutson, and E.E. Davis

Summary

As a result of the U.S. Congress vote to phase out the wool and mohair program, alternatives are being examined for coping with the transition. One alternative for wool and mohair producers is to push for a target price program similar to other government supported crops. This paper discusses a target price alternative framework to the wool incentive payment. The target price developed is in line with the level of support given to other program commodities. When measured against variable cost of production, a target price for wool of $2.90/lb is estimated to be comparable to the level of support given other commodities.

Introduction

When Congress passed the National Wool Act in 1954, it was based on the premise that wool was "an essential and strategic commodity" that needed enhanced revenue as an incentive to produce "desired domestic production" and protect that production from the depressing effects of world markets (National Wool Act, 1954). In spite of this revenue support, the sheep industry has declined in size from its peak of 56 million in 1942 to 7.2 million stock sheep in 1994.

For several years, critics of the wool and mohair program have argued that it does not work, that the rationale for its existence is no longer valid, and that it is not cost effective (GAO, 1990). Proponents counter that whereas the "essential and strategic" rationale may not be as strong today, the producers of wool and mohair need the support to maintain the economic viability of their operations (GAO, 1990). Moreover, because significant wool and mohair production occurs in the most rural areas of the Western United States, without this agriculture base the economies and infrastructure of the rural areas of the West would suffer. In addition, much of the land utilized by sheep and goats is not well suited to other economic uses.

The proponents also argue that it is a no cost program to the U.S. taxpayer because tariffs are collected on imported wool and the support payments by law cannot exceed 70% of the tariff collections. The tariff collections were in place before the Wool Act, and technically the two are tied only by the 70% rationing provision. Proponents argue that there is a justified revenue offset for all expenditures on the wool and mohair incentive programs.

Recent attacks on the Wool Act during the appropriation and budget reconciliation process culminated with its elimination. Congress enacted legislation that phased out the program by 1995. One factor that likely isolated support for the Wool Act was that the program is quite different from other commodity programs. Therefore, other program commodity groups with major constituency blocks did not see its elimination as a direct attack on their program or farm programs in general.

Wool and Mohair Incentive Payments

Wool Act supports are termed incentive payments. The payment percentage is calculated as:

Incentive Payment Rate = (Support Price - Market Price)/Market Price.

The incentive rate when multiplied by the producer's actual receipts determines the payment paid by the government to the producer as an incentive for producing wool and mohair. By basing payments on actual receipts, the government has given the incentive to producers to market higher quality wool and mohair at the highest price they can get. An individual producer is encouraged to market wool/mohair at the highest price because the higher the price, the greater the additional incentive payment. The U.S. government benefits because when producers respond to the marketing incentive, average market prices are increased, incentive rates lowered, and government budget expenditures reduced.

Target Price Alternative

Other farm program commodities (e.g., wheat, feedgrains, cotton, and rice) have target price/deficiency payment programs. In this type of program the income support level (target price) minus the higher of the market price or nonrecourse loan rate is paid to producers in the form of a deficiency payment. Some will argue that because there is no multiplicative incentive to generate higher revenues in the marketplace, producers of other commodities have less incentive to improve quality than do wool and mohair producers. Regardless of the merits of this argument, the difference in the basic structure of the programs likely contributed to the lack of support for the wool and mohair program from other farm-program-supported commodity groups.

An alternative to the Wool Act support structure is to develop a target price program similar to the other farm program commodities. The advantage of this type of program for wool is that it would bring the program in line with the other government supported commodities. Economic justifications could then be utilized based on criteria such as equity relative to other commodities, contributions to rural development, market power differentials between producers and buyers and sellers, enhanced income stability due to the biological nature of production, and protection against international decisions that occur outside the forces of a competitive free market. To develop this alternative, a target price level must be determined. The purpose of this paper is to outline a method of arriving at the level of target price protection for wool that is equitable when contrasted to other farm program commodities.

The concern over equitable treatment of farm-program-supported commodities is not new. A policy issue frequently discussed is a comparison of relative farm program benefits across commodities. This paper proceeds by first determining the relative income supports provided to the target price supported commodities (corn, wheat, rice, and cotton) and then compares those to the level of income support historically provided through the wool incentive program. Second, a target price level is determined for wool that provides equitable revenue protection when compared to the levels generated for the other program crops.

Methodology

One method of measuring government program benefits across commodities is to compare effective total revenue to production costs. This is not as simple as dividing target price by a per unit measure of cost because requirements to idle acreage are normally imposed on the program crops as a condition of program participation. To effectively measure the benefits for a program crop, therefore, total revenues and costs must be adjusted to consider acreage reduction rates (set-aside requirements), maintenance costs of set-aside acres, net loan rates, and marketing loan benefits. After adjusting for such program-induced-cost, the equity issue is addressed by providing an effective measure of total revenue including government payments relative to production costs. For example, a modest target price with a low acreage reduction requirement may comprise more farm program benefits than a high target price with a high acreage reduction requirement. The formula used for determining the Program Crop Equity Ratio (PCER) is

$$PCER = \frac{([DP^{*}FPY][1 - ARP - NFA]) + (MLP) + ([MP^{*}AY][1 - ARP])}{([VCE][1 - ARP]) + (MA^{*}ARP).}$$

Table 1 includes the definitions of all variables and the sources of the data used. A more detailed discussion of the equity ratio process was given by Miller et al. (1994).

For sheep production, the formula is less complicated because the farm program variables (ARP, FPY, and DP) are not present[1]. The adapted formula for sheep and wool is

$$\text{Sheep Equity Ratio} = \frac{MRL + MRW + WIP + ULIP}{VCE.}$$

The formula used to determine a target price for wool is based on the average of the equity ratios for corn, wheat, rice, and cotton. This average program crop equity ratio represents the level of government support that a wool target price program would have to generate in order to keep the level of revenue from sheep production (including government support) relative to variable cash expenses in line with other farm program commodities. Since the government income is only applied to the production of wool, the program crops equity ratio is multiplied by the variable cash expenses for sheep in 1990 to generate a total revenue necessary to maintain the average level of support. The total support payments to producers per pound of wool is generated by subtracting out MRL returns in 1990 from the calculated total revenue. The remaining value is divided by 10 lb of wool since the USDA cost of production and returns data are calculated on a per ewe basis and assumes 10 lb of wool is generated per ewe. The result of this process is a target price for wool that if operated similar to the other program crops would provide support in terms of variable cash expenses that is on par with other program commodities.

Results and Discussion

Table 2 contains the program crop equity ratios for corn, wheat, cotton, rice, and wool for 1984 to 1990. Results for 1991 to 1993 are not included because the Economic Research Service cost of production data for sheep has not been published. The information in Table 2 indicates that wheat and corn have had the highest level of relative protection over the 1984 to 1990 time period followed by cotton and rice. It may be concluded that the level of revenue for sheep production relative

[1] This section deals only with estimating a target price for wool. A target price for mohair is not estimated because there are currently no viable cost estimations for goat and mohair production. Extension budgets are available, but are not developed using the same methodology as the USDA cost of production estimates so they were not used.

Table 1. Identification and sources of terms used in the formulas for calculating effective total revenue to production costs.

Term	Definition	Source
AR	Acreage Reduction Percentage	ASCS, Commodity Fact Sheet
AY	Actual Yield	USDA,Economic Indicators of the Farm Sector
DP	Deficiency Payment Rate	ASCS, Commodity Fact Sheet
FPY	Farm Program Yield	USDA, ASCS, Press Release
MA	Maintenance Costs on Set Aside Land	Estimated at $20.00 per Acre
MLP	Per Unit Marketing Loan Payment	Estimated for USDA Marketing Loan Expenditures
MP	Average Market Price	ASCS, Commodity Fact Sheet
MRL	Market Returns for Lambs and Culls	USDA, Economic Indicators of the Farm Sector
MRW	Market Returns for Wool	USDA, Economic Indicators of the Farm Sector
NFA	Normal Flex Acreage	ASCS, Commodity Fact Sheet
ULIP	Unshorn Lamb Incentive Payments	USDA, Economic Indicators of the Farm Sector
VCE	Variable Cash Expenses	USDA, Economic Indicators of the Farm Sector
WIP	Government Wool Incentive Payments	USDA, Economic Indicators of the Farm Sector

Table 2. Relative farm program benefits across selected program commodities as measured by effective total revenue to variable cash expenses (equity ratio), 1984 to 1990.

Item	1984	1985	1986	1987	1988	1989	1990
Corn	2.239	2.228	2.434	2.579	2.456	2.423	2.265
Wheat	2.615	2.608	2.645	2.731	2.693	2.428	2.284
Rice	1.953	2.018	1.887	1.886	1.869	1.981	1.851
Cotton	1.985	2.059	2.032	2.114	2.070	2.047	1.910
Four crop average	2.198	2.228	2.250	2.328	2.272	2.220	2.078
Sheep	1.976	2.250	2.380	2.707	2.254	2.097	1.936

to cost has been in line with the other commodities over the time period studied.

The 1990 average equity ratio of effective total revenue to variable cash expenses for the four program crops included in this study was 2.078. Multiplying the 2.078 factor times variable cash expenses for sheep in 1990 of $32.17/ewe yields a targeted total revenue of $66.85. Subtracting out the 1990 market returns for feeder lamb, slaughter lamb, and cull ewe sales of $37.83 generates $29.02 of government returns per ewe. Dividing $29.02 by 10 lb of wool generates a target price of $2.90/lb of wool. If the lowest equity ratio generated (1.851) is used a target price of $2.17/lb of wool is generated. The highest equity ratio, 2.284, generates a target price of $3.57/lb of wool.

It is important to note that this target price is irrespective of wool quality or breed of sheep. The incentive payments encourage higher quality wool production by tying individual payments to actual individual receipts. The target price concept does not do this. Adjusting the target price for quality is beyond the scope of this study.

The sheep industry has a complicating factor in this procedure that is not present in the other commodities. This is the fact that meat generates the majority of receipts for sheep producers. The government support for the industry is on wool which generated only 20% of total market receipts in 1990 (USDA, 1990). Cotton is similar in that there is dual production of cotton lint and cottonseed. In this case, however, cotton lint generates the majority of cotton revenue which is supported under the program relative to the cottonseed byproduct that is not directly supported.

Conclusions

The historical benefits of the wool program relative to the other program crops do not appear to be out of line when analyzed on the basis of effective revenue to variable cash expenses. In each year studied from 1984 to 1990 the equity ratio for sheep production fell within the range generated for the other program crops analyzed (corn, wheat, cotton, and rice). Converting sheep production to a target price type income support program via wool would require a target price for wool of approximately $2.90/lb for the program to remain equitable to the other studied program crops.

If such a program was envisioned, sheep producers would have to address many challenges to developing a target price program. Not the least of which is that government support would be targeted to an output (wool) that represents a minority of the total revenue from sheep. That minority, however, is very critical in determining profitability.

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Effect of Prostaglandin on Results of Artificial Insemination in Goats

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Summary

Spanish does (N=108) were synchronized for breeding by artificial insemination during the natural breeding season. The synchronization regimen consisted of insertion of a CIDR for 16 days with an injection of 250 IU of PMSG given 48 hours before CIDR removal. Prostaglandin was given 48 hours before CIDR removal to a random half of the does. Breeding was by laparoscopic artificial insemination with frozen-thawed semen between 37 and 42 hours after CIDR removal. The mean conception rate was 59%. The mean litter size was 1.67 kids/doe kidding. There was no effect of prostaglandin on conception rate or litter size.

Introduction

The recent importation of Boer goats into the United States has increased the interest in the use of artificial insemination (AI) with goats. The use of AI increases the number of progeny that a buck can sire in a season and makes it feasible to use one buck on several ranches at the same time. A successful AI program requires the females to ovulate during a short, predictable period of time if timed inseminations are to be used. Synchronization of estrus and ovulation is usually accomplished by use of a progestin for 9 to 16 days together with a gonadotropin such as pregnant mare serum gonadotropin (PMSG), administered between the time of removal of progestin and 48 hours prior to removal of progestin. Corteel et al. (1982) reported that the addition of prostaglandin to the progestin/PMSG treatment resulted in a better synchronized and more fertile estrus in anestrous dairy goats. The reason for this effect of prostaglandin in noncycling does was unknown. However, the prostaglandin was associated with a shorter progestin treatment (11 vs 21 days), so the isolated effect of the prostaglandin could not be estimated. The purpose of this report is to estimate the effect of an injection of prostaglandin on conception and kidding rate of Spanish does that were synchronized with a progestin/PMSG regimen during the natural breeding season.

Experimental Procedure

A total of 108 mature Spanish does with an average body weight of 82 lb were maintained on pasture at the Winters Ranch near Brady, Texas. Sterilized teaser bucks with marking harnesses were placed with the does on September 2, 1993. The first two breeding groups consisted of does that had been marked by the teaser bucks. The intention was to use only females that had completed a full length cycle in order to avoid transitional period heats that might be followed by early luteal regression. However, some of the does in the third group had not been marked by the teaser bucks prior to the start of the synchronization regimen. Dates of the three breeding groups are shown in Table 1. The synchronization regimen consisted of insertion of a controlled internal drug release (CIDR) dispenser (Wheaton et al., 1993) in the vagina for 16 days and injection of 250 IU of PMSG 48 hours before CIDR removal. A random half of the does received prostaglandin (5 mg of dinoprost tromethamine, Lutalyse®) by intramuscular injection at the same time that the PMSG was administered. The numbers of does by breeding group and prostaglandin treatment are shown in Table 1. Teaser bucks were put with the does at 20 hours after CIDR removal. Laparoscopic insemination using frozen-thawed semen was started 37 hours after CIDR removal. Does that were observed standing for a teaser buck at 24 hours after CIDR removal were inseminated first. Insemination was completed at 42 hours after CIDR removal.

Differences in conception rate and litter size were tested for significance with Chi-square statistics.

Results and Discussion

The kidding results are summarized in Table 2. The average percentage of does kidding was 59%. The group that received prostaglandin had 58% of the does kid, and the control group had 60% of the does kid. There were no significant differences in conception rate

Table 1. Number of does by breeding date and prostaglandin treatment.

Date of CIDR	Date of insemination	Prostaglandin	Control
10/11/93	10/29/93	13	14
10/25/93	11/12/93	20	20
11/01/93	11/19/93	20	21
Total		53	55

due to the prostaglandin treatment in any of the 3 breeding groups.

The litter size, number of kids born, per doe kidding was not affected by prostaglandin treatment (Table 3). The number of does having litter sizes greater than two was too small for a meaningful statistical test.

The lack of effect suggests that prostaglandin was unnecessary in this synchronization regimen. However, when a progestin is used for a shorter time (less than 16 days) in cycling goats, prostaglandin may still be necessary to ensure that all functional corpora lutea are removed prior to the time of progestin withdrawal. The variation in conception rate, evidenced by the nonsignificant difference in conception rate between the prostaglandin treatments in groups inseminated on November 12, and November 19, 1993, indicates that conclusions should not be drawn from one unreplicated trial. A successful AI program in goats requires proper feeding and management as well as an effective synchronization and insemination program. Prostaglandin and CIDR's are not approved for use in goats.

Table 2. Percent of does kidding by breeding date and prostaglandin treatment.

Date of insemination	Prostaglandin (%)	Control (%)
10/29/93	69	71
11/12/93	55	40
11/19/93	55	71
Overall	58	60

Table 3. Number of does by litter size and protaglandin treatment.

Litter size	Prostaglandin	Control
1	12	13
2	17	17
3	0	3
4	1	0
Total	30	33

Implications

When a synchronization regimen consists of a 16-d CIDR treatment and PMSG 48 hours before CIDR removal in goats during the natural breeding season, an injection of prostaglandin does not affect conception rate or litter size.

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Effects of Transportation and Electro-Ejaculation Stress Superimposed on Stress Induced by Consumption of Phenolic Monoamines in Male Angora Goats

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Summary

Twenty-four male Angora goats were used to determine the effects of handling and electro-ejaculation stress superimposed on stress induced by the consumption of phenolic monoamines. Phenolic monoamines are widely distributed in native browse species in South Texas. Animals were allotted by body weight to either a 4-acre pasture dominated by guajillo and blackbrush (GB) or a diet of alfalfa hay and a commercial concentrate ration (Control) fed in a pen at approximately 2.7% of body weight. Before being placed on treatments, the animals were electro-ejaculated to ensure sexual activity. After 10 days on pasture, and at two-week intervals thereafter over 56 days during the 66-d trial, each group (n=12) was gathered and blood sampled. Each group was transported by trailer to a central location where a second blood collection was immediately obtained. Following a rest period, the animals were blood sampled a third time and immediately electro-ejaculated. After electro-ejaculation the animals were blood sampled a final time. At each two-week interval, scrotal circumference was measured, as was ejaculate volume, sperm cell concentration (sperm cells x 10^6/ml), total sperm cells per ejaculate (sperm cells x 10^6), and percent motility. Blood was processed to yield serum and analyzed for serum cortisol concentration. Animals remained on diet treatment for an additional 33 days before being slaughtered, when the testes and associated organs were removed. After 38 days on pasture, scrotal circumference began to decline in the GB group, while remaining relatively constant in the Control group. There were no differences in sperm motility or semen concentration between the two groups. Weights of testes, left epididymis, vesicular gland, and bulbourethral gland were all lower ($P<.01$) in the GB group. Consumption of amine-containing plants appears to have reduced scrotal circumference and, therefore, may have negatively affected reproductive performance in the GB animals. Serum cortisol concentration was affected by transportation ($P<.03$) and electro-ejaculation ($P<.05$). Adrenal exhaustion was apparent in the guajillo-blackbrush group following transportation.

Introduction

Most woody plants found on the Rio Grande Plains of South Texas contain secondary chemical compounds, many of which are toxic to some degree to browsing animals. Among the most important compounds are the phenolic monoamines that are widely distributed between the acacias and other members of the South Texas flora (Camp and Norvell, 1966; Smith, 1977). The phenolic monoamines are economically important due to their sympathomimetic activity, and in some cases (mescaline and amphetamine for example) their psychosomatic properties. It is known that consumption of large amounts of guajillo (*Acacia berlandieri*) over extended periods results in an ataxic condition in sheep and goats, colloquially known as "guajillo wobbles" (Price and Hardy, 1953). Further, it has been shown that guajillo contains relatively high concentrations of the amines n-methyl-ß-phenethylamine (NMP) and tyramine (Forbes et al., 1991). NMP was found to interfere with progesterone production in Angora nannies (Forbes et al., 1993), and to reduce the production of luteinizing hormone by the pituitary gland in heifers (Carpenter et al., 1994) and in wethers (Forbes et al., 1994). These findings suggest that NMP affects the hypothalamic-pituitary-gonadal axis via its effects on the adrenal glands. The finding that NMP causes the release of cortisol and norepinephrine (Forbes et al., 1994) suggests that animals consuming range plants containing NMP are likely to be under some degree of chronic stress. An experiment was conducted to determine if there was any evidence to support the hypothesis that NMP consumption under typical management conditions leads to chronic stress in male goats. The effects of the superimposition of the stress of handling and transportation followed by electro-ejaculation were examined, as were the effects of amine consumption on indices of reproductive function.

Experimental Procedure

Twenty-four male Angora goats (initial BW 60 lb) were selected on the basis of sexual maturity from a group of 50 ten-month-old animals. Animals (twelve per group) were then randomly allotted to receive a

diet of alfalfa hay and commercial 14% protein pellets fed at approximately 2.7% of body weight (Control) or be placed on a 4-acre pasture dominated by guajillo and blackbrush (*A. rigidula*), (GB). Dietary treatments were designed to represent 1) a level of feeding to allow moderate rates of gain and 2) conditions typical of poor-condition, brush-infested rangeland.

Animals were placed on their respective treatments at the end of September, 1993. At two-week intervals over a 66-d period, the animals were gathered at their respective locations and blood sampled. Each group was then transported by stock trailer to a central location, where the animals were again blood sampled upon arrival to determine the effects of transportation stress. Following a rest period of between one and two hours, the animals were blood sampled again and electro-ejaculated. Scrotal circumference was measured and a final blood sample collected. Blood samples were collected by jugular venipuncture using Vacutainers®, placed on ice for 24 hours, and then processed to yield serum. Serum was analyzed for cortisol concentration using a commercially available radioimmunoassay procedure. Following electro-ejaculation, ejaculate volume was measured, as was sperm cell concentration (sperm cells x 10^6/ml), total sperm per ejaculate (sperm cells x 10^6), and percent motility.

Animals remained on dietary treatment for a further 33 days during which time effect of treatment on cortisol release following GnRH challenge was examined. At the end of this period, the animals were transported to the School of Veterinary Medicine at College Station, Texas, and slaughtered. For logistic reasons, slaughter was delayed until after the Christmas vacation. At slaughter, animals were weighed and the testes and accessory organs removed.

Body weight, scrotal circumference, sperm per ejaculate, and ejaculate volume data were analyzed using repeated measures analysis of variance in PROC GLM (SAS, 1988). Where appropriate, least squares means were separated using the PDIFF option. Cortisol concentrations and testis and accessory organ weights were analyzed by analysis of variance. Cortisol concentrations were analyzed as the differences between post-transportation less pre-transportation values, and post-ejaculation values less pre-ejaculation values.

Results and Discussion

The trial was conducted during a particularly dry fall, with only .4 inches of precipitation being recorded between July and December on the guajillo-blackbrush pasture. In addition, an unusually early (Sept. 30) frost resulted in a reduction in the amount of actively growing browse for the goats on pasture. Because this pasture had been selected on the basis of its poor range condition, there was very little grass and no forbs available to these animals. Browse availability became limited between day 80 and slaughter, and supplementary browse was cut and fed to the GB group.

The repeated measures treatment x time interaction for body weight was significant (P<.0001), though the Control group was significantly (P<.02) heavier than the GB group only on day 66 (Table 1). Whereas we can offer no evidence,it is interesting to speculate whether the lower rate of gain in the GB animals is a result of appetite suppressing properties held by the amines contained in the browse, or from a decline in browse availability. Although no measurements of browse biomass were attempted, visual observation indicated both guajillo and blackbrush to have adequate leaf biomass at all levels on the plants, at least through day 66. Amphetamine, an amine structurally similar to NMP, is a known appetite suppressant, and results from other studies (Forbes et al., 1993) indicate the possibility that NMP might reduce intake. By slaughter the groups differed significantly (P<.0001) in body weight (76.8± 1.77 vs 49.1± 2.20, Control and GB groups, respectively), with the GB group having lost weight between day 66 and slaughter. In addition, there were difficulties associated with weighing the animals prior to slaughter, and the Control group was weighed with larger amounts of rumen fill than the GB animals. This no doubt contributed somewhat to the differences in body weight reported.

For scrotal circumference, the treatment x day interaction was significant (P<.0001). Scrotal circumference of the GB group declined over the course of the trial, the reduction in size occurring by day 38 (Table 1) and the difference between the two groups increasing over days 52 and 66. Ejaculate volume declined (P<.002) over the course of the trial in the GB group, while increasing in the Control group. Differences between means were apparent by day 52 (Table 1). Number of sperm per ejaculate, however, was not affected by treatment or the length of time on treatment. Total testis weight was reduced (P<.0001), as were epididymal weights (P<.0001), vesicular gland weights (P<.0001) and bulbourethral gland weights (P<.05), in the guajillo-blackbrush group compared to the Control group (Table 2). Whereas differences in accessory organ weights may be due to weight differences at slaughter, declines in scrotal circumference had occurred by day 38, and presumably accessory organ weights had decreased similarly. Changes in cortisol release in response to transportation stress were recorded on day 38 in the GB group (Table 3).

Pre-transportation and the change due to transportation values for serum cortisol concentrations are given in Table 3. These data show that the pre-transportation concentrations of cortisol of the two groups

Table 1. Body weight (lb), scrotal circumference (inches), total sperm/ejaculate (sperm cells x 10^6), and ejaculate volume (ml) in Angora male goats on a control diet or on guajillo-blackbrush (GB) pasture during the rutting season.

	Days on treatment				
Item	10	24	38	52	66
Body weight					
Control	52.9	58.5	59.8	61.8	65.6[a]
GB	53.0	57.3	59.4	57.3	58.9[b]
SEM	1.79	1.97	1.97	1.90	1.97
Scrotal circumference					
Control	8.5	8.5	8.1	8.3[c]	8.6[a]
GB	8.5	8.3	7.6	7.6[d]	7.7[b]
SEM	.24	.24	.27	.27	.26
Sperm/ejaculate					
Control	250	832	711	775	762
GB	704	536	936	732	654
SEM	158.5	270.6	242.6	225.7	185.3
Ejaculate volume					
Control	.44	.47	.52	.68[a]	.56[a]
GB	.56	.37	.54	.34[b]	.39[b]
SEM	.094	.049	.059	.058	.059

[a,b]Within a sampling date means with different superscripts differ (P<.05).
[c,d]Within a sampling date means with different superscripts differ (P<.07).

differed (P<.01) as time passed. The GB animals showed increasing cortisol concentrations at each pre-transportation collection in contrast to the relatively stable levels shown by the control animals. The control animals responded to transportation by releasing additional cortisol into the peripheral blood supply, as indicated by the change due to transportation values (Table 3). In contrast, the guajillo-blackbrush group was unable to release as much additional cortisol in response to transportation, especially in the latter weeks of the trial. From this it

Table 2. Effect of control or guajillo-blackbrush (GB) diet on mean testis weight (g), epididymal weight (g), vesicular gland weight (g), and bulbourethral gland weight (g) in Angora male goats at slaughter after the rutting season.

