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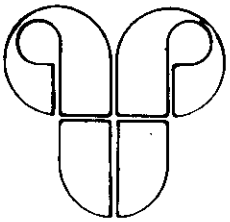
RESEARCH REPORTS

Sheep and Goat, Wool and Mohair--1982



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Carcass Quality

A portion of the above reported research is jointly financed by the Texas Agricultural Experiment Station and the U.S. AID Title XII Small Ruminant Collaborative Research Support Program.

THE EFFECTS OF FLUSHING ON FINEWOOL EWES

Phil Thompson and Maurice Shelton

SUMMARY

A total of 489 finewool ewes were used to study the effects of flushing prior to and at the time of mating for two years on the leased Winters Ranch at Brady, Texas. The data recorded included body weight, body weight changes, reproductive potential, and realized lamb crop for each treatment. Random samples were slaughtered for ovulation and conception data while the remaining ewes were lambed out either in barns or small pastures for lamb production. These data suggest that under the range conditions which occurred at this particular location during the study, flushing showed no significant improvement in lamb production. The body condition of the ewes used may not have been sufficiently critical to show a response to supplemental feeding. Also the occurrence of fall rains during each year of the study may have prevented the expression of any potential response to feeding.

INTRODUCTION

The improvement of lamb production and the increased income it generates is of major concern to the sheep industry. A vast amount of literature has been written about the reproductive potential of finewool ewes and the reproductive losses from ovulation to parturition. The actual lamb crop realized by Texas sheep producers is only a portion of their livestock's potential. One recognized means which is often suggested to improving the conception rate and eventual lamb crop is to "flush" or improve the daily nutrition of the breeding flock at or near breeding. A study was conducted on the leased Winters Ranch at Brady, Texas with two age groups of ewes in the years of 1980 and 1981.

EXPERIMENTAL PROCEDURE

During the early Fall breeding periods (August and September) of 1980, one flock of 156 solid mouth and another flock of 116 3-year-old finewool ewes were weighed, randomly sorted into two treatment groups, and assigned to different pastures. The two control groups received salt ad libitum and the two treatment groups were supplemented with a 20% crude protein salt limited feed. The amount of supplement was restricted to not more than 0.5 pounds/head/day. Ewes were supplemented

for 30 days prior to joining with the rams and 20 days after that date. At mating, ewes were again weighed and rotated within the assigned pastures. At the end of a 45-day breeding season, all ewes were placed in one flock with a small sample removed for slaughter at a commercial abattoir to obtain ovulation and conception data. Just prior to lambing, 25 ewes from each group were sorted off and lambed in a barn for individual lamb identification. All remaining ewes were subsequently lambed out in small pastures by treatment groups. This same study and utilizing the same procedure was again repeated in the Fall of 1981 at the Winters Ranch using the same two ewe flocks. In both years conditions were dry at the start of the experiment and a response to feed was expected. However, in both years some rains occurred during the breeding season.

RESULTS AND DISCUSSION

Tables 1 and 2 summarize the overall data from the two studies. During the first year the younger ewes did not consume the desired amount of supplement. The older ewes supplement intake approached the desired level. A modest response to feed in body weight change was obtained in the first year and no response was obtained during the second year.

Data collected from the slaughtered subsample groups indicated that there was no response to additional feeding prior to breeding. The average number of corpora lutea and the number of embryos per ewe was actually greater for the non-fed ewes.

Lambing performance both in barn and pasture treatment groups tended to confirm the slaughter data. Flushing with supplemental protein feeds had no significant effect on the number of ewes bred or the number of lambs born. It was noted that under confinement lambings, ewes which had been flushed tended to be the first ewes to lamb out with the older non-fed ewes being the last to lamb. The age group and year within the trial periods appeared to be more of a contributing factor than the treatment. Over the two years of the study the older ewes used may have surpassed their reproductive peak while the younger ewes were just achieving theirs as 4-year-olds in 1981. The percent of actual lamb crop of the older ewes within both treatments dropped from 124 in 1980 to 102 in 1981. During the same time the lamb crop percentage of the younger ewes increased from 90 to 130. At the time of this writing, actual weaning data from the 1981 matings is not available. Counts made during shearing showed that the number of lambs to be weaned should be approximately 98% of the total lambs marked for each group.

TABLE 1. THE EFFECT OF FLUSHING ON AVERAGE WEIGHT CHANGE AND REPRODUCTIVE POTENTIAL

Year	Group	No.	Initial Wt.	Breeding Wt.	Final Wt.	Ave. Body Wt. Change(lbs.)	Ave. Daily Feed
Breeding Data:							
1980	Mature Fed	78	107.8	105.8	114.9	7.1	0.48
	Mature	78	99.7	96.5	103.8	4.1	--
	Young Fed	58	97.1	104.8	117.6	20.5	0.21
	Young	58	92.2	99.5	108.6	16.4	--
	Ave.		100.4	102.1	111.5		

Year	Group	No.	Corpora lutea Per ewe	Embryos Per ewe
Slaughter Data:				
1980	Mature Fed	7	1.28	1.00
	Mature	7	1.43	1.28
	Young Fed	7	1.14	1.14
	Young	7	1.43	1.14
	Ave.		1.32	1.14

Year	Group	No.	Initial Wt.	Breeding Wt.	Final Wt.	Ave. Body Wt. Change(lbs.)	Ave. Daily Feed
Breeding Data:							
1981	Mature Fed	50	110.3	108.1	119.2	8.9	0.56
	Mature	50	106.6	110.4	115.4	8.8	--
	Young Fed	59	105.6	112.1	125.3	19.7	0.56
	Young	58	104.6	116.1	124.4	19.8	--
	Ave.		106.6	111.3	121.4		

Year	Group	No.	Corpora lutea Per ewe	Embryos Per ewe
Slaughter Data:				
1981	Mature Fed	8	1.38	1.00
	Mature	8	1.38	1.25
	Young Fed	8	1.13	1.13
	Young	8	1.50	1.25
	Ave.		1.34	1.15

TABLE 2. THE EFFECTS OF FLUSHING ON LAMB PRODUCTION

Lamb Production of Ewes Lambed in Barn:

Year	Group	No. Ewes	Ewes Lambing	Ewes Open	Lambs Born	% Lambs/ Ewes Bred
1980	Mature Fed	25	23	2	31	124.0
	Mature	25	21	4	31	124.0
	Young Fed	25	20	5	22	88.0
	Young	25	20	5	23	92.0
	Ave.		21.0	4.0	26.7	107.0
1981	Mature Fed	25	18	7	24	96.0
	Mature	25	20	5	27	108.0
	Young Fed	25	25	0	33	132.0
	Young	25	25	0	32	128.0
	Ave.		22.0	3.0	29.0	116.0