	Treatment		
Organ weight	Control	GB	P[a]
Total testis	178± 10.4	97 ± 9.3	.0001
Left epididymis	12.8 ± .65	7.1 ± .65	.0001
Vesicular gland	5.6 ± .70	2.5 ± .22	.0001
Bulbourethral gland	1.14 ± .08	.78 ± .16	.047

[a]P values for treatment differences.

Table 3. Pre-transportation and change in serum cortisol concentrations (ng/ml) due to transportation, and pre-ejaculation and change in serum cortisol concentrations due to ejaculation in male Angora goats on a control diet or guajillo-blackbrush (GB) pasture during the rutting season.

	Days on treatment					
Treatment	10	24	38	52	66	P
Pre-transportation						
Control	19 ± 1.9	27 ± 3.3	22 ± 3.0	23 ± 3.5	24 ± 3.7	.8[a]
GB	18 ± 1.8	19 ± 1.9	25 ± 2.3	26 ± 2.4	30 ± 1.8	.01[b]
Change due to transportation						
Control	48 ± 5.1	23 ± 2.38	26 ± 4.1	28 ± 3.8	29 ± 5.4	.03[a]
GB	38 ± 4.3	34 ± 4.5	18 ± 4.5	16 ± 4.9	5 ± 4.9	.0006[b]
Pre-ejaculation						
Control	12 ± 1.4	12 ± 1.6	15 ± 2.5	12 ± 2.9	15 ± 3.4	.002[a]
GB	8 ± .8	9 ± .8	9 ± 1.5	10 ± 1.9	7 ± .6	.4[b]
Change due to ejaculation						
Control	28 ± 3.2	21 ± 1.9	25 ± 2.4	25 ± 2.9	24 ± 4.5	.05[a]
GB	17 ± 2.3	19 ± 2.0	21 ± 3.2	21 ± 2.4	23 ± 1.9	.3[b]

[a]P values for treatment effect.
[b]P values for treatment x time interaction.

would appear that a degree of adrenal exhaustion occurred in the GB animals during transportation.

Pre-ejaculation serum cortisol concentrations and the change in concentrations due to electro-ejaculation are given in Table 3. The effect of treatment was significant ($P<.05$), but the treatment x time interaction was not. Both groups were capable of responding to the stress of electro-ejaculation following the rest period between transportation and electro-ejaculation, but the response was less in the GB group. Both groups showed evidence of cortisol clearance during the time between the post-transportation blood sample and the pre-ejaculation blood sample. The lower cortisol concentrations in the GB group may reflect the slightly longer rest period between the end of transportation and electro-ejaculation experienced by this group compared to the Control group.

This study shows conclusively that male goats browsing exclusively on guajillo-blackbrush dominated range at high stocking rates during periods of drought are likely to have impaired reproductive performance. This impairment is linked to dysfunction of the adrenal-pituitary-gonadal axis resulting from consumption of secondary compounds in browse species in combination with less than ideal management. These results complement previous studies conducted with wether sheep (Forbes et al., 1994), and the data provide even stronger evidence of the danger associated with overstocking and excessive reliance on acacia species browse for reproductively active livestock.

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Loss of Sperm Motility in Male Angora Goats Grazing Buffelgrass-Dominated Range

T.D.A. Forbes, H. Vera-Avila, and R.D. Randel

During an experiment designed to examine the effects of the superimposition of handling and electro-ejaculation stress on stress induced by the consumption of phenolic monoamines (Forbes et al., this publication), goats grazing a buffelgrass-dominated pasture exhibited an almost total loss of sperm motility. Thirty-six, 10-month-old, male Angora goats were allotted by body weight to graze either a 4 acre pasture dominated by guajillo-blackbrush (GB), a 4 acre pasture dominated by buffelgrass (*Cenchrus ciliaris*), or were penned and fed a diet of alfalfa hay and a commercial concentrate ration (Control). Dietary treatments were designed to represent poor and good range conditions, respectively, and a control diet providing nutrients adequate for growth. Prior to being placed on treatments in the fall (September 29, 1993), the animals were electro-ejaculated to ensure sexual activity. Blood sampling to characterize cortisol response to handling and transportation was conducted after 10 days on pasture, and at two-week intervals thereafter through 66 days. At each sampling period, scrotal circumference was measured, as was ejaculate volume, sperm cell concentration (sperm cells x 10^6/ml), and percent motility. At 52 days, sperm motility declined dramatically ($P<.0001$) relative to the other two groups of animals (Table 1). Sperm cell concentration was greatly reduced on day 52 in the buffelgrass group compared to the others (Table 1), but the time x treatment interaction was of low significance ($P<.08$). Ejaculate volume was reduced ($P<.05$) in the buffelgrass pasture group relative to the controls on the last sampling date. Scrotal circumference was not impacted by grazing buffelgrass-dominated pasture. In addition all animals on buffelgrass gained weight during the study, and live weight did not differ ($P>.3$) among treatment groups.

Table 1. Live weight (lb), scrotal circumference (cm), ejaculate volume (ml), sperm motility (%), and sperm cell concentration (sperm cells x 10^6/ml) in Angora male goats on a control diet or on guajillo/blackbrush (GB) or buffelgrass pastures during the rutting season.

	Days on treatment				
Treatment	10	24	38	52	66
Live weight					
Control	52.9	58.5	26.7	27.6^{ab}	29.3^{a}
GB	53.1	57.3	26.5	25.6^{b}	26.3^{b}
Buffelgrass	56.0	59.8	27.9	28.3^{a}	28.3^{ab}
SEM	1.77	1.90	.90	.85	.89
Scrotal circumference					
Control	21.5	21.5	20.5^{ab}	21.2^{a}	21.9^{a}
GB	21.6	21.1	19.4^{b}	19.4^{b}	19.6^{b}
Buffelgrass	22.6	22.5	21.5^{a}	21.5^{a}	21.6^{a}
SEM	.57	.57	.67	.67	.63
Ejaculate volume					
Control	.4	.5	.5	.6^{a}	.6^{a}
GB	.6	.4	.5	.3^{b}	.4^{b}
Buffelgrass	.5	.5	.6	.6^{a}	.4^{b}
SEM	.09	.07	.05	.07	.05
Sperm motility					
Control	55	61	54	66^{a}	64^{a}
GB	54	59	66	63^{a}	55^{a}
Buffelgrass	56	69	49	4^{b}	15^{b}
SEM	6.5	5.7	7.0	4.9	6.4
Sperm concentration					
Control	938	2496	2629	1570^{ab}	2197
GB	1674	1997	2271	2682^{a}	2368
Buffelgrass	1254	2143	1232	591^{b}	1079
SEM	311.1	616.9	496.2	458.4	483.5

^{a,b}Within a sampling date, means with different superscripts differ ($P<.05$).

The cause of the loss in sperm motility is unknown at this point. The pasture had not been grazed for two years previously and had adequate biomass of buffelgrass (estimated to be in excess of 2000 lb/acre). Eight species of browse were recorded in the buffelgrass pasture, including twisted acacia (*Acacia schaffneri*), catclaw acacia (*Acacia greggii*), guayacán (*Porlieria angustifolia*), mesquite (*Prosopis juliflora* var. *glandulosa*), persimmon (*Diospyros texana*), spiney hackberry (*Celtis pallida*), wolfberry (*Lycium berlandieri*) and whitebrush (*Lippia ligustrina*), with guajillo (*Acacia berlandieri*) being the most common. Although many other areas remained dry, isolated thunderstorms dropped over 3 inches of rain on the pasture in July. Dry conditions then developed, and during the study the buffelgrass was largely standing hay. An early frost (September 30) damaged much of the browse, and snow was recorded in early October. Whereas it is impossible to determine the true cause of the reduction in sperm motility in the buffelgrass group, two possibilities may be suggested. Firstly, it is possible that ergot developed on the buffelgrass flowerheads in the summer which were then consumed by the goats in the fall, with subsequent damage to the sperm produced early in the trial and subsequently stored in the epididymis. However, ergot is not commonly found in buffelgrass in the upper regions of the Rio Grande Plains (M. Hussey, personal communication). Secondly, consumption of one or more of the browse species may have had a similar effect on sperm stored in the epididymis. One or more phenolic amines are known to occur in guajillo, twisted acacia, catclaw acacia and mesquite (Camp and Norvell, 1966; Smith, 1977), and it is likely that the same and/or other alkaloids occur in the other browse species. One or more of these compounds could have been responsible for the sperm death. It is known from previous studies that phenolic monoamines can adversely affect aspects of the hypothalamic-adrenal-gonadal axis in cattle (Carpenter et al., 1994), goats (Forbes et al., 1993), and sheep (Forbes et al., 1994). Further studies are required to determine the loss of sperm motility in these animals.

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Reproductive Performance of Rambouillet and Australian Merino x Rambouillet Cross Ewes

T.D. Willingham, D.F. Waldron, M. Shelton, P.V. Thompson, and G. Snowder

Summary

Crossbred lambs generated with frozen semen from six rams from each of three different breed-types (Rambouillet [R], Australian strong-wool Merino [ASW], and Australian fine-wool Merino [AFW]) inseminated in Rambouillet ewes were evaluated for reproductive performance when managed under Texas range conditions. These data represent reproductive performance of ewes at ages two and three yr. Rambouillet ewes were 6.5 and 10.7 lb heavier (P<.05) than ASW and AFW ewes. Fertility of ewes and mean weaning weight of lambs were similar (P>.05) for the three breed-types evaluated. Rambouillet ewes were more prolific (P<.05) having a 137.8% lamb crop born of ewes lambing as compared to 119.2 and 110.7% for the ASW and AFW ewes, respectively.

Introduction

In recent years, interest has been shown by some producers in the inclusion of Australian Merino sheep in a crossbreeding program with Rambouillet. Whereas the main focus of this breeding program was the improvement of fleece characteristics, particularly increased clean wool weight, producers in the United States require information on reproductive performance of the crossbred ewe in comparison to the Rambouillet to fully assess the desirability of introducing the breed. The importance of reproduction to the producer may be of greater importance currently due to the phasing out of the wool incentive program. A cooperative multistate project was initiated to provide data on fleece characteristics, reproductive performance and carcass traits of Australian Merino x Rambouillet cross animals compared to Rambouillet. This report provides preliminary data from one station (Texas) on a few reproductive traits of Rambouillet and Australian Merino x Rambouillet ewes.

Experimental Procedure

Ewes of three different breed types, Rambouillet (n = 46), Australian strong-wool Merino x Rambouillet (67), and Australian fine-wool Merino x Rambouillet (50) were produced and managed at the Winters ranch near Brady, Texas. Numbers vary among breeds due to availability of animals and between the two yr due to loss of some animals. Data were collected on the same animals for two consecutive years. Ewes were weighed in August at approximately 18 and 30 mo of age. Ewes were then exposed to mature Suffolk rams at 18, 27, and 30 mo of age. Rambouillet rams were added late in the season as cleanup. Ewes were placed in small pastures prior to lambing and then lambed in a barn. Data collected at lambing included birth date, birth weight, birth type, and sex. At weaning, lamb weights and date of weaning were recorded. Statistical analysis of data was performed using the Mixed procedure of SAS (1992). Because all ewes were born in 1990, yr and age were confounded. The model used to estimate breed differences for fertility and prolificacy included fixed effects for yr or age (1992 and 1993 for fertility, spring 1992, fall 1992 and spring 1993 for prolificacy), and breed, and random effects for sire of dam, nested within breed, and dam, nested within breed and sire of dam. Weaning weights were analyzed with a model that contained fixed effects for yr, breed, sire of lamb, sex of lamb, birth type and a linear covariate for age at weaning. Random effects included sire nested within breed, ewe nested within breed, and sire of dam. Linear contrasts were used for comparison of breed types. Preliminary analysis showed no significant interactions.

Results and Discussion

Breeding weights, and reproductive performance for Rambouillet (R), Australian strong-wool Merino x Rambouillet (ASW), and Australian fine-wool Merino x Rambouillet (AFW) ewes, evaluated under Texas range conditions are shown in Table 1. Rambouillet ewes were heavier (P<.05) at breeding than ASW or AFW (6.5 and 10.7 lb, respectively) ewes. Fertility, or the number of ewes lambing from ewes exposed to rams, did not differ (P>.05) statistically for the three breed types evaluated. Prolificacy or the number of lambs born per ewe lambing was greater (P<.05) for R ewes than ASW or AFW ewes. When these data are expressed on the basis of lambs born per 100 ewes lambing, R ewes produced 18 and 27 more lambs than ASW and AFW ewes, respectively. The low fertility observed was due primarily to the first lambing (73.9, 61.2, and 61.2%; R, ASW, and AFW, respectively). Each of the three breeds had fertility ranging between 90 and 91.5% in the second

Table 1. Least squares means of fertility and prolificacy by breed.

Sire breed	Breeding weight (lb)	Number of ewes exposed	Ewes lambing of ewes exposed (%)	Lamb crop born/ewe lambing (%)	Weaning weight (lb)
Rambouillet	115.8[a]	86	82.3[a]	137.8[a]	58.9[a]
Aust. Merino strong wool	109.3[b]	128	75.6[a]	119.2[b]	56.6[a]
Aust. Merino fine wool	105.1[b]	97	75.7[a]	110.7[b]	56.7[a]

[a,b] Means within columns having different superscripts differ (P<.05).

year. Although fertility did not differ significantly between breed types when age or yr was accounted for, lambing data for the first year suggest that Australian strong-wool Merino and Australian fine-wool Merino ewes are less fertile when compared to Rambouillet ewes at 24 mo of age. ASW and AFW ewes were less prolific than R ewes at 24 and 36 mo, respectively. In addition, preliminary data suggest that the difference in reproductive performance may decline as age increases. However, additional data are needed to confirm these trends. Lamb body weights at weaning were similar (P>.05) for the three breed types and preliminary analysis indicates similar survival rates of lambs from birth to weaning for R, ASW, and AFW ewes.

Implications

These data indicate that using strong- or fine-wool Australian Merino x Rambouillet crossbred ewes will result in smaller ewes, yet fertility of ewes or the average weaning weight of lambs will not differ statistically from that of Rambouillet ewes. The ASW and AFW ewes will, however, give birth to significantly fewer lambs. The reduction in the number of lambs born to ASW and AFW ewes must be considered with respect to gains in wool production (Willingham et al., 1994) of ASW and AFW ewes. The effect of this difference in reproductive performance on total income will most likely increase with the phasing out of the wool incentive program. It should be pointed out however, that these results are from only two years data collected from ewes at ages two and three yr. Additional data are being collected to determine if the lower reproductive performance of ASW and AFW ewes are still evident in mature ewes.

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Fleece Traits of Rambouillet and Rambouillet x Australian Merino Cross Ewes

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Summary

Crossbred lambs generated with frozen semen from rams representing three different breed-types (Australian Merino strong-wool [ASW], Australian Merino fine-wool [AFW] and Rambouillet [R]) bred to Rambouillet ewes were evaluated for differences in fleece characteristics when produced under range conditions in the United States. These data represent the first three consecutive years of ewe wool production in Texas only. The ASW and AFW ewes produced an average 1.5 and 1.2 lb more grease wool, and 1.5 and 1.2 lb more clean wool than R ewes (P<.01). Clean wool fiber present values were 64.3 and 63.1% for ASW and AFW ewes, as compared to 58.5% for R. Staple lengths and fiber diameters were similar for all three breed types. Visual scores indicated that Merino cross ewes have more (P<.01) body folds, less (P<.01) belly wool (more uniform wool extending down further into the belly region), and similar face cover scores compared to R ewes.

Introduction

In recent years, some sheep producers have shown interest in the improvement of fleece traits, particularly increased clean wool weight, by crossing Australian Merinos to domestic breeds, primarily Rambouillet. Whereas the current (winter, 1994) level of interest in improving the domestic clip appears to be declining due to the phasing out of the wool incentive program, a residual effort at improvement must be maintained because wool from fine-wool sheep will likely continue to provide an important source of income. Although the main interest in the Australian Merino stems from their fleece characteristics, producers in this country must also consider their effects on reproductive efficiency and value of the market animal. A cooperative, multi-state project was initiated in 1990 to provide data addressing reproductive rates, fleece characteristics, and carcass values of these crossbred sheep. This report provides data on ewe fleece characteristics under Texas range conditions.

Experimental Procedure

This study consisted of 170 ewes representing three breed types. Lambs were produced and managed at the Winters ranch near Brady, Texas. Breed types were Rambouillet (n=48), Australian strong-wool Merino x Rambouillet (67), and Australian fine-wool Merino x Rambouillet (55). Numbers vary among breed types due to availability of animals and vary among years due to loss of some animals. Data were collected for three consecutive years, beginning with the first shearing when the ewes were approximately 14 mo of age. Fleece traits evaluated were grease fleece weight, clean fleece weight, fiber diameter, staple length, and clean wool fiber present. Clean wool fiber present was determined from wool samples (approximately 100 g) taken along the midline near the 12th rib. Subsamples were taken from each 100 g sample for fiber diameter measurements. Diameters were determined by using the Peyer Texlab FDA 200 System. Average staple lengths were calculated from three measurements made along the midline at the shoulder, side, and thigh. Additional subjective scores were given by a committee (at least two people) for face cover, amount of belly wool (wool that may be shorter and differs in appearance from wool found along the midline, and possibly having more black fibers), and body folds. Scores were on a scale of 1 to 4, with 1 being more desirable.

Statistical analysis of data was performed using the Mixed procedure of SAS (1992). The model used to estimate breed differences for wool traits included fixed effects for year and breed, a linear covariate for body weight nested within breed and random effects for sire, nested within breed, and ewe nested within breed and sire. Face cover, body folds, and belly wool scores were analyzed with a model that contained fixed effects for year and breed and random effect for sire and ewe. Preliminary analysis showed no significant interactions. Linear contrasts were used for comparison of ASW and AFW mean fleece traits and visual scores with R ewes. Breed means were predicted for fleece traits when adjusted to a common body weight.

Results and Discussion

Mean body weights and fleece characteristics for the three years observed are pooled and shown in Table 1. Australian Merino fine-wool x Rambouillet (AFW) ewes and Australian Merino strong-wool x Rambouillet (ASW) ewes weighed less (-8.8 and -5.6 lb, respec-

tively, P<.05) than Rambouillet (R) ewes, yet produced heavier, higher yielding (P<.01) fleeces. The ASW ewes had a longer staple than R ewes, but this difference was not statistically significant (P>.05). Fiber diameter was similar (P>.05) for the three breed types.

The body weight of Merino-cross ewes can be changed over time by selecting for increased body weight. Because some of the fleece traits are affected by body weight, values in Table 2 were calculated to show the differences among these breed types that might be expected at a common body weight. The difference in fiber production between the crossbred ewes, as compared to R ewes, was more pronounced when fleece traits were adjusted to the mean body weight (101.3 lb) of all animals evaluated. The ASW and AFW ewes produced heavier grease fleece weights (1.7 and 1.5 lb, P<.01, respectively) compared to R ewes. The advantage of the Merino-cross ewes remains evident when comparing clean fleece weight, which is a function of clean wool fiber present (%) and grease fleece weight. At a common weight, the ASW ewes were predicted to produce a slightly longer (P<.05) staple than R ewes (4.2 in vs 3.9 in). In addition, the ASW ewes were coarser (.4 μm) than AFW ewes and R ewes (.3 μm), although these differences were not significant (P>.05). While results are not shown by year, the trend was the same in each of the three years evaluated.

Data for visual scores are given in Table 3. The number of observations varies among traits because body fold scores were assessed in only two of the three years, and face scores in the first year only. Year effects were statistically removed for body folds and belly wool. All breed types were similar for face cover with none being objectionable. The ASW and AFW ewes had lower (P<.01) visual amounts of belly wool than R ewes. This is interpreted to mean that crossbred ewes produced normal wool in places where most Rambouillet ewes were growing undesirable belly wool. In addition, ASW and AFW ewes had more (P<.01) body folds than R ewes; and whereas a few of these individual animals may prove objectionable to most producers, the majority of the Merino-cross ewes should be acceptable in terms of this trait.

Table 1. Mean fleece traits by breed type pooled across years.

Breed	Number of observations	Body wt (lb)	*Grease fleece wt (lb)	*Clean fleece wt (lb)	Clean wool fiber present (%)	*Staple length (in)	Fiber diameter (μm)
Rambouillet	129	106.1[a]	8.4[a]	4.9[a]	58.5[a]	4.0[a]	19.7[a]
Aust. Merino (strong-wool)	191	100.5[b]	9.9[b]	6.4[b]	64.3[b]	4.2[a]	19.9[a]
Aust. Merino (fine-wool)	147	97.3[b]	9.6[b]	6.1[b]	63.1[b]	4.0[a]	19.4[a]

* Values based on 365 days of growth.

[a,b] Body weights are least squares means, and means within the body weight column without a common letter superscript are significantly different (P<.05).

[a,b] ASW ewes or AFW ewes are significantly different (P<.01) from R ewes within columns if they have different letter superscripts.

Table 2. Least squares means of fleece traits by breed type adjusted to a common mean body weight and pooled across years.

Breed	Number of observations	Body wt (lb)	*Grease fleece wt (lb)	*Clean fleece wt (lb)	Clean wool fiber present (%)	*Staple length (in)	Fiber diameter (μm)
Rambouillet	129	101.3	8.3[a]	4.8[a]	58.3[a]	3.9[a]	19.6[a]
Aust. Merino (strong-wool)	191	101.3	10.0[b]	6.5[b]	64.3[b]	4.2[b]	19.9[a]
Aust. Merino (fine-wool)	147	101.3	9.8[b]	6.2[b]	63.0[b]	4.0[ab]	19.5[a]

* Values based on 365 days of growth.

[a,b] Means within columns having different superscripts differ (P<.05).

Table 3. Subjective visual score of three traits by breed.

Sire breed	Number of observations	Face cover score	Number of observations	Body fold score	Number of observations	Belly wool score
Rambouillet	48	1.0[a]	89	1.3[a]	128	1.6[a]
Aust. Merino (strong-wool)	67	1.1[a]	130	1.7[b]	189	1.4[b]
Aust. Merino (fine-wool)	55	1.1[a]	101	1.9[c]	144	1.4[b]

Scores are on a scale of 1 to 4 with 1 being most desirable.

[a,b,c] Means within columns having different superscripts differ (P<.01).

Implications

These data indicate that using strong- or fine-wool Australian Merino x Rambouillet crossbred ewes will increase the quantity of wool produced without improving or markedly down grading the quality of the clip as compared to Rambouillets. However, Australian Merino x Rambouillet ewes have at least two traits, smaller size and greater number of body folds, that will prove objectionable to some producers. Of these two traits, size may be the more critical because many in the sheep industry are suggesting we need to produce larger and leaner carcasses. Obviously, this cannot be achieved using smaller dam breeds. Earlier research (Willingham et. al., 1992) with only one year of data, showed that ASW and AFW lambs were not different from R lambs (P>.05) in terms of carcass quality grade or yield, but the AFW lambs tended to finish (deposit fat) at a lighter weight. This suggests that it will be difficult to produce leaner yet larger carcasses using AFW dams. In addition, we caution that this report does not give any indication of reproductive performance of either the ASW, AFW, or R ewes and reproduction will likely be of greater short-term concern. Reproductive efficiency will be discussed in another article.

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Evaluation of Boer x Spanish Cross versus Spanish Goats for Meat Production

D.F. Waldron, P.V. Thompson, and T.D. Willingham

The strength of the slaughter goat market and the recent availability of Boer goats to ranchers in the United States has generated considerable interest in increasing meat production from goats. There is little objective comparative research information available about the performance of the Boer goat relative to other goat breeds. In order to make wise decisions, goat producers need information about the growth and reproduction of Boer goats in a commercial West Texas environment. It would be desirable to evaluate purebred Boer and Boer-crosses with Spanish and Angora goats. However, because of limited resources, we concentrated on evaluating Boer x Spanish cross goats with Spanish goats. The objective of this research is to answer the question: What differences in performance can be expected between offspring of Boer and Spanish sires?

In breed comparison experiments the choice of representatives of the breeds is important. Frozen semen was obtained from six Boer sires, from two firms in New Zealand. Sires were chosen in order to represent a range in growth performance. An effort was made to choose sires that were not closely related. The population of Boer goats available from New Zealand has a narrow genetic base. All animals can be traced to three sires. Therefore, the sires that were used were not all unrelated, and they may not be representative of Boer goats in South Africa. The sires used were representative of the Boer goats available to U.S. breeders in 1993.