Lamb Production of Ewes Lambed in Pastures:

Year	Group	No. Ewes	% Ewes Lambing	% Lamb Crop/ Ewes Bred	Ave. Weaning Wt. (lbs.)
1980	Mature Fed	46	86.9	60.9[a]	73.4
	Mature	46	100.0	128.3	70.9
	Young Fed	33	96.9	109.1	74.1
	Young	30	80.0	76.7[a]	66.5
	Ave.		95.3	98.0	
1981	Mature Fed	17	88.2	76.5	--[b]
	Mature	17	88.2	94.1	--[b]
	Young Fed	25	96.0	108.0	--[b]
	Young	25	92.0	100.0	--[b]
	Ave.		91.7	96.4	

[a] Due to predator problems within pastures, these data are incomplete.

[b] At this writing, these data are not available.

ACCURACY OF ESTIMATION OF TESTIS WEIGHT AND VOLUME FROM IN SITU MEASURES IN INTACT MALE SPANISH GOATS

Gary Snowder

SUMMARY

At a mean live weight of 78.8 ± 10.1 lbs., 42 male Spanish goats were castrated to evaluate the accuracy of the estimation of testis weight and volume from in situ testis measures (testis circumference, diameter and length). In situ testis circumference was moderately related to actual (after castration) circumference (.74). Measures of in situ diameter and length were not good indicators of actual measures. Testis weight and volume were both predicted from circumference and length as weight (gm) = 560.30 - 75.83 circumference (cm) + 2.60 (circumference, cm)^2 + 7.98 length (cm) and volume = 754.35 - 98.16 circumference (cm) + 3.27 (circumference, cm)^2 + 7.40 length (cm), R^2 = .844 and R^2 = .820, respectively.

INTRODUCTION

In situ or live testis measurements have been widely used as indicators of reproductive status and spermatogenic capacity in rams and bulls (1,3). Testis weight was shown to be greater in sheep breeds with higher ovulation rates, indicating that quantitative expression of reproductive characteristics in rams and ewes is genetically correlated (2). Therefore, it might be possible to increase fertility in the female by selection on reproductive characteristics of the male.

Little or no research has been accomplished in this area with the Spanish goat. Therefore, the purpose of this study was to determine normal live testis measurements of Spanish male goats. The accuracy of live testis measurements was evaluated by their ability to predict testis weight and volume, and by comparison of actual (after castration) testis measurements.

EXPERIMENTAL PROCEDURE

Live testis measurements were taken on 42 male Spanish goats ranging in age from 10 to 13 months. The mean live body weight, calculated from a standard dressing percent, was 78.8 ± 10.1 lbs. Testis circumference was taken from the average circumference of each testis as

measured with a circular metal tape at the point of maximum circumference. Testis diameter was an average measure of each testis' maximum diameter as estimated with calipers. Testis length was also an average value based on caliper estimates of maximum length of each testis. Immediately after castration maximum circumference, diameter, length and weight were determined for each testis. The epididymis was included in all measures. Testis volume was measured by water displacement in a graduated cylinder.

Correlations among live and after castration measures were calculated. Testis weight and volume was predicted from live measures by multiple linear and quadratic regression using a step-wise procedure.

RESULTS AND DISCUSSION

Descriptive statistics for testis weight, volume and measures are shown in Table 1. Mean actual testis diameter and length values are greater than those of live testis diameter and length. This may be explained in part by the suggestion that the testes, when laid on a flat surface for easy measurement, may have settled; thus, increasing its diameter and length. Although testis size is influenced by degree of maturity or age, the large range of testis size indicates that variation does exist within the population for which selection may act.

Correlations among testis measurements and live body weight are presented in Table 2. Testis measures were not influenced greatly by body size as measured by weight. Although live measures of diameter and length appear to be inaccurate measures of their actual size, live testis circumference was moderately related to actual circumference (0.74). These values were lower than expected and may reflect measurement error, or low repeatability of the measure. In rams, Notter et. al. (4) found live testis diameter highly related to the actual diameter (0.92). Although circumference and diameter measures are related, circumference measure may be less sensitive to error than diameter as measured in goats. Circumference measure was the strongest estimator of testis weight and volume. Other live measures were of low accuracy in predicting weight and volume.

Testis weight could be predicted (R^2 = 0.844) by the following regression equation:

> Testis weight (gms) = 560.30 - 75.83 (Average circumference, cm) + 2.60 (Average circumference, cm)^2 + 7.98 (Average length, cm).

Testis volume was less accurately predicted (R^2 = 0.820) by the following equation:

Testis volume (cc) = 754.35 - 98.16 (Average circumference, cm) + 3.27 (Average circumference, cm)^2 + 7.40 (Average length, cm).

The similarity in both equations is due to the high correlation among testis weight and volume (.98).

LITERATURE CITED

1. Hahn, J., R. H. Foote and G. E. Serdel, Jr. 1969. Testicular growth and related sperm output in dairy bulls. J. Anim. Sci. 29:41.

2. Land, R. B. 1973. The expression of female sex-limited characters in the male. Nature 241:208.

3. Lino, B. F. 1972. The output of spermatozoa in rams. II. Relationship to scrotal circumference, testis weight, and the number of spermatozoa in different parts of the urogenital tract. Australian J. Biol. Sc. 25:359.

4. Notter, D. R., J. R. Lucas and F. S. McClaugherty. 1980. Accuracy of estimation of testis weight from in situ testis measures in ram lambs. Therio. 15:227.

TABLE 1. DESCRIPTIVE STATISTICS FOR TESTES WEIGHTS AND MEASURES IN INTACT MALE SPANISH GOATS [a]

Item	Mean	Standard Deviation	Range
Average in situ testis circumference (cm)	16.80	1.09	13.30- 18.85
Average in situ testis diameter (cm)	4.58	.70	3.65- 8.40
Average in situ testis length (cm)	8.84	.69	7.60- 10.50
Average actual testis circumference (cm)	13.77	.93	12.15- 15.90
Average actual testis diameter (cm)	4.66	.37	3.30- 5.50
Average actual testis length (cm)	8.98	.65	6.85- 10.10
Average testis weight (gm)	94.24	16.52	66.00-131.00
Average testis volume (cc)	96.64	15.57	72.50-132.50

[a] Forty-two intact males.