Ranchers that have invested in Boer genetics are primarily interested in improving meat production from their herd. An alternative route for genetic improvement would be to select within the Spanish goat population. Four of the six Spanish sires that were used in the trial were obtained on loan from breeders that have been selecting their Spanish goats for increased meat production. The other two Spanish sires were selected from research herds owned by the Texas Agricultural Experiment Station and are probably more representative of the unselected Spanish goat population of this area. Therefore, the sires chosen were not intended to sample the average Spanish goat but to sample those Spanish goats that a rancher might purchase in an effort to improve meat production.

The females in this trial are Spanish goats and were randomly allotted to breed of sire and sires within breeds. The does averaged 82 lb body weight on October 1, 1993. The Spanish bucks were each turned in with approximately 13 does that were randomly allotted to them in single sire mating pastures on October 8. Does were added to these pastures in late October so that each sire had approximately 18 does. The does that were randomly allotted to Boer sires were artificially inseminated on Oct. 8, Oct. 20, Oct. 29, Nov. 12 and Nov. 19. Pregnancy detection by ultrasound at approximately 42 days post-insemination indicated that approximately 60% of the 183 artificially inseminated goats conceived. Body weights at various ages (Birth, 60, 120, and 180 days) will be recorded and differences between the sire breeds will be estimated. A random half of the males will be put on feed after weaning until slaughter at approximately 8 months of age. The other half will remain on pasture until slaughter. Animals will be slaughtered and carcasses evaluated at the Rosenthal Meat Science and Technology Center at College Station, Texas. Females will be retained and managed under range conditions for further trials to evaluate the two breeds of sire with respect to reproduction and maternal ability.

The Boer goat has potential to change the amount of meat produced from goat herds and, therefore, the income earned from goats. This trial will evaluate the changes in meat production due to using Boer sires in place of using Spanish sires. The amount of meat produced from a herd of goats is a function of growth rate of the animals to be slaughtered and the reproductive rate of the females. The first year of this trial will provide information about the growth rate of Boer x Spanish kids compared to Spanish kids. Subsequent trials will provide information about the reproduction traits that will impact the production of meat from goat herds. Further trials, that will evaluate other goat breeds or crosses, are also in the planning stages for subsequent years.

Acknowledgment

The assistance of Tom Carter in coordinating the loan of Spanish sires was gratefully appreciated.

1993 Texas A&M Pasture to Packer Program

B.F. Craddock, R.V. Machen, and D.S. Hale

Summary

Feedlot performance for the 1993 Texas A&M Pasture to Packer Program indicated that 36% of the lambs gained less than 0.5 lb/day. Feed efficiency for the entire group was 7 lb of feed/lb of gain. When fed to the same backfat thickness end point, days on feed were very similar across the three frame groups: 74, 78 and 79 days for small, medium and large frames, respectively. When fed to a constant live weight of 130 lb, differences in genetic ability to gain as expressed by days of feed were 109, 90 and 72 days for small, medium and large frames, respectively.

If the optimum carcass weight is assumed to be 65 lb, then greater than 90% of the lambs yielded lighter than optimum carcasses when slaughtered at a fat thickness of approximately .25 inch. For the 224 carcasses that were ribbed, over 85% of the lambs had loineye areas of less than or equal to 2.5 in^2. Loineye measurements ranged from 1.5 to 4.35 in^2.

Price of carcasses was not influenced by carcass weight or fatness. A small but significant portion (9%) of the lambs yielded nonprofitable results. Approximately 30% of the lambs made $0 to $5/head while 61% made $6/head or more. The range in returns for the consignments of the 62 producers varied from an average loss of $3.25/head to an average profit of $20.32/head. The extremely profitable entries were characterized by rapid gains, fewer days on feed, thick muscle structure and heavy carcass weights. Implementation of a value based marketing system would provide an economic incentive for producers to improve the quality of lambs being produced.

Introduction

Fine-wool sheep are the backbone of the Texas sheep industry. Selection efforts to improve fleece characteristics have been successful; however, little selection pressure, other than for increased size, has been applied toward sheep that will produce lean, fast-growing, muscular lambs. Consideration of fleece characteristics is the single largest impediment to improving carcass merit. Impending changes in the Wool Act may change the financial significance of wool selection and improvement. If lamb is going to successfully compete for an ever-shrinking portion of the retail meat case and producers are going to survive, several changes will have to be made. Lamb producers will have to reevaluate the appropriate selection emphasis for fiber and carcass production in their enterprise.

Commercial, purebred and registered producers need to determine how their sheep fit the needs of the entire lamb production system. The Texas A&M Pasture to Packer Program was designed to 1) provide commercial lamb producers, purebred sheep breeders, stocker operators, and lamb feeders the opportunity to determine the feedlot performance and carcass characteristics of lambs they are producing and the factors that influence value and 2) familiarize producers with lamb feeding and retained ownership as a possible alternative marketing method.

Experimental Procedure

One thousand two hundred seventeen lambs were delivered by 62 producers from 18 counties to the Denis Feedlot in Vancourt, Texas, on June 22-23, 1993. Stratification of lambs by breed and sex is given in Table 1. Upon arrival the lambs were eartagged and weighed. Each lamb was assigned an initial value based on the San Angelo feeder lamb market during the delivery week. Feeder lamb prices used to determine value were ≤ 60 lb - 60¢/lb; 61 to 80 lb - 62.5¢/lb; 81 to 90 lb - 60¢; > 90 lb - 58¢/lb. Twenty percent of each consignment was selected at random for inclusion in a group to be fed to a target slaughter weight of 130 lb. The remaining lambs were assigned a frame score (small, medium, or large) and were slaughtered at an appropriate weight to yield carcasses with ≤ .25 inch backfat. Target weights for the frame score groups were 105, 115 and 125 lb for the small (S), medium (M), and large (L) framed lambs, respectively. Within one week after arrival at the feedyard, all lambs were vaccinated for enterotoxemia

Table 1. Stratification of lambs by breed and sex.

Item	No. of head	%
Fine-wool	899	73.9
Wethers	772	85.9
Ewes	127	14.1
Crossbred	303	24.9
Wethers	137	45.2
Ewes	166	54.8
Medium-wool	5	0.4
Texel/Texel cross	10	0.8
Total	1,217	100

and dewormed. In terms of ration changes, illness, shearing, etc., lambs were managed like all other lambs in the feedyard. Lambs were weighed every three or four weeks and were slaughtered at Monfort, Inc. in San Angelo when they reached their target slaughter weight. Carcass data collected included hot carcass weight, fat thickness, leg score, and quality grade. Loineye area was collected on the 224 lambs in the 130 lb slaughter group. All expenses were deducted from carcass income, and the balance was sent to the owners along with a detailed performance, carcass, and financial summary report. The initial value of the feeder lambs upon arrival at the feedyard was subtracted from the balance to determine the return each producer made by feeding their lambs.

Results and Discussion

Performance Data

Feedyard performance data are given in Table 2. The average weight upon arrival at the feedyard was 71 lb with a range of 37 to 107 lb. Average slaughter weight was 114 lb and ranged from 64 to 143 lb. Several poor-doing lambs (primarily rectal prolapses) were railed in an attempt to salvage some value for the producer. Nineteen lambs prolapsed during the study with the majority of the lambs belonging to producers that raise club lambs that are short docked. Overall death loss was 2.5% (30 head), which was well within the range experienced by lamb feeders. Days on feed ranged from six to 123 with an average of 79 days. Total gain averaged 43 lb with a range of -11 to 82 lb. Average daily gains ranged from -.27 to 1.10 lb/day with an average of .55 lb. Experiences in the Denis feedyard indicate, in order for lambs to return a profit, they must gain at least .5 lb/day. As shown in Figure 1, 64% of the lambs gained greater than .5 lb/day. The combin-

Table 2. Means and ranges for feedyard performance, carcass and financial data for all lambs (1,217 head).

Item	Mean	Range
Initial wt, lb	71.1	37 to 107
Final wt, lb	113.7	64 to 143
Gain, lb	42.6	-11 to 82
Average daily gain, lb	.55	-.27 to 1.1
Days on feed	78.7	6 to 123
Carcass wt, lb	58.7	36 to 77.5
Leg score[a]	11.3	8 to 18
Backfat, in.	.26	.03 to .65
Yield grade	2.96	.70 to 6.9
Quality grade[b]	11.3	10 to 14
Loineye area, in.^{2}[c]	2.33	1.55 to 4.35
Initial value, $	43.66	22.2 to 62.06
Total value, $	80.4	0 to 104.82
Total cost, $	28.99	19.68 to 39.36
Balance, $	51.42	-28.8 to 84.49
Return, $	7.78	-28.8 to 27.46

[a] Leg conformation scores are equivalent to 8 = average good, 9 = high good, 10 = low choice, ... 15 = high prime. Values above 15 represent heavy muscled carcasses.

[b] Quality grades are equivalent to 10 = low choice, 11 = average choice ... 14 = average prime.

[c] Loineye area measurements represent 224 lambs rather than 1,217 lambs.

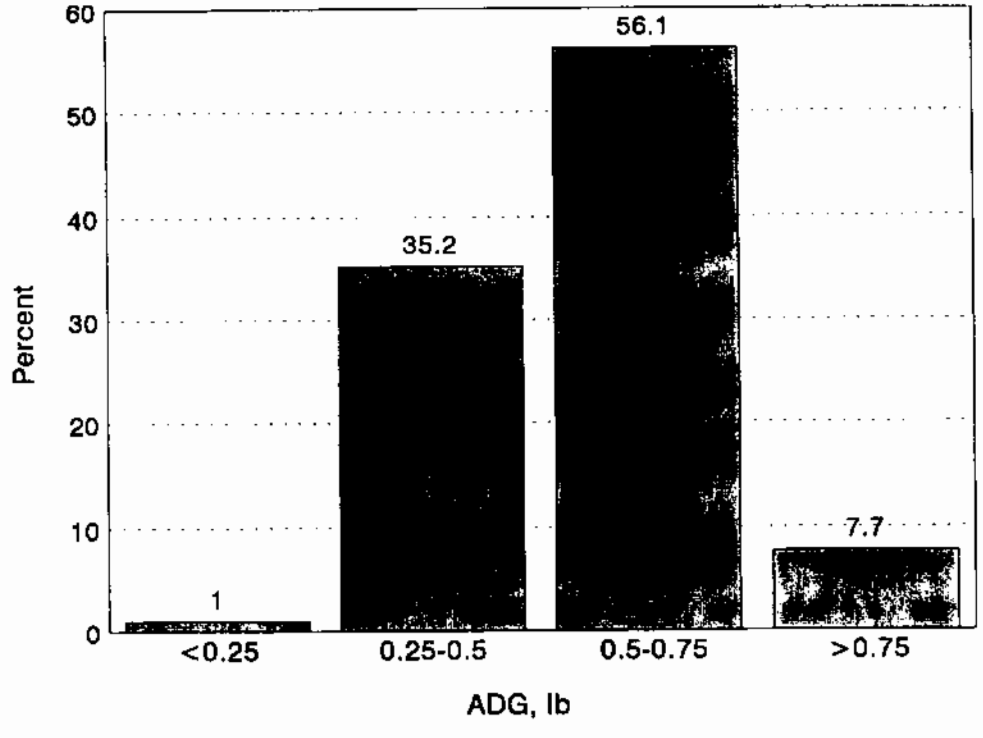

Figure 1. Average daily gain distribution for all lambs.

ing of pens and shuffling of lambs to accommodate incoming feeder lambs precluded collection of feed consumption data by feeding group. Comparison of feed records and total weight gained indicates a feed:gain conversion of 7:1 for the entire group.

Mean feedyard performance data by breed and sex group are given in Table 3. Crossbred lambs outgained fine-wool lambs by .05 lb/day and were on feed 12 days less. Fine-wool wether lambs outgained fine-wool ewe lambs by .07 lb/day. Crossbred wether lambs outgained crossbred ewe lambs by .05 lb/day. Fine-wool and crossbred wether lambs were on feed eight days less than fine-wool and crossbred ewe lambs.

Mean feedyard performance data for fine-wool and crossbred lambs within S, M, and L frame groups are given in Table 4. In general, as frame size increased, lambs gained faster and were on feed fewer days.

Table 3. Mean feedyard performance data by breed and sex group.

	Fine-wool		Crossbred	
Item	Ewe	Wether	Ewe	Wether
No. of lambs	127	756	165	131
Initial wt, lb	67	71	71	75
Final wt, lb	110	115	111	115
Gain, lb	43	44	40	40
ADG, lb	.48	.55	.57	.62
Days on feed	89	81	73	65

Mean feedyard performance data for small, medium and large framed lambs slaughtered at either 130 lb or at a constant fat thickness of .25 inch or less are given in Table 5. When lambs were slaughtered at 130 lb regardless of frame size, they tended to gain slightly less; however, days on feed increased tremendously for the smaller framed lambs.

There were 25 extremely heavy muscled lambs on this study. When compared to the conventional lambs, they were 7 lb heavier going on test (78 vs 71), gained .26 lb/day more (.81 vs .55) and were on feed for 36 less days (43 vs 79).

Carcass Data

The lambs were sold on a carcass basis with no price difference being paid for carcasses of various weights and fatnesses. Carcass price was $129.43 per hundred weight. As a result, heavier carcass weights resulted in greater return to the producer. Upon initiation of this program, carcasses of approximately 65 lb were the size of greatest demand by packers and breakers. Assuming the average lamb will have a dressing percentage of 50%, a 130 lb slaughter weight should yield such a carcass, thus the reasoning behind inclusion of the 130 lb slaughter weight group (130#). All other lambs were fed according to frame size (FS). Means and ranges for carcass data for all lambs are given in Table 2.

Table 4. Mean feedyard performance data for fine-wool and crossbred lambs within small, medium, and large frame groups.

	Fine-wool			Crossbred		
Item	L	M	S	L	M	S
No. of lambs	28	527	322	4	100	192
Initial wt, lb	83	73	65	85	79	69
Final wt, lb	129	118	106	122	119	110
Gain, lb	46	45	41	38	40	40
ADG, lb	.60	.56	.51	.79	.64	.57
Days on feed	79	83	83	48	64	74

Table 5. Mean feedyard performance data for small, medium, and large framed lambs slaughtered at either 130 pounds or at a constant fat thickness of .25 inch or less.

	≤ .25 in. backfat			130 lb		
Item	L	M	S	L	M	S
No. of lambs	16	512	436	16	118	90
Initial wt, lb	79	73	67	87	78	69
Final wt, lb	127	116	104	129	128	123
Gain, lb	48	43	38	42	50	54
ADG, lb	.64	.57	.53	.60	.57	.50
Days on feed	79	78	74	72	90	109

The impact of feeding group management on carcass weight is shown in Figure 2. When fed to a .25 inch or less backfat target (FS), lambs yielded lighter than desirable carcasses. However, when fed to a 130 lb target weight, regardless of frame size, the number of carcasses over 65 lb increased dramatically.

Interestingly, when fed to approximate a backfat thickness endpoint of .25 inch or less, days on feed were very similar across the three frame groups; 74, 78, and 79 days for S, M, and L framed lambs, respectively. However, when fed to a constant carcass weight of 130 lb, differences in genetic ability to gain was expressed by days on feed; 109, 90 and 72 for S, M, and L framed lambs, respectively. Distribution of backfat measurements for all carcasses is shown in Figure 3.

Loineye area measurements were limited to the 224 head slaughtered in the 130 lb feeding group. As shown in Figure 4, over 85% of the lambs in this group had less than or equal to a 2.5 in^2 loineye. Loineye measurements ranged from 1.5 to 4.35 in^2.

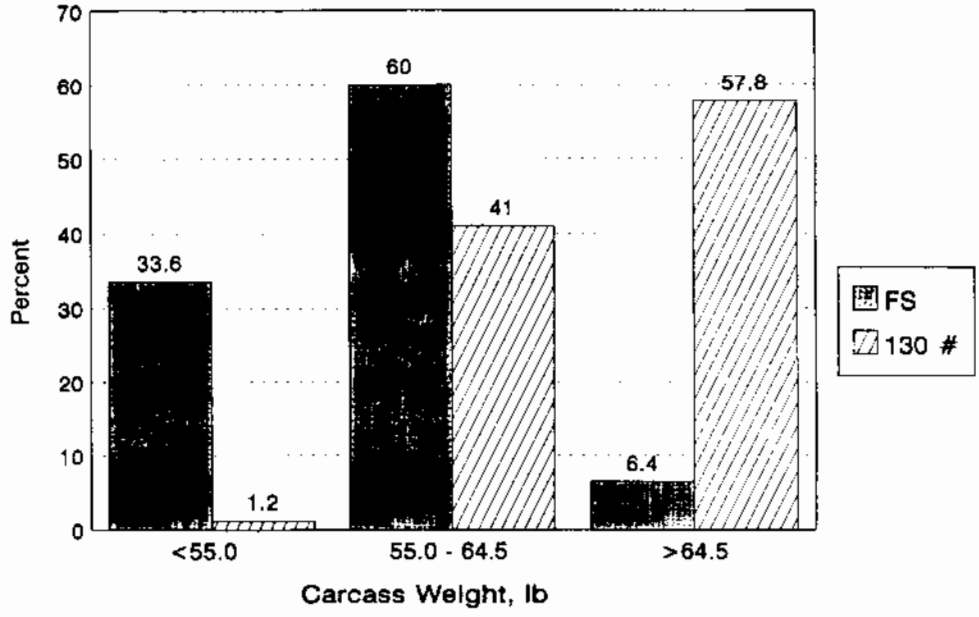

Figure 2. Carcass weight distribution by feeding group.

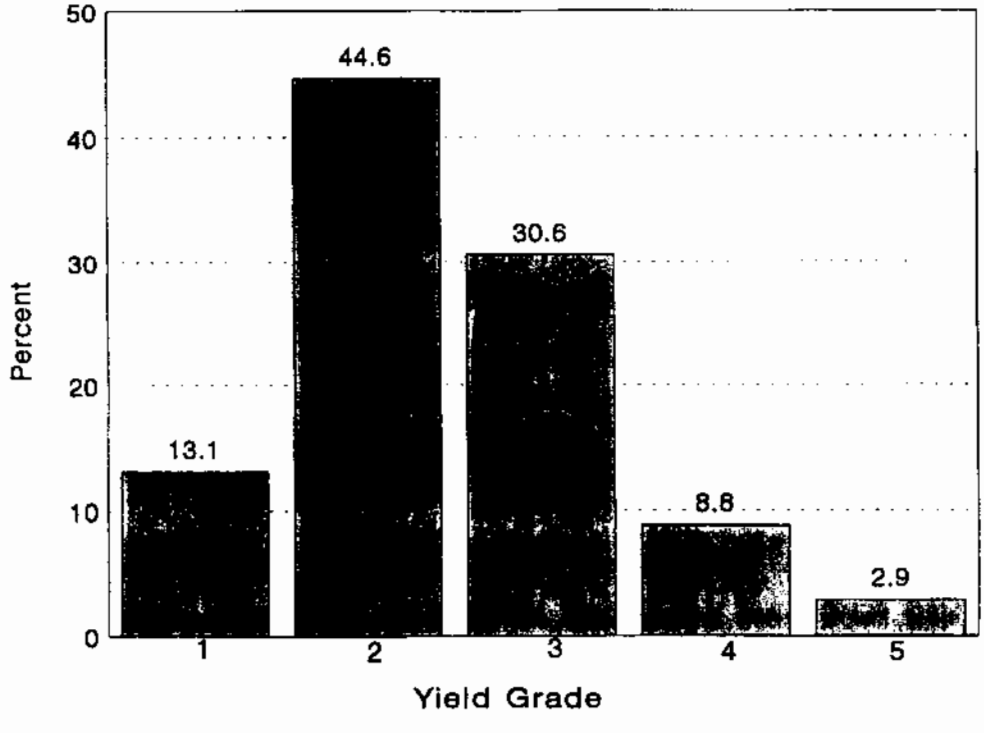

Figure 3. Backfat distribution for all lambs. The relationship between backfat and yield grade is YG1 ≤.15"; YG2 = .16 to .25"; YG3 = .26 to .35"; YG4 = .36 to .45"; YG5 ≥.46".

When compared to normal lambs, the extremely heavy muscled lambs had heavier carcasses (65 vs 59), higher dressing percentages (57 vs 51), higher leg conformation scores (16 vs 11), and less backfat (.18 vs .26). There were no differences in quality grades between normal and heavy muscled lambs.

Financial Data

Means and ranges for financial data for all lambs are presented in Table 2. Factors affecting income and expenses are presented in Table 6. Good fat lamb markets and relatively cheap feed costs resulted in a positive return for all but two producers. Lambs were sold on a carcass weight basis. During the time their lambs were marketed, lamb meat was in short supply. As a result, the value of the carcasses was not influenced by carcass weight or fatness. The average return per lamb was $7.78 with a range of -$28.80 to $27.46. The range in returns per consignment for the 62 producers varied from an average loss of $3.25/head to an average profit of $20.32/head.

Table 6. Factors affecting income and expenses.

Item	
Income	
Carcass value	$129.43/cwt
Drop credit (pelt & offal)	$4.51/hd
Wool sales	$1.38/hd
Expenses	
Slaughter charge	$7.75/hd
Processing	$1.36/hd
Freight	$0.45/hd
TSGRA Commodity Board Checkoff	$0.20/hd
Interest	$0.08/hd
Shearing	$1.39/hd
Feed	$0.225/hd/day
Yardage	$0.015/hd/day

The distribution of net returns on a per head basis is shown in Figure 5. Almost 9% of the lambs lost money when retained and sold on the rail. Over 60% of the lambs made at least $6/head more than if they had been sold as feeders in late June. The extremely profitable entries are characterized by rapid gains, fewer days on feed, thick muscle structure, and heavy carcass weights.

Returns for fine-wool ewe lambs, fine-wool wether lambs, crossbred ewe lambs, and crossbred wether lambs were $4.51, $7.52, $9.25, and $10.19, respectively. Returns for small, medium, and large framed lambs were $6.00, $9.05, and $11.91, respectively.

Acknowledgments

The authors wish to express their appreciation to Denis Feedyard, Monfort, Inc., Texas A&M University Animal Science Department - Meat Science Section, Angelo State University students and County Agricultural Extension Agents who had producers involved in the program for their cooperation and assistance during the study.

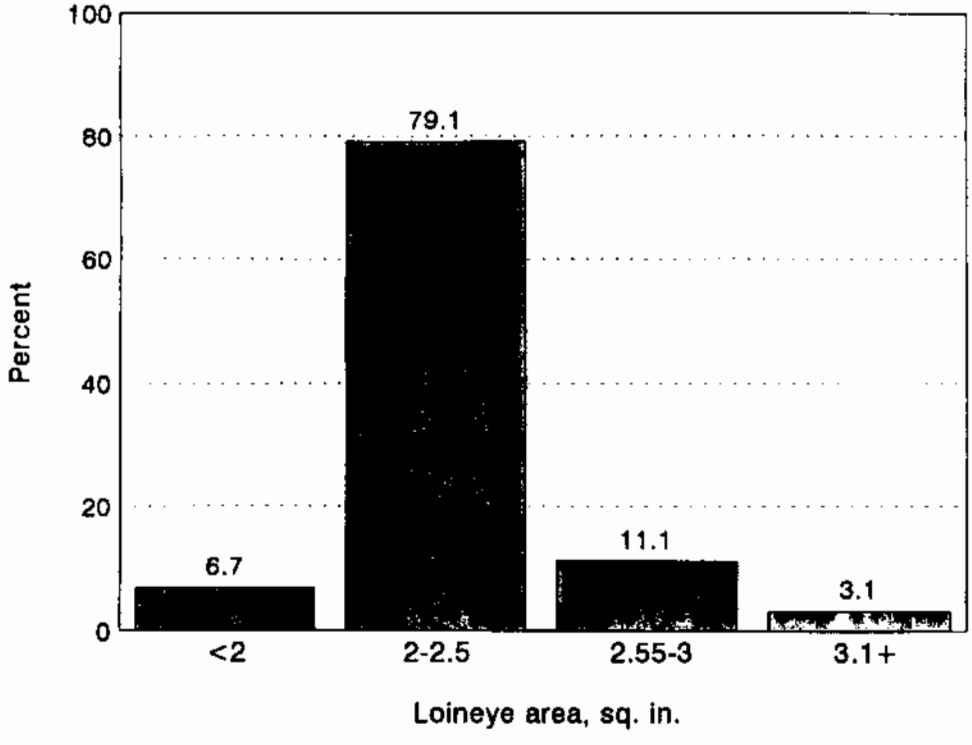

Figure 4. Loineye area distribution for 130 lb slaughter group (data from 224 head).

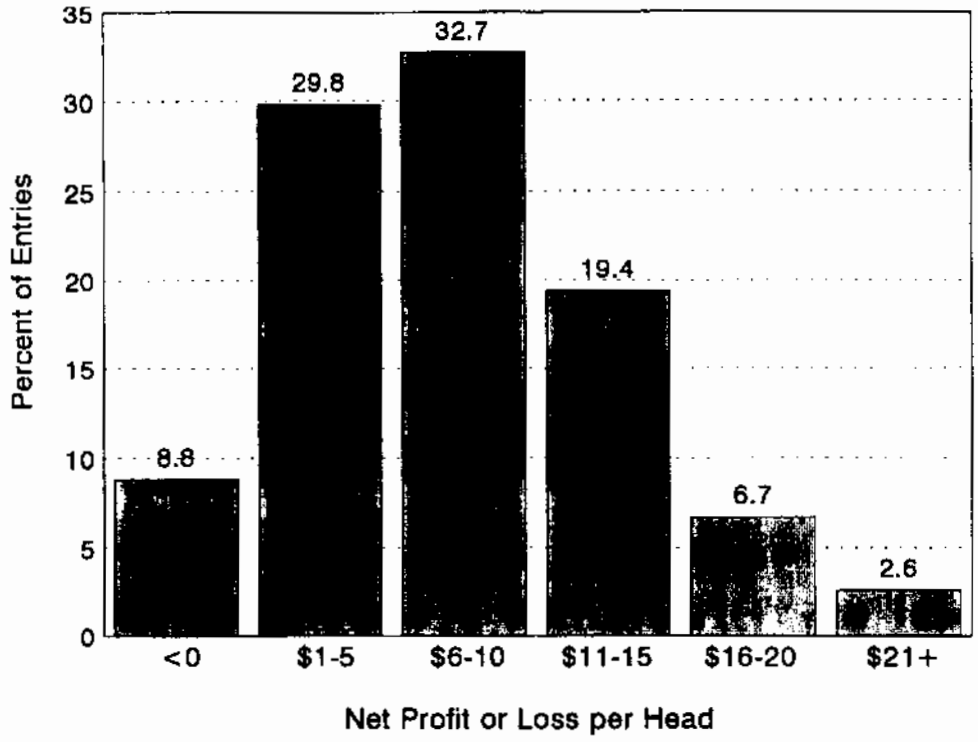

Figure 5. Net returns per head.

A Look at Feeding Frequency in Fall-Lambing Rambouillet Ewes on Rangeland

J.E. Huston and K.W. Bales

Summary

Adult Rambouillet ewes (120) were used in a study to compare the effects of types and amounts of supplements fed at different intervals. Cottonseed meal (CSM), a low-protein supplement fed at a low level (LOW), and a low-protein supplement fed at a high level (HIGH) were fed individually at 1-d, 4-d, and 7-d intervals between September 20 and December 13. Lambing occurred from October 21 to December 3. With daily feeding, supplement type and amount did not affect body weight change of the ewes. When CSM was fed, feeding frequency did not affect body weight change. However, HIGH was less effective when fed at 7-d compared with more frequent intervals (P = .08) and compared with CSM when both were fed at 7-d intervals (P = .003). The LOW treatment showed intermediate effects. The low protein supplement (high grains) fed at a high level at 7-d intervals had a negative effect on body weight change which probably was a result of depressed forage intake and (or) digestibility caused by disruption of normal ruminal activity.

Introduction

Decisions on supplemental feeding are based on considerations of animal needs, labor, and price. Usually, the final decision is a compromise. A cheaper feed may not meet animal needs, but the lower feed cost may be perceived to more than offset a small reduction in production. An expensive feed may be worth the price if an absentee producer can dispense the feed at infrequent, irregular intervals rather than on a frequent schedule.

Studies with beef cows suggested that infrequent feeding may be as acceptable as daily feeding (Melton and Riggs, 1964; Huston et al., 1987). Two studies were conducted during 1993 to 1994 to determine the effects of feeding frequency and supplement type on Rambouillet ewes on rangeland. The data in this report are for fall-lambing ewes. Data for spring-lambing ewes are not available at this time.

Experimental Procedures

Study Site

The study was conducted at the Texas A&M University Agricultural Research and Extension Center at San Angelo, Texas. Soils on the site are mostly Angelo and Mereta clay loam and support herbaceous vegetation that is mostly warm-season, perennial grasses including sideoats grama (*Bouteloua curtipendula*), plains bristlegrass (*Setaria macrostachya*), kleingrass (*Panicum coloratum*), and King Ranch bluestem (*Bothriochloa ischaemum*). Rainfall, thus plant growth, prior to first fall frost date was approximately normal (April to September = 12.44 in). Precipitation during October, November, and December was below normal (October to December = 1.78 in). Overall diet quality was considered average.

Experimental Design, Animals, and Management

The study was conducted in a 3 x 4 factorial arrangement of treatments with feeding frequency (1-d, 4-d, and 7-d; FREQ) and feed type/amount (TREAT) as main effects. Feed type/amount included a negative control (NC; no supplement), cottonseed meal (CSM), a low protein/low level supplement (LOW), and a low protein/high level supplement (HIGH) fed as indicated in Table 1. The LOW provided equal energy with CSM but less crude protein and HIGH provided equal crude protein with CSM but more than twice the amount of energy. Ten adult Rambouillet ewes that displayed breeding marks and were presumed pregnant were assigned to each of 12 treatment groups. Four treatment groups (NC, CSM, LOW, and HIGH) were assigned to each of three pasture groups designated as 1-d, 4-d, and 7-d feed groups. The 1-d, 4-d, and 7-d groups were gathered into a feeding facility daily, every fourth day, and every seventh day, respectively, between September 20 and December 13, 1993, and feed treatments were applied (Table 1). The NC group in each pasture group received no feed but otherwise was treated as the fed groups. Fed ewes were placed in individual stalls and allowed 1 h to consume supplement after which they were returned to the pasture. Ewe weights were taken at the beginning of the study and at 28-d intervals. Each 28 d, pasture groups were rotated so that each pasture group resided in each pasture for equal periods. Lambing occurred between October 21 and December 3.

Statistical Analyses

The data were analyzed using the GLM Procedure (SAS, 1991) for differences among TREAT (NC, CSM, LOW, HIGH) and FREQ (1-d, 4-d, 7-d) and for TREAT

x FREQ interactions. Individual animals were used as observations since each was treated (fed) individually. Contrasts were examined among TREAT comparing NC vs CSM, LOW, and HIGH; CSM vs LOW; and CSM vs HIGH at each feeding frequency. Tests were run for differences among FREQ for each supplement type/amount. The NC groups were used to adjust pasture effect. Because an NC group was in each pasture group and was not fed, differences in performance were used to correct pasture effects of the fed groups. Therefore, NC groups were equalized and were not tested as a TREAT among FREQ.

Results and Discussion

Of the 120 ewes that were involved in the study, only 49 were included in the final analysis of the data. Several ewes either did not lamb or lost lambs. Also, several ewes refused substantial portions of the feed offerings. Data included are from ewes that 1) gave birth and were nursing at least one lamb at the end of the study and 2) consumed greater than 90% of feed offerings.

Pasture effects were removed by equalizing weight losses of the NC ewes to losses of the NC 1-d pasture group (-16.4 lb) then applying correction factors to fed groups. Although the interaction of main effects was not significant (P = .26), data for each treatment at each frequency are shown with the within group statistical notations (Table 2).

The small number of experimental animals in the different groups precludes strong evidence on the effects of feed type and feeding frequency. It appears that the supplements were approximately equal in their effects when fed daily but not when fed infrequently (7-d). Whereas CSM had approximately equal effects on body weight loss irrespective of feeding frequency, HIGH was as effective as CSM when fed daily (P = .32) but not when fed 1-time/wk (P = .003). This increase in weight loss when the low-protein (high-grain) supplement was fed infrequently likely was a result of a reduction in forage consumption and (or) digestibility as was previously observed in goats fed "starchy" supplements (Huston, 1994).

Table 1. Supplemental feed treatments for fall-lambing ewes fed at either 1-day, 4-day or 7-day intervals.

	Feed treatment			
Item	NC	CSM	LOW	HIGH
Ingredients				
Cottonseed meal	0	100	35	35
Sorghum grain	0	0	65	65
Total	0	100	100	100
Daily feeding equivalent				
Dry matter, lb/d	0	.25	.23	.50
Crude protein, lb/d	0	.11	.05	.11
Digestible energy, Mcal/d	0	.32	.32	.75
Actual DM feeding levels, lb				
1-d group	0	.25	.23	.50
4-d group	0	1.00	.92	2.00
7-d group	0	1.75	1.62	3.50

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Melton, A.A., and J.K. Riggs. 1964. Frequency of feeding protein supplement to range cattle. Texas Agric. Exp. Sta. Bull. B-1025.

Table 2. Effects of supplemental feed treatment and feeding frequency on weight change (lb) in fall-lambing ewes.

	Feed treatment				Contrast P[a]		
Item	NC	CSM	LOW	HIGH	1	2	3
1-d							
Number of ewes	3	4	4	5			
Body wt change	-16.4	-11.4	-6.1	-4.9	.16	.44	.32
4-d							
Number of ewes	2	4	6	5			
Body wt change	-16.4	-8.9	-11.1	-11.1	.28	.64	.65
7-d							
Number of ewes	4	3	6	3			
Body wt change	-16.4	-6.6	-11.3	-20.3	.19	.17	.003
P[b]	—	.70	.52	.08			

[a] Probability of differences: 1) Control vs fed groups, 2) CSM vs LOW, and 3) CSM vs HIGH.

[b] Probability of differences among feeding frequencies.

Use of Juniper as a Supplemental Feed Limiter

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

Summary

Two experiments were conducted to determine the efficacy of juniper oil and juniper foliage as limiting agents in supplemental feeds for Angora goats. In Experiment 1, 40 yearling Angora females were self-fed alfalfa hay and a concentrate supplement containing either 0, .4, .8, or 1.2% juniper oil during a 26-d feeding period. Intakes of hay and supplement were almost the same at the 0 and .4% levels of juniper oil in the supplement. There were reciprocal downward and upward trends in intake of supplement and hay, respectively, as the juniper oil content in the supplement was increased to .8 and 1.2%. In Experiment 2, foliage from redberry juniper and blueberry juniper were fed at 0, 6.25, 12.5, and 25% of complete mixed rations to 70 yearling Angora females. Intake was slightly lower for the redberry-containing rations, but only the redberry-containing ration at the 25% level decreased intake compared with the control (0%) ration. These results suggest that neither juniper oil nor juniper foliage will adequately restrict intake of a supplement unless included at an unrealistically high level. Juniper foliage in a mixed ration fed to goats did not induce the goats to eat more juniper when they were given access to fresh juniper foliage.

Introduction

Sheep and goats in the Edwards Plateau region of Texas generally require additional nutrients during the winter to achieve satisfactory levels of reproduction and fiber production. Many ranchers use self-fed supplements during this time to reduce labor costs and minimize the disturbance of sheep and goats during lambing and kidding. Salt is commonly used to limit intake of supplemental feed to a desired level. From 10 to 30% salt has been successfully used; however, high levels of salt in supplements can reduce protein retention (Huston and Shelton, 1967). This is probably of minor importance unless an animal is on a maintenance ration containing a marginal level of protein or when an animal is the state of increased production (e.g., late pregnancy). However, salt is rather expensive ($80.00/ton) and contributes nothing to the diet once an animal's requirement for salt is met.

Because of the aforementioned factors, we tested alternate substances that might be used to limit supplement intake. A group of chemicals which can affect forage intake are plant secondary compounds. Secondary compounds produced by some plants protect them against insect attack or deter grazing (Barry and Blaney, 1987). A variety of secondary compounds are found within plants, and each affects animals differently.

Volatile oils are secondary compounds in juniper species and are thought to affect their palatability and digestibility. Juniper is considered to be a relatively unpalatable, non-toxic emergency browse for grazing ruminants. Because of the availability of both juniper foliage and juniper oil, two experiments were conducted to determine the effectiveness of using extracted juniper oil and juniper foliage as ingredients in supplemental feed.

Experimental Procedures

Experiment 1

Forty yearling Angora does were assigned randomly to eight treatment groups to study the effects of juniper oil as an ingredient of supplemental feed on the voluntary intake of the supplement and free-choice alfalfa hay. A basal, high-protein supplement was formulated (Table 1), and blueberry juniper oil (obtained from Chem-Pac, Inc., Junction, Texas, at $40/gal) was mixed with the supplement at 0 (Control), .4 (Low), .8 (Moderate), and 1.2% (High) on an air dry basis. Both supplemental feed and alfalfa hay were offered to the goats free-choice each day. Intake of supplement and hay was estimated by subtracting weight of orts from amount fed. Treatments were replicated twice with pens designated as experimental units (five goats/pen). The goats were weighed at the beginning and end of the 26-d feeding period.

Experiment 2

Seventy yearling Angora does were assigned randomly to fourteen treatment groups to determine the effects of foliage from redberry juniper (*Juniperus pinchotii*) and blueberry juniper (*Juniperus asheii*) as ingredients in supplemental feed on voluntary intake of the supplement and free-choice alfalfa hay. Formulations of the supplements are shown in Table 2. Supplements designated as low, med, and high were formulated for blueberry and redberry juniper. Therefore, the seven experimental treatments were control (Control), low blueberry (LBB), medium blueberry (MBB), high

blueberry (HBB), low redberry (LRB), medium redberry (MRB), and high redberry (HRB). The juniper foliage was hand-harvested, air dried, and coarse ground through a small hammermill and included in the mixed ration at the indicated levels. The supplemental feeds and alfalfa hay were offered to the goats and intake determined by the same procedure as in Experiment 1. Treatments were replicated twice with pens designated as experimental units (five goats/pen).

A second phase of Experiment 2 was a preference trial to determine if supplements containing juniper fed to the goats would affect subsequent diet selection when the goats were offered blueberry and redberry juniper. After the feeding trials described above, the goats were kept in the experimental groups and all were given a pelleted ration at 3% of the group average body weight (approximately 75% of *ad libitum* intake) for 3 days during which juniper foliage was not fed. Then on days 3 and 4, four similar sized branches each of blueberry and redberry juniper were wired to two 3-ft lengths of 2x4 lumber that were attached to the end of each pen. The goats were allowed to browse the foliage for twenty minutes on each day. The branches were weighed before and after browsing, and consumption for each species of juniper was calculated per pen. Percentage of juniper consumed was calculated by dividing juniper consumed by juniper offered. Moisture losses were accounted for by recording weight losses of similar branches that were hung outside the pens.

The General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 1991) was used to analyze the data generated in these experiments. The pen was the experimental unit. Variation among pens receiving the same treatment was used as the error term. Comparisons among means were tested by partitioning the sums of squares into a set of orthogonal contrasts.

Table 1. Percentage ingredient composition of supplemental feed.

Ingredients	Percent of ration
Alfalfa	10.0
Cottonseed meal	50.0
Sorghum grain	36.8
Molasses	3.2

Table 2. Percentage ingredient composition of supplements used in the juniper foliage feeding study.

	Juniper level			
Item	Cont	Low	Med	High
Alfalfa meal, %	10.00	5.00	2.50	.0
Cottonseed meal, %	50.00	51.50	53.00	56.00
Sorghum grain, %	36.80	34.05	28.80	15.80
Molasses, %	3.20	3.20	3.20	3.20
Juniper, %	.0	6.25	12.50	25.00
	100.00	100.00	100.00	100.00
CP, %	26.50	26.30	26.30	26.40
TDN,%	69.50	69.60	69.10	67.40

Results and Discussion

Experiment 1

Supplemental feed intake (% of body weight) was greater for the control, low and moderate treatments (2.5, 2.5, and 2.3, respectively) compared to the high treatment (2.0) (P = .12) (Table 3). Total intake (supplement + hay) averaged 4.1% of body weight for all of the goats in the study. There were no differences in total intake among the treatments (P = .95). Goats fed the high level of juniper oil increased their total intake by consuming more hay per day than the controls (1.1 vs .8 lb/hd, respectively).

Weight gains were not significantly different among the treatments. All goats averaged positive net gains that ranged from a low of 5.6 lb for the moderate treatment to a high of 6.7 lb for the low treatment.

The data indicate that supplemental feed consumption can be limited if enough juniper oil is added. Furthermore, there appeared to be no adverse effects associated with intake of juniper oil. The question then becomes one of economics: "what level of juniper oil is needed to limit intake of the supplement at the desired level and how much does this add to the cost of the supplement?" This experiment indicates that the supplemental ration should contain at least 1.2% juniper oil before intake of the supplement starts to be limited. In reality, a higher percentage of juniper oil would probably be needed for goats in suboptimal nutritional conditions. However, if we figure the additional cost of the supplement with juniper oil mixed into the ration at 1.2%, it would amount to $114.30/ton of supplement.

Some supplemental feeds contain up to 30% salt. Salt at this level has proven to be effective in restricting intake of supplement on range conditions. The additional cost of the supplement with 30% salt would be $24.00/ton which is significantly cheaper than the juniper oil.

Table 3. Intake (% of body weight) of hay, supplement and total intake by yearling Angora does as affected by percent juniper oil in supplemental feed.

Juniper oil	Hay	Supplement	Hay + Supplement
		%	
0.0	1.5	2.5	4.0
0.4	1.7	2.5	4.2
0.8	1.8	2.3	4.1
1.2	2.0	2.0	4.0

Experiment 2

Supplement intake (% of body weight) for the control, LBB, MBB, HBB, LRB, MRB and HRB averaged 3.2, 3.3, 3.4, 3.0, 3.2, 3.0, and 2.1, respectively. Redberry juniper at the high level significantly reduced supplemental feed intake compared to the control (P = .02). Intake of supplement containing redberry juniper was lower than that of the blueberry supplement (P = .04). Other research has shown redberry juniper to be significantly less palatable to goats than blueberry due to its terpenoid composition (Straka, 1993). For example, the concentration of terpineol, a monocyclic terpene alcohol classified as a oxygenated monoterpene, was negatively correlated with consumption of juniper and represented a greater percentage of the oil composition in redberry compared to blueberry juniper. The significance of this may indicate the importance of specific terpenes on juniper intake.

This theory was further supported by the palatability study in which blueberry consumed averaged 30% compared to 16% for redberry juniper (P = .05). There were no differences for juniper selection among the different treatment groups. This indicates that offering juniper to goats in a quality feed mix for 3 days will not influence their subsequent selection for the two different juniper species. However, the short-term nature of this experiment could make the data on preference misleading. Although the results of these experiments appear to nullify the use of both juniper foliage and juniper oil in feed as a means to improve the nutritional management of livestock, our interest in plant secondary chemicals remains high.

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Seroprevalence of Ovine Progressive Pneumonia Virus in Texas Sheep

A. de la Concha-Bermejillo, M. Shelton, and S. Magnus-Corral

Ovine progressive pneumonia (OPP), also known as visna or maedi, is a debilitating disease of adult sheep caused by a lentivirus called ovine progressive pneumonia virus (OPPV) (Narayan and Clements, 1989; DeMartini et al., 1993). The word lentivirus actually means slow virus and refers to the fact that it takes several years for infected animals to develop the clinical disease. Ovine progressive pneumonia can be manifested in different forms. Most commonly, OPP-affected animals lose body weight and condition (thin ewe syndrome) and have increased respiratory rate, difficulty of respiration, open mouth breathing, and exercise intolerance (lungers). Coughing, fever, and inappetence are common especially if secondary bacterial complications occur (Cutlip et al., 1978; Oliver et al., 1981). Another manifestation of the disease is chronic indurative mastitis (hardbag). Ewes affected by this form of the disease have bilateral enlarged, firm udders and poor lamb growth due to insufficient milk production (Bulgin et al., 1985). Some sheep affected by OPP may develop arthritis and lameness; and very rarely when the virus affects the brain, the disease may result in abnormal hind limb gait, incoordination, and paralysis over a period of weeks to months (Cutlip et al., 1978; Narayan et al., 1992).

The OPPV is transmitted mostly through the colostrum and milk from infected mothers to their offspring during nursing. In addition, the virus can be transmitted in older sheep by close contact between infected and non-infected animals. Transmission of OPPV from mother to fetus in the uterus also occurs; however, it is very sporadic (Pearson et al., 1989).

Infection by OPPV is widespread in North America, but there is some variation in the infection rates among states and among farms (Cutlip et al., 1992). Ovine progressive pneumonia virus has been isolated from a Texas sheep (de la Concha-Bermejillo et al., 1992). The purpose of this study was to determine the prevalence rate of antibodies to OPPV in Texas sheep flocks and to detect associations, if any, between infection with OPPV and breed, sex, age, type of lambing management (range vs shedding), and source of replacements (purchased vs raised). Two thousand and five serum samples were collected from sheep in twenty-five different Texas locations. Ovine lentivirus precipitating antibodies were determined by the agar gel immunodiffusion test using a commercially available kit (Veterinary Diagnostic Technology, Inc. Wheat Ridge, CO).

Ten sheep out of 2,005 tested (0.5%) had serologic evidence of exposure to OPPV. The ten positive reactors were from five different locations in west central and north central Texas. Because of the low prevalence of OPPV in Texas sheep, associations between breed, sex, age, and type of lambing could not be established. However, the origin of eight of the ten positive sheep was traced to three states, Idaho (one Suffolk ram), Iowa (three Suffolk ewes), and Missouri (three Finn/Dorset rams and one Polypay ewe). The ninth sheep had been bought at an auction, and the origin was unknown. However, the owner thought that the ram could have been brought from another state. The tenth positive sheep was a Texas-born 4 to 5 month old lamb, that was the offspring of a ram bought at an auction. Thus, most or possibly all OPPV seropositive cases can be traced to animals introduced into Texas.

The low OPPV seroprevalence in Texas sheep contrasts with the high prevalence reported in other sheep-producing states such as Idaho (67.5%), Utah (45.1%), California (43%), and Colorado (41.7%) (Cutlip et al., 1992). The reasons for this difference in OPPV seroprevalence are not clear but may be related to sheep replacement practices (most Texas producers maintain closed flocks or buy replacement sheep in Texas). Other factors that may influence the low OPP prevalence could be climatic conditions, management, and breed. Most sheep in Texas are raised in the western part of the state under extensive conditions. The hot and dry weather of West Texas, the low concentration of sheep per square mile, and practices of lambing on the range are all factors that decrease the chances of contact transmission between infected and non-infected animals. In addition, the most prevalent breed in West Texas is the Rambouillet. It has been speculated that this breed is more resistant to OPP (Gates et al., 1978). The fact that a Texas-born lamb was found positive to OPPV antibodies indicates that transmission can occur under Texas conditions. Because this lamb was never in direct contact with the infected sire, it is thought that the lamb acquired the infection (or antibodies) from the dam. However, at the time of the survey the lamb had already been weaned and the ewe was not available for testing.

Due to the rapid changes in the trends of sheep markets, some of the traditional management methods

in Texas are likely to change, and with them the risk of introducing OPPV in sheep of West Texas may increase. Producers need to be aware of the risks involved by introducing sheep from OPP-infected areas. On the other hand, there is an increasing demand for OPP-free sheep throughout the world, and Texas producers should take advantage of the situation when trying to market their sheep.

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Ovine Fetal Malformations and Fetal Death Associated with Infection by Several North American Bunyaviruses

J.F. Edwards, A. de la Concha-Bermejillo, N. Karabatsos, and E.W. Collisson

Summary

Pregnant Rambouillet ewes were inoculated in utero with one of three bunyaviruses, San Angelo virus, Main Drain virus and LaCrosse virus, at 32 to 35 days of gestation. All three viruses produced lesions similar to those of Cache Valley virus. Virus-induced lesions included arthrogryposis, hydrocephalus, limb malformations and fetal death. Ovine fetal malformations may be produced by in utero infection of lambs by several bunyaviruses endemic to North America.

Introduction

Cache Valley virus (CVV) infection of lambs in utero causes multiple congenital malformations including crooked limbs, twisted spinal columns and hydrocephalus. It belongs to the genus *Bunyavirus*, whose members are endemic throughout North America (Calisher et al., 1986; Beaty and Bishop, 1988; Beaty and Calisher, 1991). Within this genus, there are 19 antigenically-determined serogroups. In 1991, there were more than 155 members of the genus isolated from mosquitoes, gnats (*Culicoides*), and a variety of vertebrates. Included in this genus is Akabane virus which is exotic to North America but causes teratogenic disease in ruminants similar to that seen with CVV (Parsonson et al., 1988). Although many of these viruses have an overlap of geographical distribution (sympatric) and because they cross react serologically, infection by one virus may lead to exclusion of another serologically similar virus from an area if the viruses utilize a common vertebrate host (Calisher et al., 1986). Therefore, the sylvatic cycle of CVV (the cycle that maintains CVV in nature) would be broken if a virus that cross reacts with CVV infects a vertebrate host normally used for CVV. The reason for this is that the host's immune response mounted against the first virus would prevent CVV from infecting its vertebrate host. In the absence of CVV-infected vertebrate hosts, the infection cannot be transmitted back to uninfected mosquitoes. This series of events would exclude CVV from a particular geographical area. Many of the North American bunyaviruses are closely related, and some arbovirologists believe that isolation of a bunyavirus at a different geographical site requires that a new species be created. This concept is perhaps justified in view of the fact that more than one bunyavirus may infect a mosquito and allow their genomes to recombine while in the arthropod host to make viruses of different virulence. The following study had the hypothesis that several bunyaviruses from different serogroups in North America could induce fetal death and malformations in fetal lambs.