TABLE 2. CORRELATIONS AMONG TESTIS MEASUREMENTS AND LIVE BODY WEIGHT [a]

Item	Item						
	Live Body Weight	Average *in situ* testis measure			Average actual testis measure		
		Circumference	Diameter	Length	Circumference	Diameter	Length
Average *in situ* measure							
Circumference	.22						
Diameter	.59	.26					
Length	.29	.49	.21				
Average actual measure							
Circumference	.22	.74	.15	.62			
Diameter	.11	.77	.11	.48	.61		
Length	.21	.32	.10	.38	.54	.34	
Average testis weight	.22	.80	.22	.67	.91	.73	.62
Average testis volume	.21	.83	.13	.62	.91	.83	.56

[a] Correlation coefficients in excess of .304 are significant ($P<.05$).

A COMPARISON OF HORMONE RESPONSES IN VARIOUS BREEDS OF SHEEP AND GOATS IN RELATION TO FERTILITY

Max S. Amoss, Jr., Gary Snowder, and Maurice Shelton

SUMMARY

The pituitary gland was stimulated with gonadotropin releasing hormone (GnRH) in 4 breeds of sheep both before and after puberty and after puberty in 2 breeds of goats. Plasma levels of LH and testosterone were determined by radioimmunoassay (RIA). All breeds responded to the GnRH by an increased secretion of LH which in turn produced an increase in testosterone, the male sex hormone. In all breeds studied, the rise in plasma testosterone was greater in sexually mature rams than in sexually immature animals. The same relationship was not seen with respect to LH. Individual variation in both the induced rise in LH and testosterone was very large and was probably due to differences in the degree of maturity. Increased testosterone responses of mature rams would support the hypothesis that there was a development of the LH receptor system in the testis and/or a maturation of the synthesis of testosterone or its secretion. At present there appears to be little if any correlation between hormone levels and fertility when measured between breeds.

INTRODUCTION

To be able to predict the reproductive capacity of an individual animal has been a goal of animal breeders for years. The earlier this can be accomplished, the larger the savings because poor reproducers could be culled before they would affect future generations. Previous studies by others (2,4) have investigated pituitary and testicular responses in rams during changes in photoperiod. No reports have been published in which breed differences in these hormone responses have been determined.

The brain ultimately controls the secretions of the testis (3). Molecules, called neurotransmitters, are released from nerve endings in the brain which activate specialized secretory nerve cells in a lower part of the brain called the hypothalamus. These neurosecretory cells release a small molecule called gonadotropin releasing hormone (GnRH) which in turn specifically stimulates the pituitary gland to release the gonadotropins, luteinizing hormone (LH) and follicle stimulating hormone (FSH). The two gonadotropins stimulate the gonads (the ovaries or testes) to produce the ovum and sperm cell and additionally stimulate the secretion

of estrogens and progesterone in the female and testosterone in the male. It is apparent from the complexity of this control system that there exists multiple sites for alterations in secretion patterns of hormones that may lead to changes in reproductive capacity.

The hypothesis for this research project was based on the ability to obtain more information on the relationship between the brain, pituitary and testis by injecting GnRH and quantitating the pituitary and testicular responses rather than obtaining a single measurement of these hormones (1). It was felt that a dynamic test of the hormone responses in both prepuberal and mature rams and billies of different breeds would provide an indication of the reproductive capacity of these animals.

EXPERIMENTAL PROCEDURE

Five prepuberal males of each of 4 different breeds, Finnish-Landrace, Barbado, Karakul and Rambouillet, were chosen from those on a longitudinal experiment (see this volume, Snowder, Amoss and Shelton). Early in June these animals received a 1 µg i.v. injection of GnRH. Blood samples were taken at 0, 30, 60, 90, 120, 150 and 180 minutes after the injection of the drug. The same protocol was repeated in mid-October of the same year in the same group of animals. Presumably all of the rams would be mature. An identical procedure was done on 10 Spanish billies and 10 Angora billies in January and February. These animals represented mature males.

Plasma levels of LH and testosterone were measured by specific radioimmunoassays. Peak responses and time to peak responses have been analyzed in this report.

RESULTS AND DISCUSSION

A 1 µg dose of GnRH administered i.v. produced an increase in plasma LH in both prepuberal and post puberal males of all breeds tested (Fig. 1). The magnitude of the response was less in mature goats of both breeds than in any of the breeds of sheep regardless of the stage of maturity. The tremendous variation in the responses of the prepuberal sheep was probably due to variations in the degree of maturity, i.e. some of the males were sexually mature and some were not at the time the experiment was performed.

Interestingly enough, whereas the LH responses were not different between prepuberal and sexually mature rams, the testosterone response (Fig. 2) was greater in mature animals than prepuberal animals. In all breeds tested, the highest concentration of plasma testosterone attained after injection of GnRH was greater in post puberal males than that attained in prepuberal males. It is also of interest that the same amount of GnRH produced the same maximum concentration of plasma testosterone (approx. 1000 pg/ml) in the Spanish and Angora billies and the Rambouillet rams. This same dose of GnRH produced peak levels

of testosterone of 2000 pg/ml in the Finnish-Landrace, Karakul and Barbado rams. The physiological significance of these observations remains to be determined.

Another parameter of hormone secretion which was determined was the duration of the testosterone release. Whereas the LH release curve is very short (less than 1 hour), the duration of the testosterone release following a single injection was much longer (Table 1). These values ranged from 1.5 hours in the prepuberal Barbado ram to 5 hours in the mature Angora billy and the Karakul ram. The duration of the response increased in the mature rams (as compared to the sexually immature animals) in the Karakul and Barbado rams and stayed the same in Finnish-Landrace and Rambouillet rams. The physiological implication of these data is that the longer the testosterone is elevated, the higher the probability it will produce the desired biological effect. The male sex hormone, testosterone, is responsible for sexual behavior and continued sperm production.

At the present time, it is difficult to determine why there is no change in the LH response to GnRH between pre- and post-puberal males and there is an increase in testosterone. It would appear as if there must be a maturation of either the synthesis or the release mechanisms of testosterone in the testes. A series of experiments in molecular biology will be needed to determine the mechanisms involved in this maturation process.

In summary, these experiments have identified differences in hormone responses in males of different breeds. Further analyses will attempt to relate these differences to reproductive capacity. A more practical dynamic hormonal testing method is being investigated this year in an effort to obtain a useful field test which would assess reproductive efficiency.