Experimental Procedure

Using a ventral midline surgical approach, sixteen pregnant Rambouillet ewes were inoculated in utero with one of three bunyaviruses, or control ewes were sham-inoculated with sterile tissue culture medium at 32 to 35 days of gestation. The three viruses used were supplied by the American Type Culture Collection and included San Angelo virus (SAV), Main Drain virus (MDV) and LaCrosse virus (LAC). After inoculation, the ewes were housed individually in isolation cages. At 28 days post-inoculation, the ewes were killed, and the fetal tissues and fluids were examined for abnormalities. Samples of fetal tissues were collected to reisolate the virus used for infection in each case.

Results and Discussion

The results of fetal inoculation with three bunyaviruses are summarized in Table 1. Each of the viruses was capable of inducing arthrogryposis (limbs fixed in flexion and often deviated laterally or medially) and hydrocephalus in ovine fetuses. Dead, resorbing fetuses were seen only with MDV infection; however, more corpora lutea were observed than fetuses in the case of all three viruses suggesting early fetal deaths may have occurred more frequently than observed grossly. Most severely malformed fetuses were edematous (anasarca) and some fetuses only showed mild arthrogryposis without brain malformations. Several inoculated ewes had normal fetuses. Five of these occurred in ewes with multiple fetuses because only one fetus was inoculated. It has been observed that with CVV the infection does not travel from one fetus to another within the uterus (Edwards et al., 1989). In four other cases, there were one or two more corpora lutea on the ovaries than fetuses in the uterus. Such extra corpora lutea may indicate there was early fetal death of some inoculated fetuses. Virus was recovered from all malformed fetuses.

Table 1. Lesions in ovine fetuses infected with bunyaviruses.

Ewe No.	Virus	No. of fetuses	CL	Lesions
1	MDV	2	2	AGH/arthrogryposis
2	MDV	2	2	normal/resorbing
3	MDV	2	2	AGH/resorbing
4	MDV	1	2	normal
5	MDV	2	2	resorbing/resorbing
6	SAV	2	3	normal/normal
7	SAV	3	3	AGH/normal/normal
8	SAV	1	2	normal
9	SAV	2	2	AGH/normal
10	SAV	2	3	normal/normal
11	LAC	1	1	AGH
12	LAC	2	2	AGH/anasarca
13	LAC	1	3	mild arthrogryposis
14	LAC	2	2	AGH/normal
15	control	2	2	normal/normal
16	control	1	1	normal

MDV = Main Drain virus
SAV = San Angelo virus
LAC = La Crosse virus
AGH = arthrogryposis with hydrocephalus
CL = corpus luteum

Like CVV, MDV is a bunyamwera serogroup *Bunyavirus* whereas LAC and SAV are bunyaviruses of the California serogroup. Although they are serologically-distinct viruses, the present study suggests that the potential to produce malformations in fetuses may be a common property of bunyaviruses. It is important to remember that there is some cross reactivity within and among serogroups of bunyaviruses in standard serum neutralization tests such as those done routinely in diagnostic laboratories. Of course, in any host, the antibodies usually react most strongly with homologous virus (*e.g.*, MDV virus with MDV antibody). However, because of the recent attention given to CVV in relation to ovine teratogenesis (Crandell et al., 1989; Edwards et al., 1989; Chung et al., 1990), most laboratories only test for anti-CVV activity. Because the members of the *Bunyavirus* genus are widespread in North America and because several bunyaviruses can induce fetal malformations, one may speculate that some malformed lambs with anti-CVV antibody activity could actually represent infections by related bunyaviruses.

It is believed that most of the lamb malformations diagnosed as due to in utero CVV infections are, indeed, due to CVV in areas where that virus is endemic. It is interesting that SAV was isolated in 1956 in San Angelo, Texas, near the area of the severe outbreak in 1987 of lamb malformations that established CVV as a teratogen of ruminants (Crandell et al., 1989; Edwards et al., 1989; Chung et al., 1990). Although CVV and SAV are in different serogroups, one is tempted to speculate that recombinations of SAV with other related, endemic bunyaviruses may be linked to the emergence of CVV as a pathogen. This may have occurred by direct contribution of virulence characteristics through genetic exchange between viruses, or it may be that cross reaction of vertebrate antibodies led to exclusion of other competing, less-virulent viruses that may have offered protection from CVV infection from the area. It also may be that sporadic cases of lamb malformations in the past in the San Angelo, Texas area were related to SAV infections.

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Bovine Fetal Malformations Caused by Cache Valley Virus

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Summary

Although there are serologic data that Texas sheep and deer are commonly infected with Cache Valley virus (CVV), there is little information regarding cattle and CVV infection. Seventeen Holstein cows had their estrus cycles synchronized and were bred by artificial insemination. They were infected in utero with CVV at various time points between 35 and 53 days of gestation. Cache Valley virus induced early death and malformations of bovine fetuses prior to 49 days of gestation. Fetuses less that 42 days of gestation are particularly susceptible to CVV infection as evidenced by all fetuses of cows inoculated at 42 days of gestation or younger having died and most of these cows aborting by 4 weeks after inoculation. Malformations observed were similar to those seen with CVV infection of sheep. The results of the inoculations confirm the susceptibility of the bovine fetus to CVV infection. Bovine fetuses beyond 49 days of gestation no longer had adverse effects of CVV infection indicating that as in sheep, there is a very discrete period of susceptibility of the bovine fetus to CVV infection.

Introduction

Serologic studies have shown that compared to other viruses of the family *Bunyaviridae*, Cache Valley virus (CVV) has a predilection to infect large mammals, particularly ruminants (Issel et al., 1970; Yuill et al., 1970; Calisher et al., 1986; McLean et al., 1987; Chung et al., 1991; Neitzel et al., 1991). Most *Bunyaviridae* maintain themselves in nature in a sylvatic cycle that involves infection of small mammals (chipmunks, squirrels, rabbits, hares, rodents, etc.) and insect vectors (Calisher et al., 1986; Beaty and Bishop, 1988; Beaty and Calisher, 1991). Wild ruminants, sheep and cattle have a high CVV seroprevalence in endemic areas where the ruminants interface with this sylvatic vector/host cycle, and there is evidence that when cattle are present, mosquitoes that are vectors of CVV preferentially feed on cattle (Yuill et al., 1970). In Texas, CVV has been isolated from cattle and sheep (McConnell et al., 1981; Chung et al., 1990). One study of CVV in deer in South Texas (Issel et al., 1970) demonstrated that the seroprevalence of CVV was 64% in the deer population. It has been shown that CVV causes fetal malformations in sheep (Crandell et al., 1989; Edwards et al., 1989; Chung et al., 1990); however, the teratogenic potential of CVV in other ruminants has not been investigated. This study investigated the susceptibility of the bovine fetus to CVV infection.

Experimental Procedure

Seventeen Holstein cows had their estrus cycles synchronized and were bred by artificial insemination. Their pregnancies were confirmed by rectal palpation or in the case of early pregnancy (<35 days fetus) by ultrasonography. The pregnant cows were infected in utero with $10^5 TCID_{50}$ CVV via an intra-allantoic cavity injection at various time points (Table 1) between 35 and 53 days of gestation. Three cows were sham-inoculated with tissue culture medium to serve as controls. The cows were observed for clinical illness twice daily. The cows were killed 28 days post-inoculation, and the fetus and fetal membranes and fluids were examined immediately after removal from the cow for evidence of abnormalities. Tissues collected during the gross examination were frozen at -70 °C and later assayed in Vero cell cultures for virus content.

Table 1. Lesions observed in bovine fetuses inoculated in utero with Cache Valley virus (CVV).

Cow no.	Date of virus Inoculation[a]	Inoculum	Gross observations
1	35	CVV	aborted
2	35	CVV	aborted
3	36	CVV	aborted
4	35	control	normal
5	38	CVV	mild limb malformation
6	42	CVV	aborted
7	42	CVV	dead fetus, resorbing
8	42	CVV	aborted
9	42[b]	CVV	dead fetus
10	42[b]	CVV	malformed
11	42	control	normal
12	46	CVV	dead fetus
13	46	CVV	malformed
14	50	control	aborted, cystic corpus luteum
15	49	CVV	normal
16	53	CVV	normal
17	53	CVV	normal

[a]Days of gestation
[b]Inoculum diluted 1:10

Results and Discussion

None of the cows showed clinical signs of disease. The effects of the in utero inoculations of CVV on bovine fetuses are summarized in Table 1. Cache Valley virus can induce early death and malformations of bovine fetuses prior to 49 days of gestation. Fetuses less than 42 days of gestation are particularly susceptible to CVV infection as evidenced by all fetuses of cows inoculated at 42 days of gestation or younger having died and most of these cows aborting by 4 weeks after inoculation. Some of the severity of the early infections may have been due to the viral titer in the inoculum; however, the results of the inoculations appear to be due to the susceptibility of the bovine fetus to CVV infection. Sheep have a period of susceptibility lasting from approximately 30 to 42 days of gestation (Chung et al., 1990); however, an identical inoculum may cause fetal death only between 30 to 35 days of gestation. The diluted inoculum used in two cows still resulted in both fetal death and malformations at 42 days of gestation. It is surprising that even without diluting the inoculum, fetuses beyond 49 days of gestation no longer had adverse effects of CVV infection which indicates a very discrete period of susceptibility. One fetus inoculated at 38 days of gestation did not die but had malformations suggesting some variation to susceptibility. The virus was recovered from all surviving fetuses that were infected in this experiment.

The malformations observed were similar to those seen with CVV infection of sheep. Arthrogryposis with or without hydrocephalus was induced in fetuses inoculated between 38 and 46 days of gestation. The loss of one control fetus sham-inoculated at 50 days of gestation was presumed due to the cystic corpus luteum found at gross examination. It has been one of the author's experience that cystic corpora lutea do not maintain pregnancies (slaughterhouse data, personal observation, Edwards) and the inoculation technique did not affect earlier pregnancies; nor did the inoculation of three other fetuses at 49 to 53 days of gestation with CVV cause fetal losses.

Although there are serologic data that Texas sheep and deer are commonly infected with CVV, there is little information regarding cattle and CVV infection. To date, no malformed bovine neonates have been confirmed to have resulted from natural CVV infection (Greene et al., 1973). As with CVV-induced malformations in lambs, CVV would be eliminated from the bovine fetus after it becomes immunocompetent and the virus can no longer be isolated from the term newborn. To confirm that CVV caused malformations in a newborn calf would require precolostral calf blood or body cavity fluids be tested for CVV antibody. These samples are not collected and tested commonly from stillborn and malformed calves. Malformed calves have been born to cows with antibody titers to CVV (unpublished data) but the relationship of the CVV infection to the pregnancy of the cow cannot be determined (i.e., one would argue that the cow may have been infected and the virus never crossed the placenta or the cow was infected prior to pregnancy). A calf is born normally without antibodies in the serum unless it has been exposed to an antigen in utero; therefore, the presence of anti-CVV antibodies in calf serum before ingestion of colostral immunoglobulins would indicate an in utero CVV infection. The finding that the bovine fetus is so susceptible to infection and death over such a short period of gestation also may explain the paucity of spontaneous cases of malformed calves observed subsequent to CVV infection. The only isolation of CVV from cattle was from a normal cow in a herd being investigated for reproductive failure. The fetal losses in that herd could have been the result of CVV infection.

The most probable reason why there is so little documented CVV-associated loss in cattle is related to the ecology of the virus and common breeding practices. Because most bunyaviral disease would be expected in areas where susceptible domestic ruminant hosts would interface with the normal sylvatic cycle of the virus, the cattle most likely to enter the viral transmission cycle are range or beef cattle. In most instances, these herds use a controlled breeding season where most cows are bred before the summer months. Therefore, there would be few cows in the early stages of pregnancy in the early fall when CVV activity appears to be greatest and these cows may experience "silent" abortions in the pasture. Cattle producers using a year-round breeding season should incur a higher risk of CVV fetal losses and malformations in CVV-endemic areas.

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The Texas Agricultural Experiment Station Image Analysis System and Its Automation

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Summary

The Texas Agricultural Experiment Station (TAES) general-purpose Image Analysis System was described. This system was assembled to analyze 1) average fiber diameter and its distribution, 2) medullation, 3) color of scoured fibers, 4) colored fiber content, 5) staple length, 6) mechanical yield of cashmere, 7) crimp in wool and cashmere, (8) style and character in mohair, and 9) luster in wool, mohair, and cashmere. The software used for developing this system included Microsoft's Visual C++, Windows Software Development Kit, and Truevision's Targa+ Compatible Toolkit. Automation of this system was achieved with a programmable stage (Nikon Optiphot) using functions of serial communication of Windows for continuous image capture, real-time analysis. To date, programs for applications 1) to 6) have been completed, while those for applications 7) to 9) are in progress. Measurements produced using programs in the TAES Image Analysis System were compared with those from standard methods for average fiber diameter ($r = .994$, $P<.0001$), color of scoured fibers ($r > .926$, $P<.0001$), staple length ($r = .998$, $P<.01$), mechanical yield of cashmere ($r = .912$, $P<.0001$), and medullation in mohair ($r = .414$, $P>.20$). The original program for analyzing colored fiber content has been modified to distinguish pigmented fibers from stained, yellowish fibers and is still under evaluation. Results indicate that the TAES Automatic Image Analysis System is versatile and promising. Commercialization of some of the finished programs is being investigated.

Introduction

Since 1988, researchers at the Wool and Mohair Research Laboratory of the Texas Agricultural Experiment Station (TAES) in San Angelo have used an Image Analyzing System (Analytical Imaging Concepts, Irvine, CA) for characterizing animal fibers. In 1992, an Optical Fibre Diameter Analyser (OFDA) was purchased (BSC Electronics Pty Ltd, Attadale, Australia) for evaluation (Qi et al., 1994). The OFDA is a promising system for rapid evaluation of average fiber diameter (AFD) and its distribution. It can measure wool, mohair, and cashmere in the form of staples, tops, and core samples. Further improvement of the OFDA is required to accurately measure the standard deviation (SD) of fiber diameter.

The aforementioned two instruments are limited in that they are only programmed to analyze black and white images and output AFD and SD. Source codes of the programs for these two instruments were retained by the manufacturers and cannot be obtained. Consequently, a new image capture board and a CCD (charge-coupled device) color video camera with several compatible programming tools were recently purchased to provide the capability to expand programming for application beyond AFD and SD.

This report is intended to 1) give a short description of this updated system and introduce the functions of the key components; 2) report the automation of this system for continuous, real-time image analysis; 3) summarize plans to apply this system to animal fiber characterization; and 4) report progress to date.

The TAES Image Analysis System

Hardware Components

The TAES Automatic Image Analysis System consists of an analytical microscope (Nikon Optiphot) with a video adapter and a programmable stage (Nikon Scanning Stage); a CCD black-and-white camera (Javelin JE2362), and a CCD color video camera (JVC TK-1070U) with a zoom lens (H6X12.5R, Fujinon-TV), both of which can be fitted to the microscope or to a camera-stand when macro rather than micro views are required; a Targa-compatible display monitor (Sony Trinitron PVM-1271Q); a Truevision Targa+ ISA (64) Graphics Engine (Truevision, Inc., Indianapolis, IN); an IBM-compatible computer (Comtrade, Inc., Industry City, CA); a laser printer (HP Laserjet III); and sample preparation and mounting devices.

The CCD cameras capture images representing fiber properties and convert them into electrical signals. These electrical signals are then transmitted to the Truevision Targa Graphics Engine (Targa board) for digitization according to their configuration. A simple example of the configurations uses Red-Green-Blue signals in a 640 by 480 resolution. This configuration offers 32,768 colors. The square pixel is the advantage under this setting. Other configurations are also available for the Targa board and resolution can be as high as 1024 by 768 with 16.7 million colors. Fiber samples in the camera-stand are illuminated by four halogen

light bulbs (32,000°K, General Motors, Detroit, MI) to provide uniform illumination of the sample surface. The processing system is a 486DX/33MHz microcomputer with 16 MB RAM, 180 KB of cache memory, and 250 MB of memory on hard disk. The make and model of the microcomputer are not crucial to the system except so far as the speed and memory of the system are concerned. The display monitor is required for programming only. For commercial usage of the developed programs, a VGA pass-through configuration could be used to monitor the image analysis and data output under a Graphic User Interface (GUI). This system now is capable of processing and analyzing both black-and-white and color images.

Program Tools

The program tools used in the TAES Image Analysis System include Microsoft Visual C++, version 1.5; Microsoft Windows Software Development Kit, version 3.1; and Targa Compatible Toolkit, release 1.0. Because Microsoft C, version 6.0 or higher, is recommended for image processing on the Targa board, both C and C++ programs from Microsoft can be used.

The Functions of CCD Cameras and Targa Board in the TAES Image Analysis System

The key components of hardware in the TAES Image Analysis System are CCD cameras and Targa board. It is worthwhile to explain their functions.

The CCD Camera

The CCD in the black-and-white camera (Javelin JE2362) of the TAES Image Analysis System is an elegant little chip of semiconducting silicon about the size of a postage stamp. Wherever light strikes the surface, a small electric charge accumulates. By measuring the size of the charges in each section of the chip, called a picture element, or pixel, a CCD provides a way to estimate accurately the amount of light striking its surface.

The CCD was invented in 1970 at Bell Telephone Laboratories by Willard S. Boyle and George E. Smith (The Editors of Time-Life Books, 1990). They intended to build a device for computer memory circuits, which could store a small electrical impulse in various tiny compartments and read out the charges later. But the chips that Boyle and Smith developed could only be read out sequentially in rows; they did not offer random access, which was important for computer memories. It became apparent that they were much better suited to imaging applications in which random access is unnecessary and sequential access is desirable.

The CCD color video camera (JVC TK-1070U) in the TAES Image Analysis System has a stamp-size (2/3") CCD solid-state pickup element with 380,000 effective pixels. A total of 480 TV lines is designed for high horizontal resolution. Optical Red-Green-Blue filters are fitted to realize superior color reproduction. It can output 3 types of video signals: composite, separate Y-C, and Red-Green-Blue. After sensing a color image using the CCD color video camera, electrical signals are fed out to the Targa Board.

The Targa Board

The Targa board (Truevision Targa+ ISA Graphics Engine) is really a capture/display video graphics adapter. It digitizes the video image fed out of the CCD camera, and stores the digitized signals in the Red-Green-Blue bands of each pixel. Then, the computer can be programmed to analyze the digitized image and output useful information. The Targa board used here is a Targa+ 64 and has 2 MB of high speed video RAM; 1024 by 768 maximum display; 16.7 million maximum colors; 16, 24, and 32 bits per pixel; NTSC/Y-C/RGB and overlay capacity; interlaced and non-interlaced modes; advanced genlock; and image pan and zoom. This Targa board also supports both NTSC (National Television Systems Committee) and PAL (European standard for television) video, AT bus or MCA bus, full digital keying, blending and mixing of live and still video images, and chroma keying. The 2 MB of video RAM allows the user to run 16, 24, and 32-bit software all on the same Targa board.

Automation of the TAES Image Analysis System for Continuous, Real-time Image Capture and Processing

The Necessity for Automation

While programming the TAES Image Analysis System for measuring average fiber diameter and distribution, medullated fiber content, and colored fiber content, it became necessary to automate the system in order to continuously capture and process images so that enough fibers could be measured to achieve specified precision (ASTM, 1993a,b,c) in a relatively short time.

The Hardware and Software Tools for Stage Automation

The analytical microscope has a programmable stage (Nikon's Scanning Stage) that can be linked to a serial port and controlled by custom-designed programs having serial communication capacity such as FORTRAN, Pascal, and C/C++.

The basic design and data format of Nikon's Scanning Stage is described in the instruction manual (Nikon, 1988). This information was used to write a program using Microsoft Visual C++ in the Windows environment to control intermittent stage movement as it travelled through a specified grid. Such an arrangement permits scanning of all the fibers on a microscope slide positioned on the stage, and permits simultaneous output of the results — the so-called automatic image analysis.

Program Development for Stage Automation

The stage was linked to the computer through a serial port (COM2). The functions: BuildCommDCB(), SetCommState(), OpenComm(), CloseComm() of Windows Software Development Kit were adapted into the program. The function BuildCommDCB() was used to translate the stage definition string into appropriate serial device control block (DCB) codes, which was used by the SetCommState() function to set the stage to the specified state. Then, the OpenComm() function opens the stage device for accepting commands. After finishing the desired movements, the CloseComm() function closes the stage device and frees the memory allocated for the stage communications.

Table 1 lists an example which uses the aforementioned functions to set up COM2 to operate at 2400 baud, with no parity, 8 data bits, and 1 stop bit.

Several other functions are defined to control the stage initialization, stage movement with certain speed, stage stopping and waiting for image capture, automatic fiber recognition, analysis, and output of results. The core of the program controlling the stage movement to scan the whole slide is listed in Table 2.

With this program controlling the stage, the TAES Image Analysis System becomes an automatic, continuous, real-time image analyzer. Consequently, it can analyze 10,000 fibers in 10 minutes. Therefore, the system has been renamed "The TAES Automatic Image Analysis System."

Proposed Applications and Achievements to Date

Fiber Characterization

Underlying the application of the TAES Automatic Image Analysis System to fiber characterization is the philosophy of grabbing as much usage as possible with a single instrument (general-purpose). Many different instruments exist for measuring individual fiber characteristics. The high cost of modern instrumentation often limits what most research and even individual groups can afford in terms of objective fiber measurement. Thus, although image analysis may not always be the optimum technology for determining a particular fiber property, it may still be feasible to develop applications to measure that property in order to extend the usefulness of the system. This approach involving a single technology should result in less expensive fiber measurements once the system is avail-

Table 1. An example showing serial communication between the microscope stage and computer.[a]

```
int CStage_Move(){
        int idComDev, val1, val2;
        idComDev = OpenComm("COM2", 1024, 128);
        if (idComDev == 0) {
                val1 = BuildCommDCB("COM2:2400,n,8,1", &dcb);
                if (val1 == 0){
                        val2 = SetCommState(&dcb);
                                if (val2 == 0){
                                movestage commands go here;
                        }
                }
        }
        CloseComm(idComDev);
        return (1);
}
```

[a] This program sets up COM2 to operate at 2400 baud, with no parity, 8 data bits, and 1 stop bit.

Table 2. An example showing the program core for scanning a whole slide.[a]

```
const X_min = 0;
const X_max = 30000;
const Y_min = 13000;
const Y_max = 38000;
const X_step = 30;
const Y_step = 45;
int Move_Stage(){
        long x, y;
        int X_step, Y_step;
        for (y = Y_min; y < Y_max; y += Y_step){
                for (x = X_min; x < X_max; x +=X_step){
                        SetLiveMode();
                        Stage.MoveTo(x, y, 8);
                        GrabFrame();
                        SetDispMode();
                        GetImageData();
                        ImageAnalyses();
                }
                X -= X_step;
                Y += Y_step;
                for (; x > X_min; x -= X_step){
                        SetLiveMode();
                        Stage.MoveTo(x, y, 8);
                        GrabFrame();
                        SetDispMode();
                        GetImageData();
                        ImageAnalyses();
                }
        }
        return(1);
}
```

[a] Stage can be moved from coordinates (0, 30000) to (13000, 38000) which is the area containing fibers.

able commercially. Table 3 lists nine proposed applications for measuring fiber properties with this general-purpose TAES Automatic Image Analysis System.

Achievements to Date

Programs have already been developed for AFD and its distribution; medullated fiber content in mohair; color of scoured wool, mohair, and cashmere; colored fiber content in animal fleeces and tops; wool staple length; and mechanical yield of cashmere.

The program for AFD analysis was shown to be highly accurate (Kumar, 1994). A set of 8 standard tops with known AFD values (17.16 to 37.73 μm) was analyzed using this program, and the results are summarized in Table 4. The correlation coefficient between the micron values (μm) and the program measurements (pixel) was r = .9940 (P<.0001). The regression equation relating the micron values (Micron value, μm) to the pixel values (Pixel value) measured by this program is

$$\text{Micron value } (\mu m) = 1.8523 + 0.2508 \times \text{Pixel value (pixel)}.$$

The program for analyzing med and kemp fiber contents looks promising, but major improvement is still required in the algorithms for med and kemp fiber recognition and in the lighting system. A set of 10 standard mohair samples with known med and kemp percentages was analyzed using this program (Table 5). The correlation coefficients (r) for med, kemp, and total medullation between the results of our program and those from the standard method (ASTM, 1993b) were .234 (P>.20), .325 (P>.20), and .414 (P>.20), respectively.

Evaluations of programs for measuring color of scoured fibers, staple length, and mechanical yield of cashmere are summarized in separate progress reports. The developed program for quantifying colored fiber content has been modified to distinguish pigmented fibers from stained, yellowish fibers and is still under evaluation. A grant proposal for mohair luster measurement has been submitted to the USDA National Research Initiative Competitive Grants Program (NRICGP) to secure funds that will permit concentration and acceleration of efforts in this application (Lupton and Qi, 1994).

To date, results indicate that the TAES Automatic Image Analysis System is versatile and promising. Commercialization of some of the advanced programs is under investigation.