LITERATURE CITED

1. Amoss, M.S. and Guillemin, R. 1969. Elevation of plasma LH concentrations induced by LRF as measured by radioimmunoassay in the sheep. Endocrinology 84:1517.

2. Lincoln, G.A. 1977. Changes in pituitary responsiveness to luteinizing hormone releasing hormone in rams exposed to artificial photoperiods. J. Endocr. 73:519.

3. Lincoln, G.A. 1978. Hypothalamic control of the testis in the ram. Int. J. Andrology 1:331.

4. Lincoln, G.A. and Davidson, W. 1977. The relationship between sexual and aggressive behavior, and pituitary and testicular activity during the seasonal sexual cycle of rams, and the influence of photoperiod. J. Reprod. Fert. 49:267.

TABLE 1. DURATION OF THE GnRH INDUCED TESTOSTERONE SECRETION IN HOURS

Breed	Prepuberal	Post puberal
Spanish Goat	---	3
Angora Goat	---	5.5 (est.)
Finnish-Landrace	2.5	3
Karakul	2	5 (est.)
Barbado	1.5	3
Rambouillet	3	3

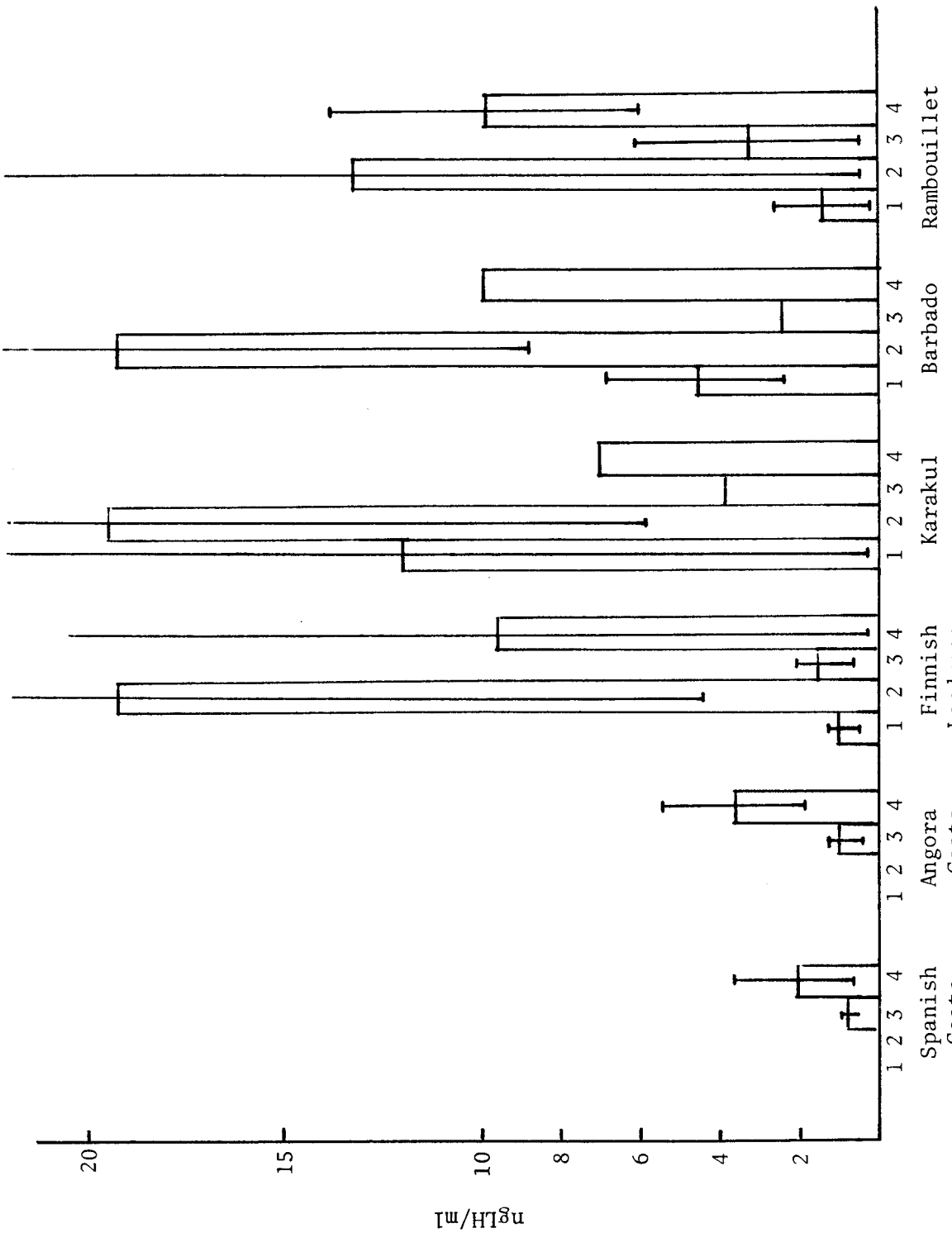


FIGURE 1. LH RESPONSE TO 1 µg GnRH

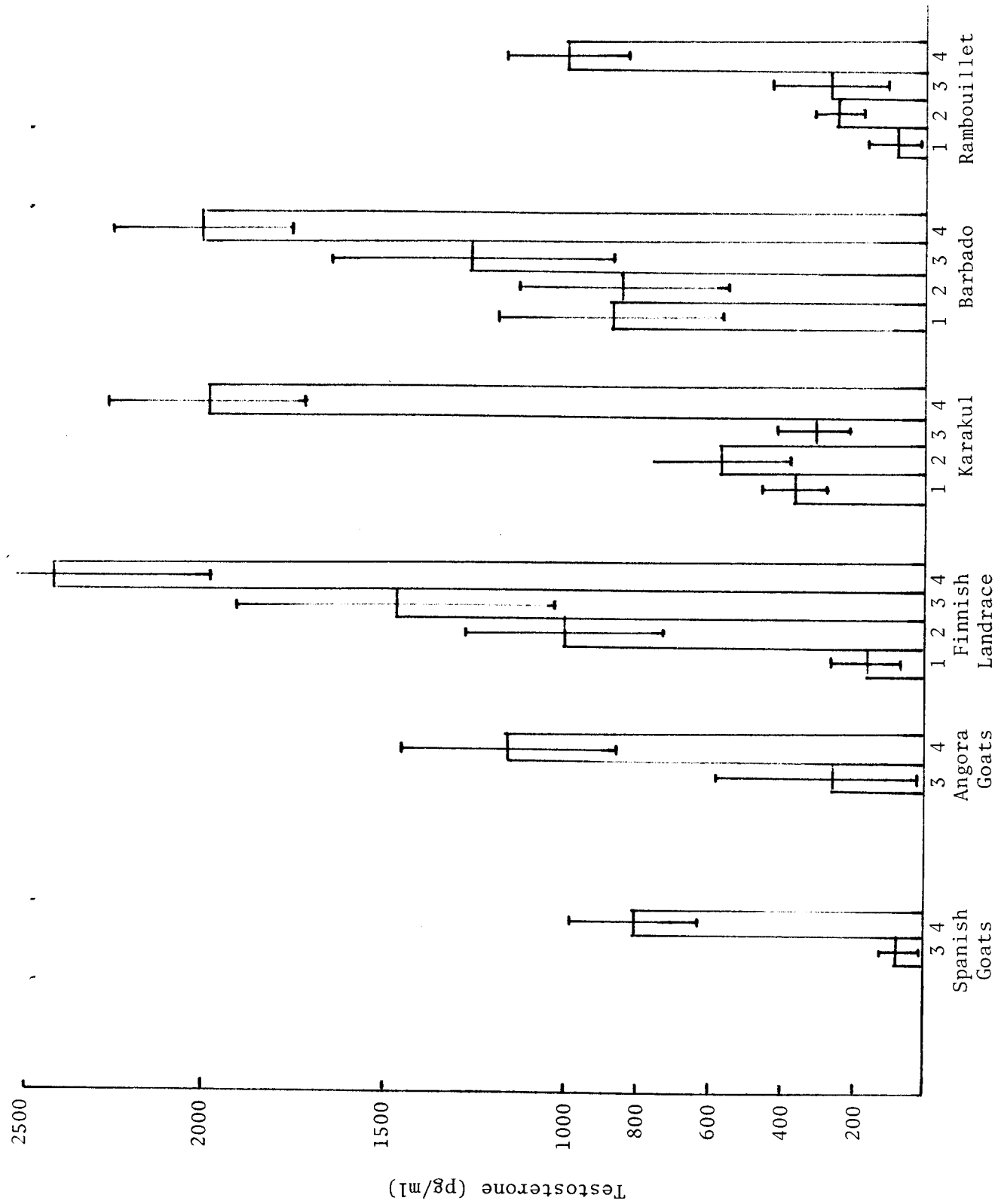


FIGURE 2. TESTOSTERONE RESPONSE TO 1 µg GnRH

MEASURES OF SEXUAL MATURITY IN FOUR BREEDS OF SHEEP

Gary D. Snowder, Maurice Shelton and Max Amoss

SUMMARY

Sexual maturity as measured by testis size, testosterone, and androstenedione production was examined in pre-puberal rams for 150 days in four breeds of sheep: Barbado, Finnish Landrace, Karakul, and Rambouillet. The Barbado and Finnish Landrace rams showed the greatest increase in testis circumference per unit of body weight gain. Testosterone production in these two breeds significantly differed from that of the Karakul and Rambouillet. No significant differences were observed between the Karakul and Rambouillet breeds.

INTRODUCTION

It has recently been suggested that selection for fertility in sheep might be accomplished through selecting for correlated characters in young rams including such measures as testis size, Lutenizing hormone, and testosterone levels (1,2). Large testis size can be shown to be associated with greater sperm production and thus potentially greater breeding capacity. However, for the present context the goal is not to predict the breeding capacity of the males, but to predict or to influence ovulation and lambing rates of ewes sired by them. Testosterone is a steroid male sex hormone which influences the development of secondary sex characteristics and the male libido or mating drive. Also, androstenedione is a precursory testosterone and thus a measure of testicular function. The pituitary hormones which stimulate follicular development and ovulation in the female is the same as those which stimulates spermatogenesis and testosterone production. This analogy provides the basis for potentially selecting males as a means of increasing female reproduction. Although selection of a ram for these characters may increase fertility, the growth stage at which selection may be applied has not been clearly determined. The purpose of this study was to compare growth and sexual maturity rates across four breeds of sheep as measured by testis size, and testosterone and androstenedione levels.