Table 3. Proposed applications for the TAES Automatic Image Analysis System.

Proposed application	Progress to date
Average fiber diameter and its distribution	Advanced[a]
Medullation in mohair (med and kemp percentages)	Advanced[a]
Color of scoured fibers	Advanced[a]
Colored fiber content (pigmented and stained fiber contents)	Advanced[b]
Wool staple length	Advanced[a]
Cashmere yield	Advanced[a]
Luster in mohair, wool, and cashmere	In progress
Crimp in wool and cashmere	Pending
Style and character in mohair	Pending

[a] Further improvement of the program may be needed to increase speed, accuracy, and/or precision of the measurement.
[b] Evaluation is pending.

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Table 4. Evaluation of the average fiber diameter program.

Identity of standard top	Average fiber diameter (μm)	Measurement using image analysis program (pixel)
1	23.70	7.86
2	37.73	11.56
3	22.73	7.47
4	17.65	6.37
5	25.62	8.19
6	20.32	6.85
7	29.16	8.84
8	17.16	6.36

Table 5. Evaluation of image analysis for measuring medullation in mohair.

	Standard measurements[a]			Image analysis measurements[b]		
Sample identity	Med (%)	Kemp (%)	Total (%)	Med (%)	Kemp (%)	Total (%)
1	4.23	1.37	5.60	4.27	1.56	5.83
2	1.27	1.96	3.23	1.58	0.61	2.19
3	1.83	2.93	4.76	6.09	2.47	8.56
4	1.75	0.23	1.98	2.26	0.72	2.97
5	1.31	2.42	3.73	3.38	1.32	4.70
6	2.70	0.86	3.56	2.98	1.18	4.16
7	2.09	3.19	5.28	1.33	0.41	1.74
8	3.25	0.74	3.99	2.82	0.89	3.71
9	2.83	2.16	4.99	5.21	2.01	7.22
10	0.61	0.44	1.05	2.93	0.73	3.66

[a] Average of more than 10,000 fibers measured by 5 technicians.
[b] Average of 5,000 fibers.

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Wool Staple Length Measurement Using the TAES Automatic Image Analysis System

K. Qi, C.J. Lupton, F.A. Pfeiffer, and D.L. Minikhiem

Summary

Wool staple length is the third most important characteristic after scoured yield and average fiber diameter. An algorithm was developed, and a C++ program was written for use in the TAES Automatic Image Analysis System to facilitate measuring wool staple length. Preliminary results indicate that program-measured wool staple lengths were highly correlated with those measured manually ($r = .9981$, $P<.0001$) and that the program could measure wool staple lengths to an accuracy of ±3%. It was concluded that this program for measuring staple length has the potential for eliminating operator errors and increasing speed of measurement.

Introduction

Economically, wool staple length is usually the third most important characteristic after scoured yield and average fiber diameter. It is closely related to mean fiber length in processed top and also determines the system on which the wool fiber will be spun (worsted or woolen) and the type of product into which the fiber will be manufactured (Lupton, 1992).

The standard technique used in the United States for determining staple length (ASTM, 1993a) requires only a ruler for measurement and a pencil for recording. This method is simple and reasonably accurate, but slow, and sometimes operator biases are introduced. The ASTM procedure calls for "relaxed" staple length to be recorded. Lupton (1992) discussed the shape differences among wool, mohair, and cashmere staples and concluded that whereas measurement of relaxed wool staples can provide useful information, straightened staple lengths should be measured in the case of mohair, and mean fiber length (ASTM, 1993b) should be measured for cashmere.

Whiteley (1984) described an instrument for automatic measurement of staple length (predominantly for wool). Several of these expensive, staple length-strength determining instruments currently are being used in Australian Wool Testing Authority facilities to provide (mainly) pre-sale data for wool buyers.

This report describes a newly-developed program for measuring staple length of wool using the TAES Automatic Image Analysis System. The system components were described in another progress report in this series (Qi et al., 1994).

Algorithm Development and Implementation

Wool staples are relatively uniform in shape. For an ideal model, they may be considered as rectangles or trapezoids. Thus, if we measure total area of a staple plus one dimension, or the perimeter plus one dimension, we can easily calculate the staple length for each staple (see Appendix 1). Since these parameters are unaffected by color, only the information contained in the red component of the image was used. Caution was taken to place the grease staples on a background having contrasting color for easier object recognition (e.g., white staple on black paper). In order to increase the accuracy of measurements, multiple staples (3 to 6) from the same sample can be measured by the program simultaneously.

Microsoft Visual C++, version 1.5; Microsoft Windows Software Development Kit, version 3.1; and Targa Compatible Toolkit, release 1.0 were used as tools to develop our program for measuring staple length. This program includes the following functions:

(1) Object constructor,
(2) Object destructor,
(3) Memory management,
(4) Hardware initialization, image grabbing and digitizing,
(5) Staple recognition and measurements,
(6) Calculation of staple length and variability,
(7) Output of results.

Program Evaluation

The program calculates staple length in pixel units. In order to convert pixel values to centimeters, a set of five standards was made and measured both by the program and by ruler (Table 1). Actual staple length can be estimated from the following regression equation:

$$\text{Staple Length (cm)} = -3.7724 + 0.0726 * \text{Program measured staple length (pixel)}$$

$(n = 5, R^2 = .9962, P<.01, SE = .272)$

To evaluate the accuracy of measurements by the program, four simulated staples were measured using the program and a ruler (Table 2). In this case, the program measured staple length to an accuracy of ±3% .

To test the repeatability of measurement by the program, one staple (9 cm actual) was repeatedly measured (10X) at different locations within the viewing field. The mean staple length was 176.503 ± 6.652 pixels or 9.042 ± 0.341 cm.

Table 1. Standardization of staple length measurement.

Staple no.	Actual staple length[a] (cm)	Program-measured staple length (pixel)
1	5.00	122.48
2	8.00	162.82
3	10.00	184.26
4	12.00	220.32
5	15.00	258.65

[a]Staples were cut into these lengths manually and were assumed as an absolute standard.

Table 2. Program-measured staple length compared with ruler measurement.

Staple No.	Program length (pixel)	Predicted length (cm)	Actual length (cm)	Residual error (cm)[a]
1	241.47	13.76	14.00	0.24
2	135.71	6.08	6.00	-0.08
3	220.03	12.20	12.00	-0.20
4	175.41	8.96	9.00	0.04

[a]Residual error calculated as actual length minus predicted length.

Implication

The developed program has reasonable accuracy and repeatability. A sample holder is now under development to simplify sample preparation. This holder will have several slots, and staple samples will be placed in these slots for measurement. The greatest potential benefits of using this program for measuring staple length lie in eliminating operator errors and increasing speed of measurement.

Acknowledgment

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Appendix 1

For the purpose of this exercise, it is assumed that the shape of a staple is a rectangle or a parallelogram. If the staple has a trapezoid shape, we can divide one staple into two parts or use two similar staples, and put one's end with another's head in parallel so that the staple shape becomes rectangular.

If W is the width of a staple and L is its length, the perimeter (P) of the staple is

$$P = 2(L + W) \quad (1)$$

and the area (A) of a staple is

$$A = L * W \quad (2)$$

From Equation 1:

$$W = P/2 - L \quad (3)$$

By inserting Equation 3 into Equation 2, and rearranging:

$$2 * L^2 - P * L + 2 * A = 0 \quad (4)$$

Solving Equation 4 for L, we get

$$L = (P + (P^2 - 16 * A)^{.5})/4 \quad (5)$$

Color of Scoured Wool and Its Measurement Using the TAES Automatic Image Analysis System

K. Qi, C.J. Lupton, F.A. Pfeiffer, D.L. Minikhiem, and A.D. Whittaker

Summary

This research report summarizes our work with the general-purpose TAES Automatic Image Analysis System for measuring color of scoured wool. The technical details are presented elsewhere in a journal article.

Introduction

Color of scoured wool is an important characteristic in determining the final usage of wool for white and(or) pastel clothes (American Association of Textile Chemists and Colorists, 1990; Lupton, 1992). Currently, colorimeters are used for measuring this important property of wool and other animal fibers (Thompson, 1989; Wyatt, 1993). However, due to the high cost of such instruments, and also because of cost of the test (A&16.75 in 1988), the usage of colorimeters for measuring color of scoured wool is limited. Moreover, for animal breeders, the difficulty in obtaining such data has hindered efforts in selective breeding. The objective of this study was to develop a computer algorithm for measuring color of scoured animal fibers using the general-purpose TAES Automatic Image Analysis System.

Materials and Methods

The general-purpose TAES Automatic Image Analysis System was fully described in another progress report in this series (Qi et al., 1994). A CCD (charge-coupled device) color video camera (JVC TK-1070U) and a Targa+ (64) ISA Graphics Engine (Truevision, Inc., Indianapolis, IN) were used to capture and digitize the fiber images. The red-green-blue color model (Judd and Wyszecki, 1975) used by the TAES imaging system was converted to tristimulus values (X, Y, Z) using a cube-root color coordinate system under the CIE (Commission Internationale de l'Eclairage) illuminant C and 0° observer angle (Glasser et al., 1958). The program tools used in the TAES Image Analysis System included Microsoft Visual C++, Microsoft Windows Software Development Kit, and Targa Compatible Toolkit.

The following tests were conducted to facilitate programming for color measurement. First, optimum light intensity was located and subsequently used throughout the study. Second, linearity of image digitization of the imaging system was evaluated using a set of six colored tiles which had been previously quantified by a colorimeter (Macbeth 1500, Kollmorgen Instruments Co., New Windsor, NY) using CIE illuminant C and 2° observer angle. The range of colors for these six tiles were: X from 6.12 to 78.08, Y from 6.25 to 79.89, and Z from 7.30 to 91.05. Third, a white tile was selected as a reference based on uniformity of reflectance at different wavelengths of light, and the system was standardized to be a colorimeter equivalent. Fourth, the effects of glass on the color image analysis were measured and compared with no glass to facilitate building a sample holder with glass to achieve a more uniform measuring surface with constant density in the scoured animal fibers. Finally, our preliminary program was optimized based on these observations.

Results and Discussions

To evaluate this program, a total of 33 scoured wool samples representing wools produced throughout the U.S. (McColl, 1993) were carded and measured using our program and the colorimeter at the International Textile Center, Lubbock, TX. The correlation coefficients between X, between Y, and between Z of the two measurements were .950 ($P<.0001$), .940 ($P<.0001$), and .926 ($P<.0001$), respectively.

These results demonstrate that the TAES Automatic Image Analysis System is capable of measuring color of animal fibers once numerous variables are brought under control. Further improvement of accuracy will be realized by establishing better methodology for sample preparation and mounting (Matthews, 1968). To further improve our system, a special sample chamber is now under investigation.

Acknowledgment

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Concurrent Determination of Cashmere Down Yield and Fiber Diameter Using Automatic Image Analysis Technology

J.R. Marschall, D.L. Minikhiem, C.J. Lupton, F.A. Pfeiffer, and K. Qi

Summary

Cashmere down yields were measured on 75 raw cashmere fleeces from the Texas Agricultural Experiment Station cashmere breeding flock using a Shirley Analyser (SA, standard method) and were estimated with an Optical Fibre Diameter Analyser (OFDA, innovative method). Overall, OFDA-estimated yields were 10.2% lower ($P < .0001$) than SA-measured yields. However, the two sets of measurements were highly correlated ($r = .91$, $P < .01$).

The OFDA instrument was also used to measure the average fiber diameter (AFD) of subsamples representative of individual raw fleeces, and the separated (Shirley Analysed) down and guard hair portions. Overall, AFD of the separated cashmere down was .28 µm finer than the down AFD estimated from histograms of the raw sample. This difference, though small, was highly significant ($P < .003$). The two sets of AFD values were also significantly correlated ($r = .91$, $P < .01$). The observed difference is possibly due to incomplete separation of down fiber from guard hairs by the Shirley Analyser.

Image analysis technology shows promise for estimating down diameter and yield of raw cashmere in a rapid, cost-effective manner.

Introduction

Raw cashmere is a mixture of relatively fine fibers ranging from 4 to 30 µm (cashmere down) and coarse guard hairs ranging from 31 to 200 µm. This raw material is produced by many breeds of goats in a multitude of colors, white usually being the most valuable. The down fineness and the relative proportion of down to guard hair largely determine the value (therefore price paid) of raw cashmere. Cashmere producers in the United States have been conscientious in selecting cashmere-bearing goats to improve both the quality and quantity of the cashmere. Lupton and Shelton (1991) estimated down yield by combining fleece weight and cashmere cover scores. Furthermore, some selections have been based on objective and subjective estimates of down length in hopes of increasing down production (Ryder, 1987). However, all such estimates of down yield tend to be inaccurate. In some cases, the selections made by cashmere producers were assisted with objective measurements of down diameter and yield. Results of cashmere down diameter and yield tests also have been used by processors to purchase fiber on an objective basis (Couchman and Holt, 1990). Because current objective test methods for yield are quite slow and expensive, a need exists for an affordable, accurate measurement of this characteristic of raw cashmere.

Measuring the average fiber diameter of cashmere down can be accurately accomplished by using standard (ASTM, 1992b) and innovative means (e.g., Peyer Texlab FDA 200 System, FDA 200, and the Optical Fibre Diameter Analyser, OFDA), once the down is separated from the guard hair. Complete separation can be achieved by manually separating the two fiber types using tweezers (Blakeman *et al.*, 1992b). Obviously, this method is quite slow and tedious. Typically, samples of raw cashmere are dehaired using the Shirley Analyser (SA), this being the standard method of separation. The process of dehairing samples from cashmere fleeces in this manner is time consuming, laborious, and expensive. Also, a complete separation of the guard hair from the down is rarely accomplished. Invariably, a small amount of guard hair remains in the down portion and vice versa. Nevertheless, Shirley dehairing efficiency remains high and apparently correlates well with results obtained in commercial dehairing. It has been suggested that automatic image analysis technology is capable of measuring fineness and yield characteristics of raw cashmere without physical separation (Blakeman *et al.*, 1992a). An experiment was designed to compare cashmere yield results estimated using the OFDA with those obtained from the Shirley Analyser (Model SDL-102A, which had been modified by the manufacturer for dehairing raw cashmere).

Experimental Procedure

Seventy-five fleeces were obtained from the cashmere goat flock of the Texas Agricultural Experiment Station, San Angelo. These fleeces were shorn from kids, does, and mature males.

Sampling Procedure

Each raw fleece was weighed (± .01 g) and then evenly distributed on a table. A cardboard template with eight rectangular holes (76 mm x 25 mm) was laid over the fleece, and small tufts of cashmere were removed through the holes from random positions in the fleece until 65 g were obtained. The raw cashmere subsamples were homogenized by hand and then divided randomly into 4 x 15 g (± .01 g) portions. Three of the sub-samples were used for SA yield determinations. The fourth sample was minicored and evaluated using the OFDA.

Yield Determinations Using the Shirley Analyser

Initially, the 3 x 15 g samples were washed separately using a standard technique (ASTM, 1992a). The wet samples were then centrifuged for a standard time (1 min) to remove excess water. Next, the damp samples were individually dehaired using a draft (IWTO, 1992) of a proposed standard method. In this procedure, each sub-sample of scoured raw cashmere was passed once through the SA. The down portion was removed from the back compartment of the SA and passed through a second time. The down portion was again removed and passed through the SA for a third time. Next, the down portion was removed and placed in a beaker. The guard hair was then removed from the front compartment and passed through the SA. The down portion was removed and reprocessed. This action was repeated once more to complete the SA separation. Cashmere down from the sixth passage was added to the cashmere in the beaker from the third passage. Guard hair was removed from the SA and placed in a separate beaker. The contents of each beaker were then dried to a constant weight at 105°C, cooled for one hour in a desiccator, and then weighed (± .01 g). After measurement in triplicate, yield (SA) of cashmere down was calculated for each fleece using the following formula: oven-dry weight of cashmere down ÷ original weight of raw cashmere sample x 117. The value 117 was used to convert the ratio to a percentage and also to convert oven-dry weight of cashmere down to "conditioned" weight.

The down portions of each subsample were combined and subsampled using a minicoring device manufactured by the South African Wool Testing Bureau. The minicores were measured for average fiber diameter (AFD) and standard deviation (SD) using the OFDA. This procedure was repeated for the guard hair portions of each subsample.

Yield Determinations Using the OFDA

A 15 g sample representative of the whole fleece was subsampled using the minicoring device. The procedure involved inserting the whole sample into the coring chamber, compressing it, and removing 12 x 30 mm x 2 mm core samples. Special attention was given to retain all the core sample which was then placed into a 60 ml Buchner funnel. The fibers composing the core sample were rinsed with 25 ml of 1,1,1,-trichlorethane at room temperature, dried for one hour at 105°C and conditioned for one hour (or more) at 20°C and 65% relative humidity. To ensure the ratio of cashmere down to guard hairs was not disturbed, the whole of the core sample was placed into the OFDA fiber spreader and distributed onto one slide. Since the density of fibers on the slide was then too great for OFDA measurement, the fiber mass was divided into thirds and each third was re-distributed onto a separate slide. Precautions were again taken to ensure transfer of all fibers. Subsequently, 10,000 fibers were measured on each slide using the OFDA instrument. The distributions of fiber diameters for each third of the raw cashmere subsample were saved on a disk file. Subsequently, the OFDA software was used to convert these data to Lotus 1-2-3 format. Once in this form, the data were used to calculate "OFDA down yield" as explained in the results and discussion section.

Statistical Analysis

Simple linear regression analysis was performed on the data set to establish relationships between SA yield and other parameters that were measured or calculated. Also, stepwise regression analyses and paired T-tests were conducted using the STEPWISE and MEANS procedures of the Statistical Analysis System (SAS, 1988).

Theoretical Considerations

A theoretical consideration of core sampling raw cashmere fleeces leads one to the conclusion that SA down yields (%) will be greater than yields estimated from core samples when guard hair length is greater than cashmere down length. By definition, SA down yield is the weight of dry, clean down x 117 ÷ the weight of raw cashmere from which the down was extracted. These two weights can be estimated from an OFDA histogram as follows. The weight of a conditioned, clean down fiber is

$$\pi d_d^2/4 \times L_d \times D_d$$

where d_d = diameter of cashmere down fiber (4 to 30 μm)

L_d = length of cashmere down fiber

and D_d = density of cashmere down fibers.

After counting the number of fibers at each micron interval, weights were calculated and summed for d_d = 4 to d_d = 30 μm and the weight of conditioned,

cleaned cashmere was obtained. Similarly, the weight of a conditioned, cleaned guard hair is

$$\pi d_g^2/4 \times L_g \times D_g$$

where d_g = diameter of guard hair (31 to 150 µm)

D_g = density of guard hair

and L_g = length of guard hair fiber. Thus, an estimate of down yield is

$$\frac{\sum_{d=4}^{d=30} n_d \times \pi d_d^2/4 \times \pi L_d \times D_d}{\sum_{d=4}^{d=30} n_d \times \pi d_d^2/4 \times L_d \times D_d + \sum_{d=31}^{d=150} n_g \times \pi d_g^2/4 \times L_g \times D_g} \times 100$$

where n_d = frequency of a down fiber for a specific diameter interval

and n_g = frequency of a guard hair at a specific diameter interval.

In addition to the bias introduced by core sampling resulting from actual length differences between guard hairs and down fibers, this formula would be expected to produce different values for down yield compared to the normal SA definition of yield because the scourable portions of the raw fleece were not accounted for. However, for a particular population of goats that had been maintained in a single environment, the amount of yolk in raw fleeces is considered to be constant for the sake of this exercise. Although the density of cashmere down can reasonably be considered constant, density of guard hair is probably quite variable due to the variability in medullation within and among fleeces. Since the degree of medullation in colored fibers is very difficult to measure, D_d and D_g were considered to be equal for the purpose of this exercise. Finally, guard hairs greater than 150 µm (the upper limit of measurement achieved by the OFDA, Version 1) are known to exist to varying degrees in cashmere fleeces. For the purpose of this calculation, the quantity of fibers greater than 150 µm was considered to be negligible. Thus, the OFDA-estimated down yield can be simplified by cancellation and assumptions to the following equation when $L_d = L_g$.

$$\text{OFDA Down Yield} = \frac{\sum_{d=4}^{d=30} n_d \times d_d^2}{\sum_{d=4}^{d=30} n_d \times d_d^2 + \sum_{d=31}^{d=150} n_g \times d_g^2} \times 100$$

Obviously, the accuracy of this equation could be improved by measuring L_d and L_g.

The distribution of cashmere down diameter differs from that of guard hair diameter. For complete dehairing of raw cashmere, the diameters of cashmere down and guard hair should differ by a factor of at least four times. Consequently, guard hair having diameter below 60 µm is relatively difficult to separate from cashmere down using the SA (Qi, 1989). For simplicity, we regarded the fiber diameters of raw cashmere as a single distribution, for the purpose of calculating AFD and SD, in this study.

Results and Discussion

Down Yield

The Shirley Analyser yields (SAY), and OFDA-estimated yields (OFDAY) were measured for 75 raw cashmere fleeces (Table 1). As expected, the two sets of yield values were different ($P < .0001$). Figure 1 shows a plot of SAY vs OFDAY. The correlation coefficient (r) between these two sets of values is .91. Thus, 82.8% (coefficient of determination, $r^2 \times 100$) of the variability in SAY can be accounted for by the variability in OFDAY. By measuring L_d, L_g, and scoured yield of raw cashmere prior to determining OFDAY, it is likely that the accuracy of the estimate of SAY from OFDAY could be improved. The simple linear regression equation relating these two parameters based on the measurement of 75 fleeces is

$$SAY = 8.13 + 1.08 \times (OFDAY)$$

for which $df = 73$, SE = 5.02, and $P < .0001$.

Table 1. Means and standard deviations for fleece characteristics measured or calculated for 75 cashmere fleeces.

Fleece characteristic	Mean	Standard deviation
Shirley down yield[a] (%)	36.02	11.83
OFDA[b] down yield[c] (%)	25.86	9.96
Shirley down diameter[d], d ≤ 30 (µm)	16.42	1.70
Shirley down standard deviation[d], d ≤ 31 (µm)	3.92	0.53
OFDA raw cashmere diameter[e], d = 4 to 150 (µm)	24.21	3.06
OFDA raw cashmere standard deviation[e], d = 4 to 150 (µm)	22.44	4.09
OFDA down diameter[f], d ≤ 30 (µm)	16.70	1.76
OFDA down standard deviation[f], d ≤ 30 (µm)	4.00	0.48

[a]Average of three determinations.
[b]Optical Fibre Diameter Analyser.
[c]Average of three determinations, 30,000 fibers measured.
[d]More than 4,000 fibers measured.
[e]Average of three determinations, 30,000 fibers measured.
[f]Average of three determinations, 20,000 fibers measured.

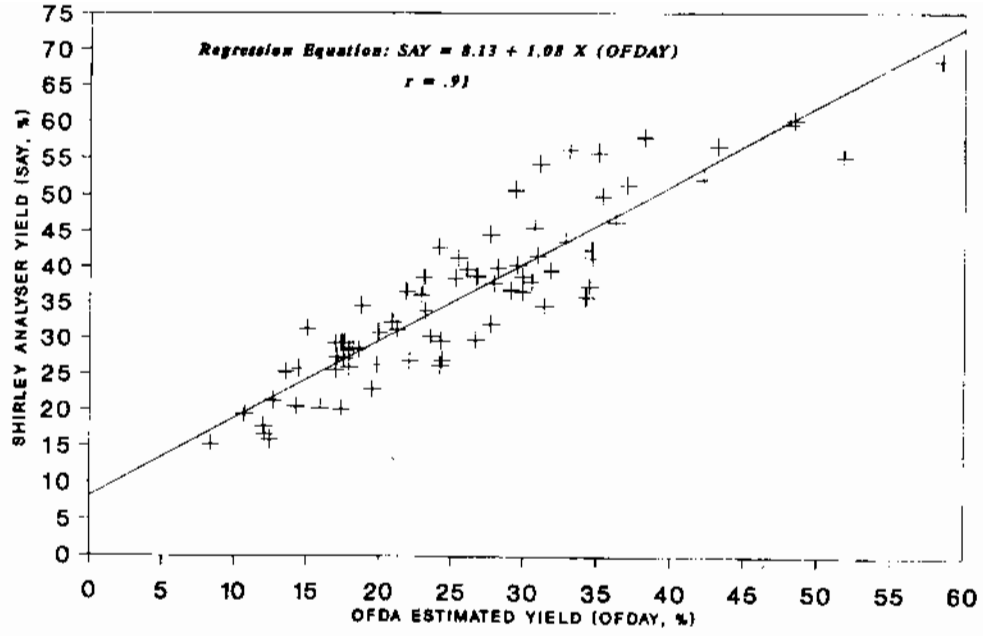

Figure 1. Shirley Analyser down yield vs OFDA-estimated down yield for 75 cashmere fleeces.