EXPERIMENTAL PROCEDURE

Data were collected from rams at the San Angelo Research Center between May and October, 1980. Rams were of four different breeds ranging in initial age from 60 to 144 days old. The breeds included Rambouillet, Finnish Landrace, Barbado, and Karakul. The Barbado and

the Finnish Landrace are considered to be more prolific breeds than the Karakul or Rambouillet breeds. All rams were managed together on oat pasture in the spring and native range during the summer. A supplemental range feed was provided as forage quality declined.

Testis measurements and blood samples were collected monthly. Testis circumference is an average of the circumference of the two testis as measured in centimeters by use of a flexible metal tape. A blood sample was collected from each ram by vacuum tube. Assays of testosterone and androstenedione levels were determined in a laboratory maintained by the Department of Veterinary Physiology and Pharmacology, Texas A&M University of College Station.

The influence of body weight and age on steriod production and their interrelationships were determined by correlation analysis within breeds. The effects of age and body weight on hormone production could not be separated by statistical procedures due to the high degree of correlation between these. Since body weight could be readily measured on all rams and not all ages were known, body weight was given greater emphasis. However, some differences between breeds may be due to age effects. Cubic regression curves were fitted to compare mean steriod levels in 10 lb. increments between breeds.

RESULTS AND DISCUSSION

Mean statistics of the growth measures during the experiment are presented in Table 1. The smaller breeds, Finnish Landrace and Barbado, did not grow as quickly in body size as the larger breeds during the 150-day period. However, final testis circumferences of the smaller breeds are not significantly different ($P<.05$) from those of the larger breeds, but are substantially larger when expressed as a function of body weights.

The influence of body weight on testis size is shown in Figure 1. Regression lines fitting the mean testis circumference on 10 lb. increments of each breed are compared. The smaller and more prolific breeds showed a tendency to increase testis size at lighter weights. The greatest increase in testis size per unit of body weight was observed in the Barbados with a leveling off of testis circumference at 20 cm. when at approximately 65 lbs. of live weight. Of the larger breeds the average testis size of the Karakuls was distinctly greater than that of the Rambouillet at all weights.