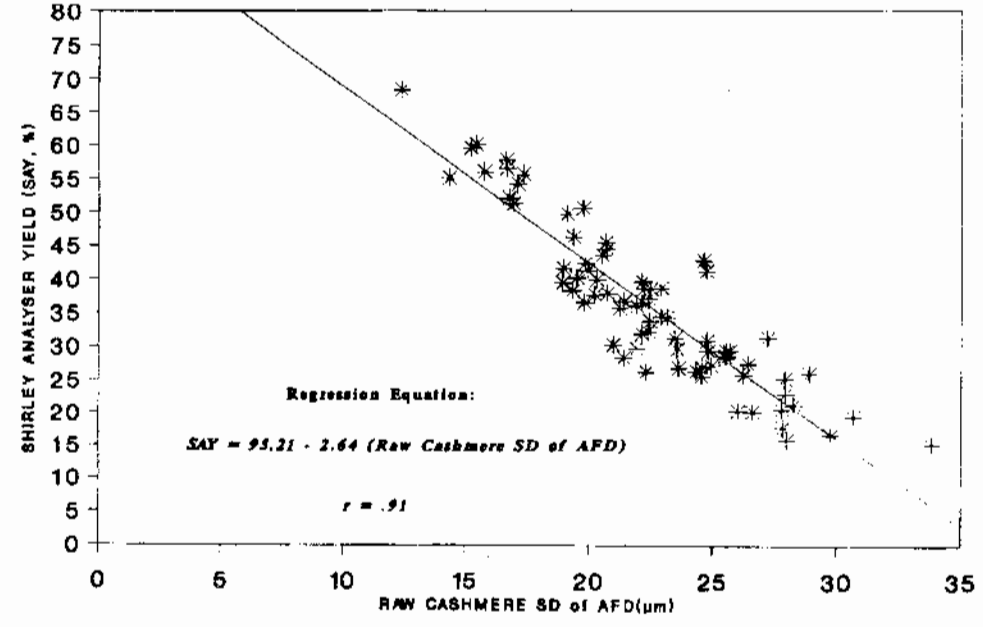

Figure 2. Shirley Analyser down yield vs raw cashmere standard deviation for 75 cashmere fleeces.

However, the correlation between raw cashmere SD of AFD and SAY was slightly higher than the correlation between OFDAY and SAY (r = .9124 vs r = .9080). The simple linear regression equation relating SAY and raw cashmere SD is

SAY = 95.21 — 2.64 X (raw cashmere SD)

for which df = 73, SE = 4.91, and P < .0001. This relationship is shown graphically in Figure 2. This prediction could possibly be improved if fibers >150 µm were measurable using the OFDA. In any case, a knowledge of the raw cashmere SD of AFD for fibers in the range 4 to 150 µm provides a good estimate of SAY.

Additional characteristics were measured and fitted into a stepwise regression procedure for predicting SAY. These included AFD and SD of AFD values for raw cashmere, separated cashmere down, separated guard hair, and OFDA down. The raw cashmere SD of AFD and OFDA yield were selected in that order for the best two-variable model using the stepwise regression analysis (SAS, 1988). No other variable met the .15 significance level for entry into the model. The r value for this relationship was .93. Both variables contributed significantly (P < .0001) to the prediction of SAY which is summarized in the following regression equation:

SAY = 54.70 — 1.45 X (raw cashmere SD of AFD) + .53 X (OFDAY)

for which $df = 72$, SE = 4.41, and $P < .0001$.

Down Diameter

The SA down mean AFD ($d \leq 30$) was slightly smaller (-.28 µm, $P < .003$) than the OFDA-estimated down mean AFD but the two measurements were highly correlated ($r = .91$, $P < .01$). Some of the differences between these two measures of down AFD could be explained by sampling error. However, most of the difference is likely due to the imperfect and variable degree of separation of down and guard hair by the SA. Some down fibers invariably remain with the guard hair and are therefore not available for measurement. Similarly, the SA down mean SD value was slightly smaller (.08 µm, $P < .002$) than the OFDA-estimated down mean SD value. This difference is probably a result of the same sources of error explained earlier.

Implications

The OFDA provided a reasonable estimate of cashmere down yield despite numerous assumptions that were known to be gross approximations. Overall, OFDA-estimated yields were lower than SA yields, but the possibility of improving the correlation between OFDA and SA yields still remains. The OFDA-estimate of down AFD was highly correlated with the AFD of the SA separated down portion. The OFDA-estimated yield measurement can be completed within 20 minutes following cleaning and conditioning of the sample. This method is therefore much faster and potentially less expensive to conduct than the SA method of determining cashmere yield. Since the two measurements are not perfectly correlated, it remains to be seen if the OFDA estimates are accurate enough to be used by breeders and (or) traders.

Table 2. Correlation coefficients and probability values for the linear relationships between Shirley Analyser yield and the listed variables.

Variable	Correlation coefficients (r)	Probability
OFDA[a]-estimated yield	.9080	< .0001
Shirley down AFD[b] ($d \leq 30$)	.4644	< .0001
Shirley down SD[c] ($d \leq 30$)	.4111	< .0002
Shirley guard hair AFD	.1775	> .12
Shirley guard hair SD of AFD	.0332	> .77
Raw cashmere AFD	.5480	< .0001
Raw cashmere SD of AFD	.9124	< .0001
OFDA down AFD	.4432	< .0001
OFDA down SD of AFD	.3571	< .002

[a]Optical Fibre Diameter Analyser;
[b]Average fiber diameter;
[c]Standard deviation.

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Measurement of Medullation in Mohair

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Summary

Official methods for measuring med and kemp content in mohair fleeces lack sufficient precision for evaluating stud animals based on fleece core sampling. Two experiments were conducted to establish the effects of operator and repeated measurements on estimates of med and kemp contents in core-sampled fleeces of mohair. In the first experiment, twenty mohair fleeces representing a range of med (.6 to 4.2%) and kemp (.2 to 3.2%) contents were repeatedly measured by three operators using standard methodology. The effects of operator on med and kemp measurements were highly significant (P<.001). The variation in med and kemp estimates among the five slides observed per fleece was partitioned into that attributable to subsample and that attributable to random variation. For med counts, 53% of the variation was attributed to subsample whereas for kemp this value was 61%. For standard med and kemp measurements on these core-sampled fleeces (one operator, one slide, 1,000 fibers), the 95% confidence limits of the means were somewhat larger (±1.25 and ±1.36% for med and kemp, respectively) than those published in the ASTM standard method. Confidence limits can be reduced to a more acceptable value (±.3%) by counting 15,000 fibers. However, measurement of this number of fibers is currently cost prohibitive. A faster, less expensive method is required for quantifying medullation in mohair. In the second experiment, the estimated 95% confidence limits of med and kemp measurements based on evaluating 1,000 fibers on a single slide were ±.81 and ±.80%, respectively. This experiment did not attempt to take into account the variation due to subsample as did the first experiment.

Introduction

A knowledge of the incidence of med and kemp fibers in mohair is of importance to manufacturers of woven or knitted fabrics because of the apparent dye resistance and light reflectance properties of these fibers. A med fiber is a medullated fiber in which the diameter of the medulla is less than 60% of the diameter of the fiber. A kemp fiber is a medullated fiber in which the diameter of the medulla is 60%, or more, of the diameter of the fiber. In practice, most kemp fibers appear to resist dye and most med fibers dye normally. From the perspective of visual and aesthetic problems, medullated fibers of normal length having an abnormally large diameter and a high degree of medullation are probably the worst kind. In the American Society for Testing and Materials (ASTM) Test Method D2968-89 (ASTM, 1993), magnified images of a fiber specimen are examined. Fibers on a slide are counted and medullated fibers are measured and classified as either med or kemp fibers. Two operators are required to observe 500 fibers each, for a total of 1000 fibers. The test method requires that percentages of med and kemp are reported. A round test conducted in 1970 using a mohair top showed that this test method is free of bias due to sampling or testing errors (when applied to homogeneous top). Data from this test were used to establish tables showing critical differences and 95% confidence limits for med and kemp test results. The critical differences appear to be very large suggesting that the method has limited use only in genetic selection of these traits. Precision data for medullation counts on mohair core samples are not available. However, compared to top, greater variability would be expected in core samples. This is very important for our evaluations of potential stud animals (e.g., in the Texas Agricultural Experiment Station's Angora Goat Performance Test). Billy goats maintained under performance test conditions are considered to have excessive medullation when med >7% and(or) kemp >.7%. Two experiments were designed to establish the effects of fleece, operator, slide (= subsample) and their interactions on measurements of med and kemp in core samples of mohair.

Materials and Methods

Experiment 1

A set of 20 scoured mohair fleeces was core sampled and measured for med and kemp contents. Using standard methodology (ASTM, 1993), five subsamples were removed from each core sample and used to make five microscope slides. Each slide was examined by three operators who each categorized 1000 fibers per slide.

Experiment 2

Each of the three operators selected 10 mohair core-sampled fleeces at random from the original 20. Each operator then removed one subsample from each of his 10 core samples, prepared a slide, and measured the same slide five times (1000 fibers per slide) for med and kemp.

Statistical Analysis

For Experiment 1, the data were analyzed using a mixed linear model in which fleece, operator, and fleece x operator interaction were treated as fixed effects whereas slide nested within fleece was regarded as a random effect. The analysis was conducted using the MIXED procedure of SAS (1992). In Experiment 2, the model included slide, operator, and operator x slide interaction as fixed effects and residual as a random effect. Because each operator had selected 10 samples at random, each operator tested a different set of samples.

Results and Discussion

Experiment 1

The analysis showed that (as planned) the 20 mohair fleeces were different ($P<.0001$) in their med and kemp contents (ranging from .6 to 4.2 and from .2 to 3.2%, respectively). However, the operator effect was also highly significant for med ($P<.00001$) and kemp ($P<.0005$) measurements (Table 1). The average variation in med and kemp estimates among the five slides observed per fleece was partitioned into that attributable to subsample (slide) and that attributable to random variation (fibers actually observed in a particular sequence of 1000 counts). For med counts, 53% of the variation was attributed to subsample whereas for kemp, this was 61%. For this particular set of fleeces and these three operators, the 95% confidence limits when measuring 1000 fibers were only ±1.25 and ±1.36% for med and kemp having a mean value of 1.65 and 1.46%, respectively. These values are of a similar order but are slightly larger than those reported in the ASTM standard for mohair top. Because top is expected to be a more homogeneous product than core samples, this is not a surprising result. Assuming the distribution of multiple med and kemp content estimates each based on 1000 fibers and made by a single operator is Normal (ASTM assume a Poisson distribution), the 95% confidence limits of the aforementioned means would be reduced to the more useful level of ±.3% by increasing the count to 15,000. Real differences in med and kemp measurements existed among these three trained operators (Table 1). Unfortunately, the time and cost of measuring so many fibers is excessive using the current manual approach. This result reinforces the need for a faster, operator-independent method for determining med and kemp. Such a method is currently under development and uses automatic image analysis technology to identify and quantify med and kemp fiber in mohair.

Table 1. Med and kemp values by operator.

Operator	Number of fleeces	Slides/ fleece	Med (%) Mean	Med (%) SD	Kemp (%) Mean	Kemp (%) SD
1	20	5	1.20	.89	1.55	1.11
2	20	5	1.80	1.20	1.32	.93
3	20	5	1.96	1.26	1.51	1.03

Experiment 2

The estimated 95% confidence limits (CL) of med and kemp measurements based on evaluation of 1000 fibers on a single slide were ±.81 and ±.80%, respectively. The slides were evaluated five times in this experiment. The CL of the average of the five values is ±.36% for med and kemp. Experiment 2 did not attempt to take into account the variation due to subsample as did Experiment 1. That is why the CL estimate for Experiment 2 is less than that of Experiment 1. The CL for Experiment 2 applies to a subsample (slide) and the CL for Experiment 1 applies to a core sample of a fleece.

Implications

The first experiment indicated that satisfactory confidence limits (±.3%) for med and kemp measurements of core-sampled fleeces can be obtained using multiple operators and slides and by counting fifteen times more fibers than the number (1000) currently recommended in the ASTM standard. A highly significant operator effect was observed which highlights the need for better operator training, particularly the aspect of recognizing med fibers. Because assessing 15,000 fibers is very time consuming and cost prohibitive, a less expensive test, free of operator bias is required. Automatic image analysis may be able to provide such a measurement. Sifting levels on the TAES Angora Goat Performance Test for med and kemp are 7 and .7%, respectively. Using the variability values established in this study and assuming the coefficient of variation (%) is constant for increasing values of med and kemp, measuring 15,000 fibers would produce 95% confidence limits about 7 and .7% of ±1.4 and ±.16%, respectively. Such measurements would obviously be more accurate than those currently used and would provide a better basis for selection for these traits.

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Effects of Style and Character of U.S. Mohair on Top Properties

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Summary

The objectives of this study were 1) to establish the impact of objectively measured style and character in greasy mohair staples on fiber characteristics of top produced on the worsted system, and 2) to determine correlations among staple and top fiber characteristics. Some processors believe that style and character of grease mohair are important for determining textile processing behavior and critical properties of mohair top, such as mean fiber length and length variability. Consequently, manufacturers have encouraged producers to select Angora goats for improved style and character traits. Twenty-nine commercial lots of mohair were sampled in the grease state and again after top manufacturing. Greasy mohair staples were measured for style, character, yield, average fiber diameter (AFD) and standard deviation (SD) of AFD, average staple length (ASL) and SD of ASL, med, and kemp. The resulting top was evaluated for AFD and SD of AFD, average fiber length (AFL) and SD of AFL, med, and kemp. Style of greasy mohair was not correlated with top AFL ($P>.55$) or SD of AFL ($P>.99$). Similarly, character and top AFL ($P>.28$) and SD of AFL ($P>.43$) were not correlated. However, style was negatively correlated with kemp in top ($r = -.63$, $P<.0003$), and character was negatively correlated with top AFD ($r = -.50$, $P<.006$), SD of top AFD ($r = -.47$, $P<.01$), staple AFD ($r = -.61$, $P<.0004$), and SD of staple AFD ($r = -.57$, $P<.002$).

Introduction

Although few studies exist on the effects of mohair style and character on topmaking and spinning performance, producers and manufacturers strongly contend that these characteristics should be considered when selecting Angora goats for mohair production. For this study, style is defined as the number of twists or curls per unit length (centimeter, cm) of relaxed staple, whereas character is the number of crimps or waves per unit length of relaxed staple (Hunter, 1993). Topmakers claim that mohair having good style produces top with "better" fiber length characteristics (presumably longer mean fiber length, narrower distribution of fiber length) than mohair with poor style but reasonable character. Strydom and Gee (1985) found that wave frequency affects different measures of fiber length and contributes to variation in top and noil yields. However, the study involved a relatively narrow range of style and character, namely, good to super style (South African terminology) kid, young goat, and adult mohair. In another study on this subject, Turpie (1985) concluded that mohair with good style and character showed more uniformity in the staple cross section. Research aside, compared to U.S. goats, many South African Angora goats exhibit a higher degree of style because breeders have selected for this supposedly desirable trait for a long time. Because it has never been proven that style is truly advantageous in any aspects of processing or in the final product, this trait has not been a primary selection criterion in many U.S. programs. As a result, true ringlet types do not comprise a significant proportion of the U.S. mohair clip (Lupton, 1992). Because of the uncertainty surrounding this issue and the lack of research results, this study was conducted to establish the importance of style and character in determining top properties.

Experimental Procedure

Twenty-nine lots of mohair (24 commercial lots, 10,000 lb or larger, from Texas International Mohair, Inc., Brady; and five of about 200 lb each that were processed at the International Textile Center, Lubbock) were grab-sampled and then evaluated at the Texas Agricultural Experiment Station's Wool and Mohair Research Lab, San Angelo, in the grease state and again after top manufacturing. The five small lots were obtained from warehouses in Texas and were representative of fine kid, average kid, yearling goat, fine adult, and average adult mohair. The 24 commercial lots were representative of a broad range of U.S. mohair in terms of style, character, and fiber diameter. Fifty staples were removed at random from each lot and later placed onto a black velvet board where their relaxed and straightened lengths were measured. Further, the total number of ringlets were counted, and the number of ringlets per cm was calculated. Likewise, the staples were examined for total number of waves, and the number of waves per cm was calculated. Also, a photographic record was made of the 50 staples from each lot so that objectively measured style and character values could be associated with commonly used trade descriptions, if desired. Thus, the greasy mohair was evaluated in terms of mean staple length (relaxed and straightened)

and standard deviation (SD), style, and character. In addition, clean mohair fiber present (CMFP) of the greasy mohair was determined following the ASTM D584 procedure (ASTM, 1993b). The average fiber diameter (AFD) and SD were measured using the Optical Fibre Diameter Analyser (OFDA) according to the procedures outlined in a draft method (IWTO, 1993). The ASTM standard microprojection method D2968 (ASTM, 1993d) was followed to determine med and kemp content of staples and tops. Average fiber length and standard deviation (AFL and SD) in top as well as AFD and SD of AFD were measured by Yocom-McColl Testing Laboratories, Inc., using ASTM Standard Test Methods D519 (ASTM, 1993a) and D2130 (ASTM, 1993c), respectively.

Statistical Analysis

Simple statistics (means and standard deviations) for raw staple and top characteristics were calculated using the MEANS procedure of SAS (SAS, 1988). Pearson correlation coefficients between top and greasy staple properties were calculated using the CORR procedure of SAS.

Results and Discussion

The mean, minimum, maximum, and standard deviation values of most of the fiber properties measured on greasy staples and mohair top are presented in Table 1. This table illustrates the broad range of U.S. mohair types used in this study. It is noted that while mean percentages of med content was .75 and .76 for greasy and top mohair, repectively, the maximum med content was appreciably higher for greasy mohair compared to top. A possible explanation for this could have to do with sampling technique. Whereas top fibers are well blended and truly representative, grease samples are grab samples and are, therefore, less representative. Lack of uniformity in grease samples could, perhaps, be responsible for this incongruency in results. Table 2 summarizes correlation coefficients between characteristics measured on greasy staples vs mohair top, and Table 3 contains similar information for style and character vs greasy staple properties.

Style of greasy mohair staples was not correlated (P>.1) with any of the characteristics measured on top except kemp. In this latter case, a significant, negative correlation (r = -.63, P<.0003) was observed (Table 2).

Table 1. Mean, minimum, maximum, and standard deviation (SD) values of fiber characteristics for 29 lots of mohair.

Greasy characteristics	Mean	Minimum	Maximum	Mean SD (within sample)
Relaxed staple length (cm)	9.93	7.50	12.70	1.93
Straightened staple length (cm)	12.85	10.70	15.60	1.92
Ringlets/cm (style)	.086	0	.150	.091
Waves/cm (character)	.452	.300	.600	.141
Clean mohair fiber present (%)	79.91	68.34	86.74	—
Fiber diameter (μm)	31.98	23.20	39.20	9.63
Med content (%)	.75	.15	7.50	—
Kemp content (%)	.38	.05	1.25	—
Top characteristics				
Fiber length (cm)	4.25	3.52	4.89	1.31
Fiber diameter (μm)	32.42	23.80	38.00	9.72
Med content (%)	.76	.10	1.60	—
Kemp content (%)	.47	.10	1.20	—

Table 2. Correlation coefficients between characteristics measured on greasy staple and mohair top for 29 lots of mohair.[a]

	Greasy staple characteristics												
Top characteristics	S	SD of S	C	SD of C	RSL	SD of RSL	SSL	SD of SSL	CMFP	AFD	SD of AFD	Med	Kemp
AFL	-.11	-.07	.20	.26	.35†	.39*	.60***	.41*	-.12	.15	.07	.20	-.10
SD of AFL	-.00	.01	.15	.04	.42*	.35†	.65***	.47*	-.02	-.02	-.12	.04	-.21
AFD	-.10	-.27	-.50**	-.02	-.27	.13	-.21	.03	.31	.87***	.72***	-.13	-.05
SD of AFD	-.19	-.27	-.47**	-.03	-.22	.06	-.19	-.00	.30	.82***	.76***	-.15	-.02
Med	-.18	-.33†	-.36†	-.09	.13	.18	.06	.20	.25	.43*	.43*	-.04	.10
Kemp	-.63***	-.25	.07	.08	-.13	-.09	-.25	-.06	-.23	-.06	.01	-.32†	-.18

[a] S = style; SD of S = standard deviation of style; C = character; SD of C = standard deviation of character; RSL = relaxed staple length; SD of RSL = standard deviation of relaxed staple length; SSL = straightened staple length; SD of SSL = standard deviation of straightened staple length; CMFP = clean mohair fiber present; AFD = average fiber diameter; SD of AFD = standard deviation of average fiber diameter; AFL = average fiber length; SD of AFL = standard deviation of average fiber length; † P<.1; * P<.05; ** P<.01; and *** P<.001.

Table 3. Correlation coefficients for style and character versus other greasy staple characteristics.*

	Greasy staple characteristics								
Criteria	RSL	SD of RSL	SSL	SD of SSL	CMFP	AFD	SD of AFD	Med	Kemp
Style	-.18	-.25	-.10	-.32†	.25	-.25	-.24	.35†	.33†
Character	-.14	-.19	.09	-.10	-.22	-.61***	-.57**	.27	.25

*RSL = Relaxed staple length; SD of RSL = standard deviation of relaxed staple length; SSL = straightened staple length; SD of SSL = standard deviation of straightened staple length; CMFP = clean mohair fiber present; AFD = average fiber diameter; SD of AFD = standard deviation of average fiber diameter; † P<.1; ** P<.01; and *** P<.001.

Style was also correlated with med and kemp content in greasy staples (r = .35 and .33, respectively, P<.1; Table 3). This positive relationship between style and kemp in grease mohair was contrary to the negative correlation of style and kemp in top. As stated previously, sampling technique involving grab samples of greasy mohair probably contributed to this disparity in results. Character of mohair staples was not correlated (P>.1) with either AFL or SD of AFL of top. In contrast, character of greasy mohair staples was correlated with AFD and SD of AFD in the raw material (r = -.61 and -.57, respectively, P<.01). The values of the correlation coefficients were somewhat reduced but still highly significant when AFD and SD of AFD were measured on the tops (r = -.50 and -.47, respectively, P<.01; Table 2). Character was not significantly correlated (P>.1) with any other property measured in the raw material (Table 3). However, a correlation between character and med content of top was observed (r = -.36, P<.1; Table 2).

In summary, it is apparent from this study that objectively determined style and character have little impact on fiber length characteristics of mohair top. However, style does provide an indication of kemp in top, and character is related to average fiber diameter, diameter variability, and med content of top. These latter relationships somewhat justify processors' continued interest in subjectively assessed style and character of raw mohair. Further, it is recognized that adequate style and character provide the desired esthetics necessary for successful Angora goat showing. However, for production-oriented selection purposes, breeders are strongly advised not to rely solely on style and character of fleeces but to use objectively measured values for specific, economically important traits.

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Evaluation of 2 1/2-in. versus 7/8-in. Core Sampling of Greasy Fine Wool Packaged in Bales

F.A. Pfeiffer, C.J. Lupton, D.L. Minikhiem, and K. Qi

Summary

Two studies were conducted in 1992 and 1993 to determine the effects of core tube diameter (2 1/2-in. versus 7/8-in.) on objectively measured yield (clean wool fiber present, CWFP), vegetable matter present (VMP), and average fiber diameter (AFD) of commercial lots of Texas fine wool. In the 1992 study, treatments (2 1/2-in. vs 7/8-in.) produced a difference (-1.4%, P<.0001) in CWFP at a commercial United States lab and a difference (-.2%, P<.03) in VMP at the TAES lab. In the second study, CWFP results on 2 1/2-in. cores were again lower overall (-1.6%, P<.0001) than those obtained from the 7/8-in. core samples when measured at the same commercial lab. Overall, core tube size did not affect VMP (P>.5). Average fiber diameter measurements of comparable core samples were not significantly different (P>.05).

Introduction

Over the past century, a high percentage of United States wool clips was bought and sold on subjective assessments (i.e., visual appraisal), but during the last several years more producers, warehousemen, and buyers have relied on objective measurements (i.e., measurements made with instruments) for determining the quality of United States wools. The physical properties and characteristics which determine the price of wool include fineness and yield as well as length, strength, color, and vegetable matter content. A procedure called "core sampling" was developed to obtain an unbiased, representative sample from a given consignment of wool for testing quality and quantity of clean wool. Core testing also gives producers an estimate of the quality of wool they produce. This information can be used for animal selection as well as for determining marketing strategies. Core sampling was introduced in the United States in 1925 by Jones and Lush (1927), who studied the relationship of a sample composed of 10% of the fleeces drawn at fixed numeric intervals at shearing time to the whole clip. In 1938, core sampling commenced on a larger scale in the United States when the Bureau of Customs initiated wool coring for tariff assessments or duties (Wollner and Tanner, 1941). The Commodity Credit Corporation (CCC) also used core testing to determine clean content of grease wool for the purpose of price support and wool loan programs (USDA, 1949). Numerous articles have been published by state (Johnson *et al.*, 1944; Nordskog *et al.*, 1945; Clark *et al.*, 1946; Johnston and Davis, 1949; Johnston, 1950; Johnson and Larsen, 1978), federal (Wollner and Tanner, 1941; USDA, 1949; Tanner and Dearing, 1949; Johnson *et al.*, 1954; LeCompte and Keller, 1955; USDA, 1956; Keller, 1957; and Keller, 1959), and private entities (McColl, 1989) regarding core sampling of domestic wool and mohair (Lineberry *et al.*, 1974). A major study (Pohle *et al.*, 1958) conducted by the United States Department of Agriculture (USDA), Agricultural Marketing Service (AMS), Livestock Division, reported data from core sampling, testing, and mill processing of 46 lots (607,000 lb) of CCC wool. Results indicated that clean wool yield from 1 1/4-in. core samples most accurately reflected the actual mill top-noil-waste yields of these lots.

More than fifty years of experience with core testing have resulted in Standard Practice D1060 for the American Society for Testing and Materials (ASTM; 1993b) which describes a procedure for obtaining samples from consignments of grease, pulled, or scoured animal fibers in bales or bags to determine clean fiber present and average fiber diameter or AFD. Size of core tube is not specified in the standard practice but a 1/2-in. tube (which is illustrated in the ASTM document) and the 2-in. tube are currently the most commonly used sizes in the industry. The absence of bias in samples obtained with a rotating 2-in. diameter tube with serrated cutting edge has been demonstrated (ASTM, 1993b). The standard practice also summarizes the number of cores to be taken per lot to produce an allowable variation of ± 1% of CWFP at a probability level of 95%.

World price levels of fine wool are strongly influenced by Australia, the leading wool producing country in the world. Most Australian bales are sampled with 7/8-in. pressure coring equipment with the coring tubes entering through the top of the bale.

Although the 7/8-in. coring tube is not universal, it is used in many countries throughout the world. With the increasing practice in the United States of skirting and classing of wool and packaging the "value-added" product in Australian-type bales, interest was expressed in using the 7/8 instead of the 2-in. coring tube. For a given number of core samples per bale, the 7/8-in. tube would obviously remove less wool and cause less dam-

age to the wool than the 2-in. tube. A further incentive to use the smaller tube was the availability of semi-automated equipment for performing the coring operation (as well as weighing and grab sampling) in a fast, efficient manner. Some United States wool buyers questioned the use of the 7/8-in. tube saying that it may produce different results from the established 2-in. tube. Although a theoretical basis does not appear to exist for any differences, two studies were designed and conducted to answer this question. Both studies were partially funded by the American Sheep Industry Association.

Experimental Procedure

Two experiments were conducted over a 2-yr period to determine the effects of size of coring tube on the objectively measured wool characteristics: yield (clean wool fiber present, CWFP), vegetable matter present (VMP), and average fiber diameter (AFD). In the 1992 study, twenty-five consignments of greasy wool (14.8 ± 2.6 bales) stored in three separate warehouses in western Texas were sampled using a 2-in. rotary and a 7/8-in. pressure coring tube. The samples were divided equally and analyzed by Yocom-McColl Testing Lab (YM) and the TAES Wool and Mohair Research Lab. The 2-in. cores were subsampled with a 1/2-in. coring device (standard practice in the United States) prior to analysis. Representative subsamples (3 x 100 g each) of each 7/8-in. sample and 1/2-in. subsample were analyzed for CWFP, VMP (in both labs) and AFD (at YM) using standard procedures of the American Society for Testing and Materials (ASTM, 1993a and 1993c). In the TAES lab, AFD was measured using a Peyer Texlab FDA 200 System (Lynch and Michie, 1976). In the second study (1993), the same three warehouses were utilized as cooperators. As part of their normal marketing procedures in 1993, these warehouses had core-sampled many lots of wool in April and May and the cores were tested at YM. Two warehouses used the manual 2-in. rotary coring tube, while the third used a semi-automated 7/8-in. pressure-coring machine. In August, 1993, TAES staff traveled to these warehouses and assisted in re-coring 10 wool lots from each warehouse. At two of the warehouses, the wool was packaged in Australian-style bales. At the third warehouse, most of the lots were composed of baled bags. This time, the 2-in. rotary coring tube was used where the 7/8-in. was previously used and a 7/8-in. manual pressure coring tube was used where the 2-in. rotary coring tube was previously used. Thirty duplicate sets of core samples (minimum weight, 1000 g) were obtained and shipped to YM in Denver and the Australian Wool Testing Authority (AWTA) in Melbourne. At YM, ASTM procedures were used for subsampling, yield, and AFD measurements. The 2-in. cores were again subsampled with a 1/2-in. subsampler and the 7/8-in. cores were scoured directly. At AWTA, International Wool Textile Organisation procedures were used for yield (IWTO, 1976) and airflow diameter (IWTO, 1982) measurements. At AWTA, the 2-in. cores were "shredded" prior to scouring whereas the 7/8-in. cores were washed without further mechanical preparation. To determine differences, the data for each experiment were subjected to paired T-tests by individual warehouse and subsequently as a single data set using the MEANS procedure for SAS (1988).

Results and Discussion

In Experiment 1, treatments (2 1/2-in. vs 7/8-in.) produced a difference (-1.4%, $P<.0001$) in CWFP at YM and a difference (-.2%, $P<.03$) in VMP at TAES, as shown in Table 1. Size of core tube did not influence AFD ($P>.4$) at either location, although a difference existed between laboratories ($P<.0001$). For the 2 1/2-in. samples, between-lab (YM vs TAES) differences ($P<.002$) existed for CWFP, VMP, and AFD (-1.1%, -.3%, and .8 µm, respectively). Similar differences were observed in VMP and AFD for the 7/8-in. samples. However, no difference ($P>.7$) was present in CWFP. For unknown reasons, size of coring tube produced a difference in CWFP at one lab (YM) even though both labs followed identical procedures (ASTM). Between-lab differences in AFD were attributed to dissimilar sample preparation and measuring methods.

In Experiment 2, the results of testing 30 lots of wool in two commercial testing labs are summarized in Tables 2 and 3. Between the sampling dates (April or May, and August), significant weight changes occurred in almost every lot. For the purpose of this analysis, the CWFP values obtained on the original core samples submitted to YM were adjusted to account for the increased or decreased amounts of moisture content present in the lots at sampling in August.

Considering the YM data in Table 2, size of coring tube did not affect AFD or VMP measurements ($P>.05$). In contrast, CWFP results obtained from 7/8-in. core samples were consistently higher (1.6% on average, $P<.0001$) than those obtained from 2 1/2-in. cores.

Restricting the comparison to comparable core samples only (Table 3), YM projection microscope and AWTA airflow measurements produced indistinguishable AFD results ($P>.05$). Similarly, AWTA and YM CWFP measurements on 7/8-in. core samples were indistinguishable ($P>.4$). However, the AWTA CWFP values measured on "shredded" 2-in. core samples were consistently higher (1.8% on average, $P<.005$) than those reported by YM. The VMP values reported by the labs were somewhat variable but did not differ ($P>.05$).

Table 1. Experiment 1: Comparison of clean wool fiber present, vegetable matter present, and average fiber diameter determined on 2½ and ⅞-in. cores by two labs.

	TAES		YM	
Wool property	2½-in. core	⅞-in. core	2½-in. core	⅞-in. core
Clean wool fiber present, %	58.2[a]	58.4[a]	57.1[b]	58.5[a]
Vegetable matter present, %	1.4[b]	1.6[a]	1.1[c]	1.2[c]
Average fiber diameter, µm	20.8[a]	21.0[a]	20.0[b]	20.0[b]

[a,b,c]Row means that do not share a common superscript differ (P<.0001, rows 1 and 3; P<.03, row 2).

Table 2. Experiment 2: Comparison of clean wool fiber present, vegetable matter present, and average fiber diameter determined on 2½ and ⅞-inch cores at the Yocom-McColl Laboratory.

Wool property	2½-in. core	⅞-in. core
Number of consignments	30	30
Clean wool fiber present, %	56.3[b]	57.9[a]
Vegetable matter present, %	1.1	1.2
Average fiber diameter, µm	19.4	19.5

[a,b]Row means having different superscripts differ (P<.0001).

Table 3. Experiment 2: Comparison of clean wool fiber present, vegetable matter present, and average fiber diameter determined on 2 and ⅞-inch cores by two commercial labs.

	2-in. core		⅞-in. core	
Wool property	YM	AWTA	YM	AWTA
Number of consignments	10	10	20	20
Clean wool fiber present, %	56.0[b]	57.8[a]	57.5[a]	57.5[a]
Vegetable matter present, %	.8	1.4	1.2	1.5
Average fiber diameter, µm	19.4	19.5	19.5	19.7

[a,b]Row means having different superscripts differ (P<.005).

Conclusions

The main conclusions from the two coring studies were that (for reasons we have not been able to identify) Yocom-McColl measurements of CWFP on 2 ½-in. core samples were consistently lower (1.4 to 1.6%) than CWFP results obtained from ⅞-in. core samples. This phenomenon is real but appears to be unique to the YM lab because similar results did not occur at either the TAES lab (Experiment 1) or AWTA (Experiment 2). Measurements of vegetable matter present and average fiber diameter are not affected by core tube size.

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Chemical and Biological Defleecing of Sheep and Angora Goats: A Review

K. Qi and C.J. Lupton

Summary

Chemical and biological defleecing methods involve the use of externally manufactured chemicals and biological agents to either disrupt the process of wool growth temporarily, or to weaken the wool already grown, so that the fleece can be removed without the use of conventional shearing machines. The intent of this paper was to review research on chemical and biological defleecing in sheep and Angora goats and to discuss the restrictions of this technology for use in the sheep and goat industry. New developments involving epidermal growth factor (EGF) as a biological defleecing agent and its practical application were summarized to give readers an update. Research with defleecing agents in Angora goats is very limited. Due to the difference in mohair growth of Angora goats compared to wool growth of sheep, more research on chemical and biological defleecing of Angora goats is required before recommendations can be made to producers.

Introduction

The removal of the fleece from sheep and Angora goats is a skilled operation and is usually performed with the assistance of shearing machines. Because of the cost involved and lack of skilled shearers, scientists have searched for alternative ways to remove wool from sheep. Inspired by the natural shedding of fleeces in some breeds of sheep and noticing the alopecia (hair-loss) caused by some natural compounds in foods and drugs used for treating human diseases, scientists began to test different compounds for chemical shearing of sheep (Dolnick et al., 1969; Terrill, 1969).

In general, the terms chemical and biological defleecing infer use of external chemicals or internal physiological agents either to disrupt the process of wool growth temporarily, or to weaken wool that has already grown, so that the fleece can be removed without the use of conventional shearing machines.

It is known that a lot of diseases, and some nutrient deficiencies, and nutrient toxicities can cause defleecing (alopecia) of sheep and other animals. Indeed, numerous papers exist in the literature which reported the use of these types of compounds for defleecing sheep, such as using high levels of methionine or zinc, and imbalance of essential amino acids (Qi, 1988). In many cases, the toxicity levels necessary to achieve the desired defleecing effects and the highly variable responses disqualified particular agents from further consideration (Reis and Panaretto, 1979).

Because of the expense of shearing and the federal plan to phase out the Wool Act, sheep and Angora goat producers are currently more interested than ever in finding a less expensive method of removing fiber from their animals. The purpose of this paper is 1) to review research that has been reported on chemical and biological defleecing, 2) to summarize progress and practical restrictions of the major chemical and biological defleecing agents (this is not an exhaustive review of every chemical that has ever been tested), and 3) to describe potential applications of biological defleecing to sheep and Angora goats in the United States.

Criteria for Selecting Defleecing Agents

Reis and Panaretto (1979) suggested that the following criteria need to be met before any chemical can be used as a practical defleecing agent. It must be safe, cheap, reliable, and easily administered. Safety must include absence of hazards to the operator, toxicity to the sheep and harmful chemical residues in the milk or carcass after slaughter. In addition, loss of wool production should be minimal, and there should be no adverse effects on the wool grown following treatment. It must also be possible to incorporate the procedure into acceptable methods of sheep management. Fifteen years later, these criteria are still applicable as we search for acceptable chemical or biological defleecing agents to harvest wool and mohair.

Mechanisms of Defleecing by Chemical and Biological Agents

Two approaches to chemical and biological defleecing may be envisaged:

(1) External approach. Wool or mohair may be attacked by the external application of a compound that dissolves the fibers near to the surface of the skin. Such a process has been used to remove wool from localized areas of skin (Ferguson et al., 1976). Generally, this approach is impractical because of the difficulties involved in removing the whole fleece, and in restricting treatment to the base of the fleece.

(2) Internal approach. The process of wool growth may be disrupted by the internal administration of a suitable chemical or biological compound. This approach appears to be more likely to succeed. In fact, almost all recently-published research uses this approach. Consequently, this review will focus on compounds that function internally.

The normal process of fiber growth has been extensively researched and reviewed (Reis, 1982; Lupton, 1994). Here, only those areas related to the mechanisms of chemical or biological defleecing are discussed.

Most wool follicles on sheep breeds that are normally used for wool production are actively growing a fiber at any given time, i.e., they are in the anagen stage of fiber growth. At least five potential targets may be considered for chemical and biological defleecing agents: 1) the bulb, 2) the keratogenous zone, 3) the zone of final hardening of the fiber, 4) the inner root sheath, and 5) the intercellular cement in the fiber. So far, the chemical and biological defleecing agents studied have been antimitotic agents and act on the follicle bulb cells. Because all dividing cells are likely to be affected by these compounds, they are not specific to the wool follicle. Consequently, many side effects of the defleecing agents have been reported, and it is normally those that limit the practical application of this technology.

Chemical defleecing generally means that the chemical agent used for defleecing is not normally involved in the physiological processes of sheep and Angora goats. Chemical defleecing agents usually are analogs of biologically important building blocks. Therefore, their mechanism of action is generally competitive inhibition of the normal biological process which causes cessation of mitosis of actively dividing cells in follicle bulbs which in turn results in defleecing. When these compounds are metabolized or excreted out of the body, the treated animal (ideally) returns to normal.

Biological defleecing refers to the use of defleecing agents which are usually synthesized in the body of animals, where their normal function is to control the natural cycles of wool and hair growth. However, when used in excess, these agents may interrupt the wool or hair growth and produce defleecing effects.

Historical Aspects of Chemical Defleecing

In the late 1960's, while testing the effects of new chemicals, Homan et al. (1969) found that cyclophosphamide (CPA), when injected intravenously, induced wool loss in Suffolk sheep, and hair loss in Poodle dogs and Angora rabbits. These findings were confirmed the same year by Terrill (1969) and Dolnick et al. (1969). This research on chemical defleecing started when scientists considered that it would be more profitable to eliminate the high cost of mechanical shearing and eventually replace skilled shearers with unskilled labor (Terrill, 1969; Dolnick et al., 1969). Also, reduced quality of wool caused by second cuts and skin damage caused by mechanical shearers could be avoided (Roberts and McMahon, 1972). Dolnick et al. (1970) suggested that wool fiber length would be more uniform in chemically removed fleeces. All these suggested benefits attracted scientists to study chemical defleecing in the 1970's. The main chemical agents studied included cyclophosphamide (CPA); mimosine; analogs of cortisol; dexamethasone, flumethasone; and, amphotalide. Shelton (1972a,b) studied the effects of CPA as a defleecing agent on reproductive performance of ewes. In 1977, an international symposium was held in Moscow, Soviet Union, on chemical defleecing (USSR, 1979). It was concluded in this symposium that "of all the defleecing agents investigated, cyclophosphamide at a dose of 30 mg/kg body weight was the best. This dosage did not adversely affect wool quality or the health of sheep". We now know that this conclusion was not entirely correct. Reis and Panaretto (1979) reviewed the research literature concerning analogs of cortisol, mimosine and related compounds, and 1-ρ-aminophenoxy-5-phthalimidopentane and related compounds, when used as chemical defleecing agents. Later, Fahmy and Moride (1984) reviewed research progress with CPA when used as a chemical defleecing agent.

However, adoption of chemical defleecing by the industry has not occurred because the research also revealed numerous potential disadvantages of using chemicals for defleecing. First, the results of cost analyses indicated only limited financial benefits, if any. The cost of chemical defleecing includes that of the drug itself, labor for handling the flock one additional time, and premature or unpredictable loss of wool under normal grazing conditions (Terrill, 1969). Second, lack of protection from the environment poses a real threat to the animals immediately after shedding. Premature shedding of the fleece leaves the animals susceptible to climatic stress such as cold and sunburn (Reis and Panaretto, 1979). Third, toxic residues might be left in the body of the animal after chemical defleecing. A study using radioactively labeled hydrogen (^{3}H) in CPA revealed that CPA taken orally was easily absorbed. One hour after dosing, the blood concentration of CPA reached a maximum. The half-life of CPA was 32 to 38 minutes in dogs, and 195 to 210 minutes in human beings (Zhou, 1982). This chemical damages all dividing cells in the body. Li (1986) studied the metabolic dynamics of CPA in sheep using ^{14}C-labeled CPA on the fourth carbon. He found that, although its half-decay time was relatively short (108 min), and CPA itself was slowly removed from the muscle, organic phosphorus residue remained in the muscle for a long time. Fourth,

animal deaths occur quite often due to CPA side effects. Many studies of CPA for defleecing sheep have reported significant animal losses (Qi, 1988). The deaths were generally attributed to the long-term inhibition effects of CPA on the immunological system and also to the damage caused to the urinary system by CPA. The substantial kidney damage caused by CPA was noticeable 30 days after dosing. Fifth, rams and ewes dosed with CPA could not breed until 2 months after dosing (Shelton 1972a,b; Qi, 1988). Sixth, the CPA dosage (30 mg/kg body weight) for defleecing was too close to the lethal dosage (LD_{50} = 45.1 ± 5.59 mg/kg body weight; Li, 1986). Extreme caution must be exercised to monitor animal body weight and dosage, and only healthy and well-conditioned animals should be used. Finally, in human medicine, CPA is used to arrest cancer because it is an analog of pyrimidine for DNA synthesis. However, CPA itself can cause mutagenesis, and is used as a positive mutagen control in studies of pathology of toxic drugs which induce cancer (Chen, 1986; Zhu, 1987). Consequently, it would probably be impossible to obtain approval of the Federal Drug Administration to use CPA as a defleecing agent.

Research results and limitations of five major chemical defleecing agents are summarized in Table 1.

New Development in Biological Defleecing

Scientists in Australia have conducted more research than any others on chemical defleecing of sheep probably because of the importance of the sheep industry to the Australian economy. Over a long period of time, they have evaluated a range of chemical compounds for their defleecing capabilities and overall have concluded that these compounds are too toxic or have major side effects associated with their administration (Reis and Panaretto, 1979; CSIRO, 1986). However, in 1980 one of the CSIRO scientists noted a reference to the effect of a biological protein, isolated from mice salivary glands, on the growth of hair in young mice (CSIRO, 1986). Subsequent testing of this protein, epidermal growth factor (EGF), revealed that it could effectively defleece a sheep, with no apparent toxic side-effects. Potential problems associated with obtaining an adequate supply of EGF (after all, the average mouse does not have very large salivary glands) has been overcome by inducing a genetically engineered bacterium to synthesize the EGF protein. However, dosage and administration of EGF still pose problems to scientists. Initial trials used a 24-hour infusion. Obviously, this is not practical in the field and some sort of slow-release technology is needed.

It was reported that after infusing 4 mg EGF into a vein of a sheep, fibers become measurably thinner within 24 hours. After 3 days, wool growth was restored to normal, and 7 days after dosing, the wool fleece can be "peeled" from the sheep (Qi, 1988).

Epidermal growth factor inhibits several important metabolic pathways in the skin and stops mitosis in the bulb for 3 to 4 days. Consequently, fiber diameter is reduced to 3 to 9 μm (from 21 to 22 μm in finewool Merinos), and fiber strength is reduced to 1 Newton from about 50 Newtons. Because of this reduction in strength, the fleece is easily removed from the sheep.

Dosage remains as a major area of concern. Too much EGF results in a naked sheep, susceptible to sunburn, chilling winds and cold rains. With too little EGF, the fleece does not break away cleanly. The object is to achieve a weakening in the wool fiber so that it will break easily once fresh wool growth has covered the treated animal.

Because large variations exist in the response to EGF among sheep breeds, within a breed, between genders, among ages, due to physiological and nutritional differences, commercial application was delayed until recently when a very practical breakthrough occurred in the application and management of EGF. After treatment with EGF, sheep are fitted with a body net for 2 weeks or longer. By that time, newly-grown wool covers the sheep's body to provide protection from undesirable environmental factors and the net prevents wool from falling onto the ground should complete fiber separation occur (Reis, 1994).

Chemical and Biological Defleecing in Angora Goats

Stapleton (1978) reported that Angora goats are similar to many breeds of sheep in that fiber growth continues throughout the year. However, during winter he observed a reduced rate of growth by many follicles and an increased proportion of resting follicles. Because all the defleecing agents investigated so far act on dividing cells in the bulb of fiber follicles, it can be reasoned that these compounds would be ineffective in the case of resting follicles. This may be an explanation for the incomplete defleecing by mimosine observed by Jacquemet et al. (1990). However, it has also been observed that coarser fibers shed at a slower rate than fine fibers after dosing with chemical defleecing agents. Fibers that did not shed after dosing Angora goats with mimosine appeared to be predominantly kemp fibers which are typically much coarser than normal mohair fibers. To the best of our knowledge, EGF has not been tested on Angora goats. The interest in chemical and/or biological defleecing of sheep and goats is renewed as indicated by the most recent study (Wansley et al., 1994). Clearly, more research is required in this field.

Table 1. Information for five defleecing compounds.[a]

Chemical	Dosing method	Dosage and time	Mechanism and effects	Problems
Cyclophosphamide (CPA)	Mainly oral and intramuscular, or intravenous dosing.	30 mg/kg BW, once; or 20 mg/kg BW, two consecutive days.	Inhibts mitosis in actively dividing cells, deactivates some functional proteins in the cytoplasm. One day after dosing, cells in the bulb and inner root sheath stop growing; three to four days after dosing, fiber growth stops completely; 14 days after dosing, the follicles degenerate; 21 days after dosing, fiber regrowth begins to appear on the skin surface.	1. Variable responses due to age, breed, location on the body, body condition; 2. Inhibits ovulation if dosed within 15 to 17 days of estrus; 3. Causes death of twins if dosed in last 10 days of pregnancy; 4. Organic P residues remain in the body for a long time.
Mimosine	Mainly intravenous or intramuscular dosing; oral dosing not as effective.	80 mg/kg BW injected on 2 consecutive days; 400-600 mg/kg BW oral dosing once.	Inhibits activities of pyridoxal-containing transaminases, tyrosine decarboxylase, and many metal-containing enzymes; also inhibits cystathionine synthetase and cystathionase. The inhibition of cystathionine prevents the conversion of methionine to cysteine, a major component of fiber protein, which stops fiber growth and finally causes defleecing. After dosing, fiber growth stops for 10 to 12 days; for 11 weeks after dosing, the regrowing fibers grow faster and fiber diameter is coarser than before dosing.	1. Need large dosage; 2. Affected by nutritional status and dietary protein level; 3. Causes damage to ewes that are 80 or more days pregnant; 4. The margin between an effective and a lethal dose is narrow; 5. Causes goiter in sheep and other ruminants.
Dexamethasone[b]	------- Intravenous dosing -------	8.5 mg/kg $BW^{.75}$ for 8 consecutive days.	Increase plasma concentration of this drug to 40 to 50 mg/mL. Depress wool growth 15 to 20%. Thirty days after dosing, freshly grown fibers emerge from the skin of sheep. Cause formation of brushends on the shed, fibers, similar to that observed in natural shedding of fibers.	1. Large dosage and costly; 2. Variable responses within sheep, locations on the body; 3. Long time inhibition of wool growth.
Flumethasone[b]		7.3 mg/kg $BW^{.75}$ for 8 consecutive days.		
1-p-Aminophenoxy-5-phthalimidopentane[c]	Oral dosing	400 mg/kg BW once.	Inhibits cell mitosis; fiber growth stops for 10 to 40 days, then starts again.	Temporary blindness was observed in some sheep 1 or 2 days after dosing, especially when larger doses than 400 mg/kg BW were given.

[a] Summarized by Qi (1988). Information was adapted from Booth and McDonald (1982), Dolnick et al. (1970), Fahmy and Moride (1984), Ferguson et al. (1976), Hughes (1959), Li (1986), Liener (1980), Reis and Panaretto (1979), Roberts and McMahon (1972), Shelton (1972), Zhou (1982), and Zhu (1987).

[b] Both are analogs of cortisol; therefore they are listed together for similarity.

[c] Common name amphotalide.

Conclusion

Chemical defleecing provides a good example of the difficulty in transferring research findings into practical application. After three decades of experimental studies on chemical defleecing, we are just now beginning to see a possible, yet to be realized, application. Old chemical or biological approaches continue to be rejected but new chemical and biological agents are being discovered. Nevertheless, the criteria for selecting suitable defleecing agents remain the same as outlined by Reis and Panaretto 15 years ago. These criteria must be used to continue the search for a suitable defleecing agent.

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