Simple correlation coefficients among measurements within breeds are reported in Table 2. Androstenedione and testosterone levels tended to increase at a more uniform rate in the Finnish Landrace and Barbado (.65 and .80, respectively) than the Rambouillet and Karakul (.56 and .58 respectively). High correlations between blood levels of

androstenedione and testosterone may well be expected since one is a precursor of the other.

Regression curves comparing the influence of body weight on testosterone and androstenedione for the various breeds are shown in Figure 1 and 2, respectively. Androstenedione and testosterone levels rapidly increased with body weight in the Finnish Landrace and Barbado when compared with the Karakul and Rambouillet breeds. These data clearly suggest that sexual maturity of Barbado and Finnish Landrace is reached at lower body weights than Karakul or Rambouillet. Little difference existed between the Karakul and Rambouillet breeds. Testicular size at the termination of the study was similar for all breeds, but when expressed as a function of body weights the more prolific breeds had larger testicular size. As reported by other workers this is suggestive of the validity of using this criterion in selection for prolificacy. It was observed that large variation in steriod levels and testis size existed between individuals within breeds. The significance of this as a valid means of selection remains to be determined.

LITERATURE CITED

1. Land, R.B. and W.R. Carr. 1975. Testes growth and plasma LH concentration following hemicastration and its relationship with female prolificacy in sheep. J. Reprod. Fert. 41:495.

2. Sanford, L.M., J.S.D. Winter, W.M. Palmer and B.E. Howland. 1974. The profile of LH and testosterone secretion in the ram. Endo. 95:627.

3. Shore, G.M. edi. 1979. Genetic variation in hormone systems. CRC Press, Vol. 1, p. 89-112.

TABLE 1. MEAN STATISTICS OF GROWTH MEASURES OF FOUR BREEDS OF SHEEP

Item	Breed			
	Rambouillet	Finnish Landrace	Karakul	Barbado
Number	20	20	18	8
Initial wt., lbs.	61.0	57.3	54.8	36.9
Final wt., lbs.	102.9	78.3	95.4	59.0
Average initial testis circumference, cm.	12.2	14.2	12.0	11.6
Average final testis circumference, cm.	19.9	20.7	22.6	19.7
Average final testis circumference in cm. per 100 lbs. body wt.	19.3	26.4	23.7	33.4

TABLE 2. CORRELATION COEFFICIENTS AMONG BODY WEIGHT, AGE, AND STEROIDS AFFECTING REPRODUCTIVE MATURITY IN FOUR BREEDS OF SHEEP

	Breed			
Relationship	Rambouillet	Finnish Landrace	Karakul	Barbado
Testis circumference/				
Body weight	.89	.76	.83	.81
Chronological age	.80	.75	.81	.75
Testosterone level	.55	.51	.34	.51
Androstenedione level		.32	.28	.38
Testosterone level/				
Body weight	.49	.53	.25	.62
Chronological age	.49	.44	.40	.45[a]
Androstenedione level	.56	.65	.58	.80
Androstenedione level/				
Body weight	.01[a]	.48	.28	.46
Chronological age	-.03[a]	.37	.22[a]	.28[a]
Body weight/				
Chronological age	.76	.67	.81	.67

[a] Correlation coefficients are not significant (P>.05).

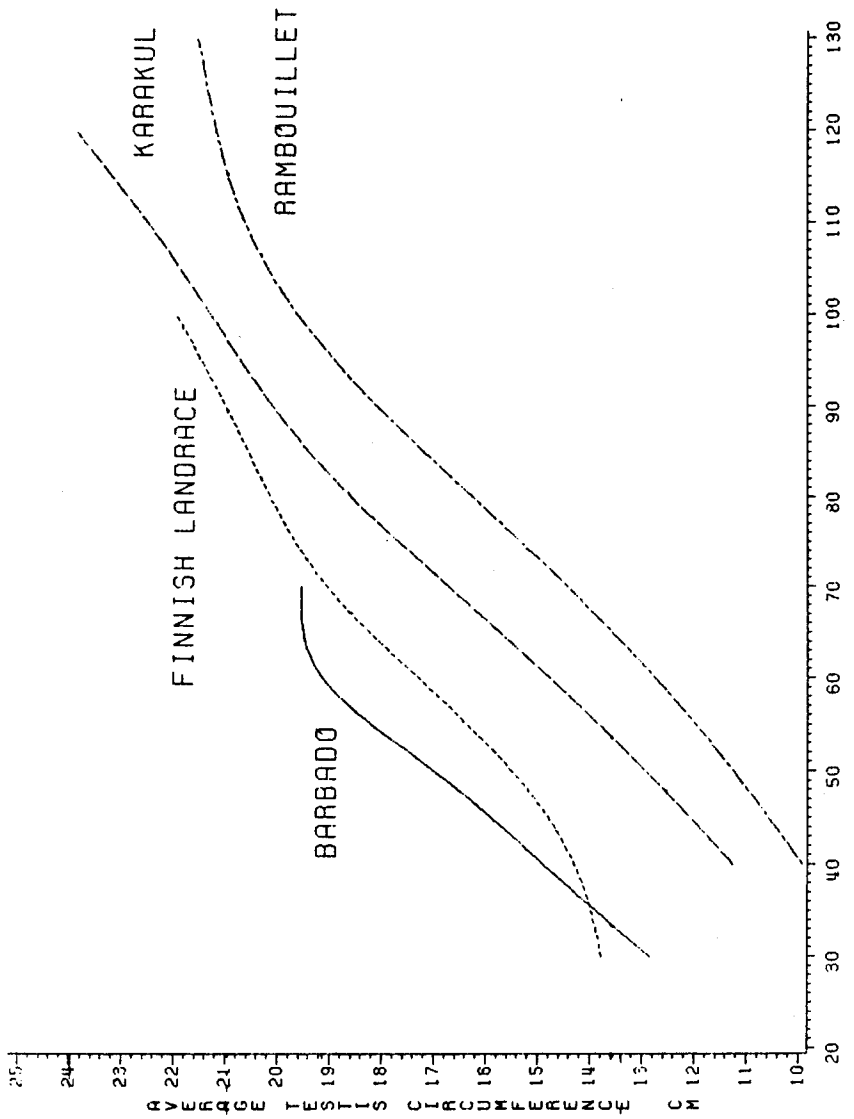


Figure 1. The Influence of Body Weight on Testicular Size in Four Breeds of Sheep.

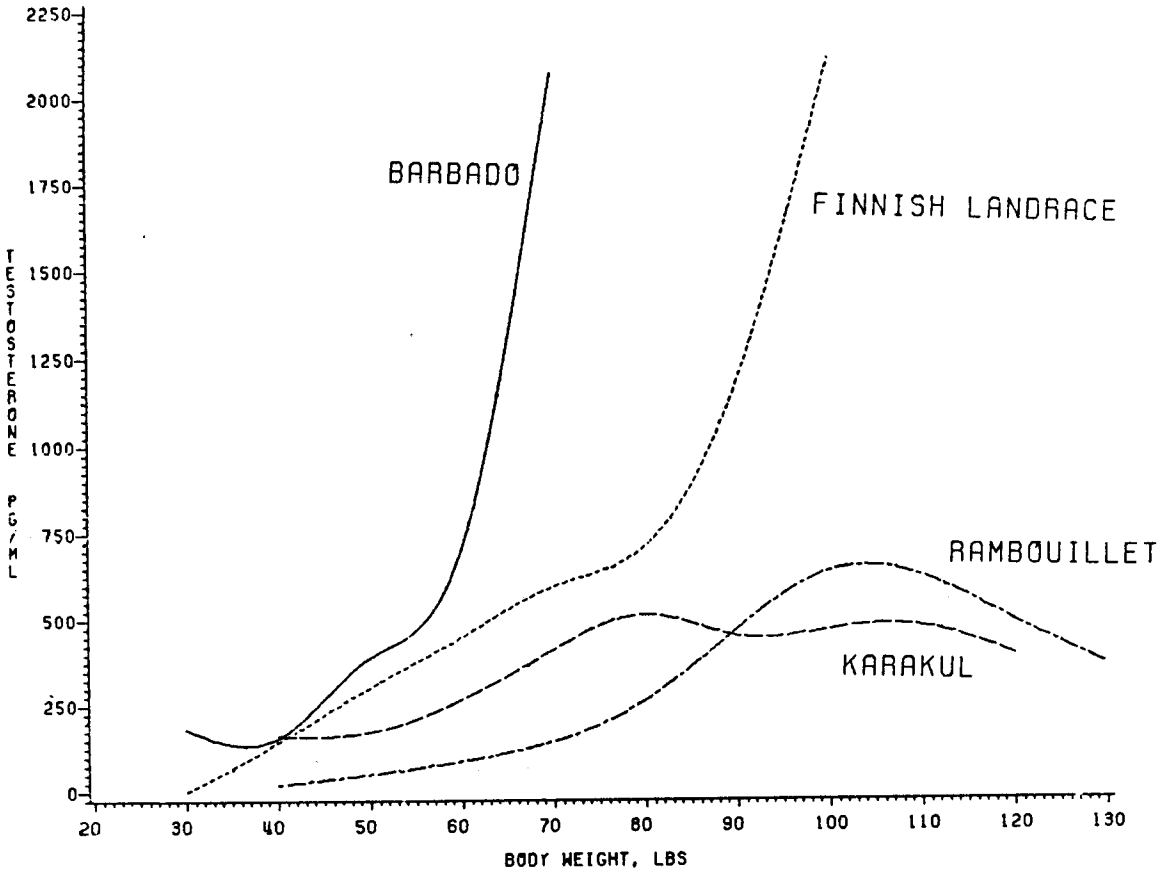


Figure 2. The Influence of Body Weight on Testosterone Production in Four Breeds of Sheep.

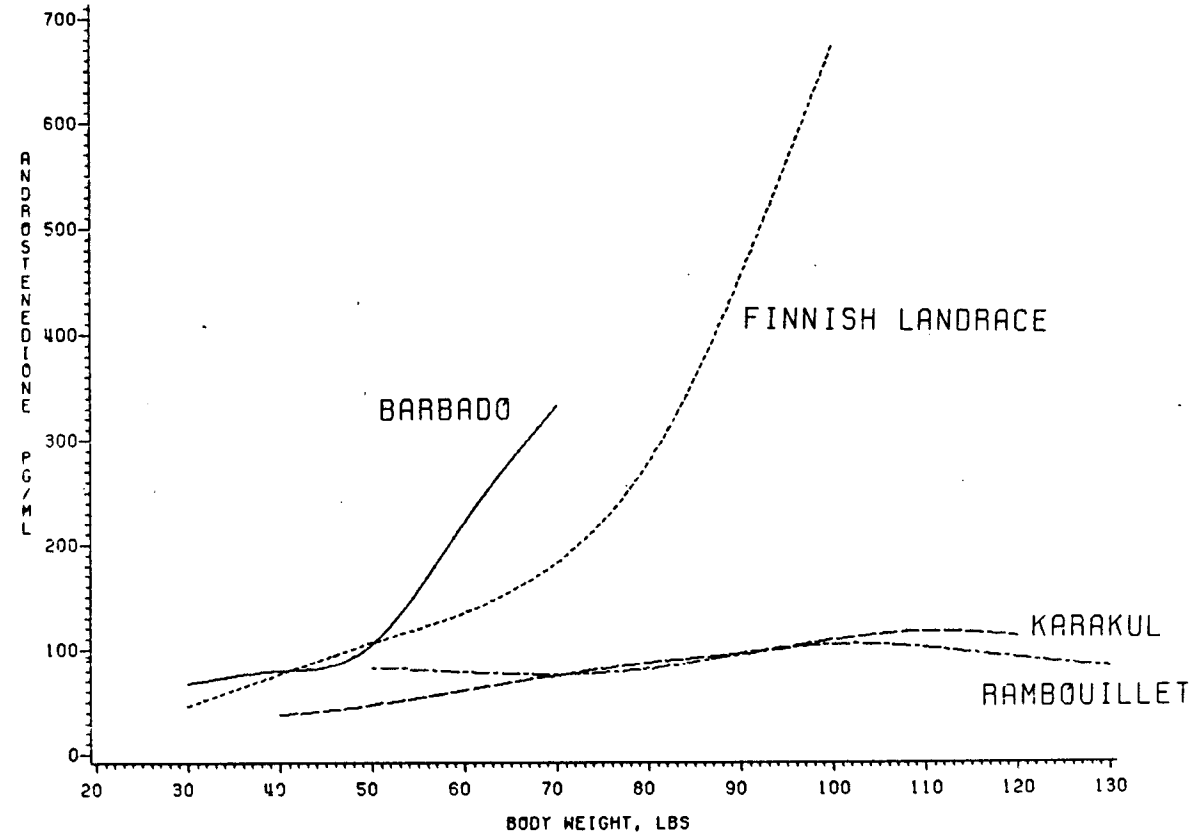


Figure 3. The Influence of Body Weight on Androstenedione Production in Four Breeds of Sheep.

MILK PRODUCTION OF SPANISH DOES AND GROWTH OF THEIR KID*

Z. G. Gathuka, Gerald Smith, Maurice Shelton,
C. R. Long and T. C. Cartwright

SUMMARY

Dairy milk production of Spanish does averaged 2 lb at day 21 of lactation and declined to .7 lb by day 120. Kid growth rate was about .25 lb per day with 120-day average weights of 37 lb. High correlations among kid weights and milk intake emphasized the importance of milk on preweaning growth and suggested that kid growth rate could be used to predict milk production of does.

INTRODUCTION

Milk production of does influences the survival and growth rate of their kids as well as their own nutritional requirements. No information existed on milk production in Spanish does; hence, this study was designed to estimate their milk production and its correlation with kid growth. The data will also be used in the application of computer models of goat production systems.

EXPERIMENTAL PROCEDURE

Data for this study were collected from 93 Spanish does with 113 kids at the Winters Ranch operated at Brady by the Texas Agricultural Experiment Station. These does were managed in 3 groups based upon kidding date: (1) February 6 to 13, 1980; (2) February 16 to March 18, 1980; and (3) February 7 to March 9, 1981. The does were kidded in pens so that kids could be correctly paired with their mothers. Milk was measured by weigh-suckle-weigh techniques on approximately a weekly schedule for 4 months beginning when the oldest kid was 3 weeks of age. After separation for about 12 hours without food or water, kids were weighed, allowed to nurse for one hour and weighed again. The difference between the two weights was the estimated milk production. This procedure was then repeated after a second separation period.

Individual animal linear regression was used to estimate milk production at day 21 of lactation and kid weight at 30, 60 and 120 days of age. Total milk yield during a 120-day lactation was also estimated from the linear regressions. Data were analyzed to remove effects of doe age, group, sex and type of rearing (single vs. twin). Correlations between kid weights and milk intake were estimated.

*This research was partially supported by the U.S. AID Title XII Small Ruminant Collaborative Research Support Program.

RESULTS AND DISCUSSION

Milk production at day 21 of lactation averaged 2 lb per day (table 1) and declined to .7 lb per day by day 120 of lactation. Production on day 21 was considered to be an estimate of peak production. Differences between years (groups 1, 2, vs. 3) were larger than between kidding times (1 vs. 2) within the same year. Does nursing twins produced 29% more milk than those nursing singles. Doe age had no significant effect on milk production but the age differences among does were small.

Kids averaged 14, 21 and 37 lb at 30, 60 and 120 days of age, respectively (table 2). They gained about .25 lb per day. Males were 12% heavier than females at 120 days.

Kid weights were highly correlated with weights at other ages as was expected (table 3). The correlations among weights and milk intake at various ages and total intake were also fairly high. These correlations emphasized the importance of milk intake on the growth rate of kids and suggest that kid growth rate should be a useful predictor of doe milk production.

TABLE 1. Milk Production of Spanish Does (lb)

Group	Daily yield		120-day total
	Day 21	Day 120	
1	1.8	.8	162
2	1.9	.7	149
3	2.2	.7	186

TABLE 2. Kid Weights (lb)

Group	Day 30	Day 60	Day 120
1	12.7	20.2	35.3
2	12.9	20.1	34.1
3	15.6	24.0	40.6

TABLE 3. Correlations Among Kid Weights and Milk Intake*

Trait	Weight			Daily intake			120-Day total intake
	Day 30	Day 60	Day 120	Day 21	Day 60	Day 120	
Weight							
Day 30	1.00	.96	.91	.76	.65	.42	.67
Day 60		1.00	.98	.78	.65	.49	.68
Day 120			1.00	.76	.64	.52	.67
Daily intake							
Day 21				1.00	.80	.59	.86
Day 60					1.00	.82	.98
Day 120						1.00	.83

* All correlations are statistically highly significant ($P<.01$)

FETAL MEASUREMENTS OF SPANISH GOATS

J. L. Lawson, D. W. Forrest, G. D. Snowder and J. M. Shelton

SUMMARY

Fifty Spanish does with known breeding dates were slaughtered and the gravid uteri removed. Weights and measurements were taken of various fetal and uterine components. A variable selection analysis was used to determine which variables were most accurate for use in an age prediction equation. All variables were used in polynomial regression analysis to determine the best fit of each variable on age. Either weight or length can be determined on most fetuses in situations where fetal age is unknown. Polynomial equations are presented which best describe the relationship of fetal age to fetal weight and curved crown-rump length.

INTRODUCTION

Information regarding prenatal growth of the goat is limited (Eaton (3), Lynset (6) and Dhingra and Tyagi (1)). A number of papers on prenatal growth of sheep may be used for comparative purposes, however, it is now acknowledged that the two species cannot be grouped together. This study using the Spanish doe is not necessarily applicable to other goat breeds. However, breed and maternal effects are not as apparent before day 100 of gestation (2). Thus it may be possible to extrapolate some of the data contained herein to other goat breeds.

Documentation of normal fetal and embryonic growth may be useful for aging aborted fetuses. It may also provide a standard against which fetuses exposed to various influences (i.e., teratogens and nutritional states) may be compared. The aim of this study, therefore, was to develop age prediction equations from anatomical measurements on 63 fetal goats.

EXPERIMENTAL PROCEDURE

Fifty Spanish does with known breeding dates (32-135 days gestation) were slaughtered and the gravid uteri (13 sets of twins and 37 singles) excised and frozen at -20^{o}C for subsequent measurements. Each conceptus was thawed at room temperature for 12-15 hours prior to weighing (gm). Scissors were used to make an incision at the bifurcation of the uterus, and the fetus(es) were removed and weighed. The placenta was separated from the uterine caruncles, drained and weighed. The placental fluid weight was also determined for each uterus. Uterine caruncles were excised, weighed and counted.

Vernier calipers were used to measure the length (cm) of the femur, metacarpal, straight crown-rump (SCR) and chest depth. The femur was dissected out while the canon (metacarpal) was measured intact. String and a metal ruler were used to measure chest circumference, curved crown-rump length (CCR) and SCR when fetus size exceeded the limit of the calipers.

RESULTS AND DISCUSSION

Before submitting these data for analysis by general linear model procedures or stepwise regression, it was necessary to determine if significant differences existed between male and female or single and twin fetuses. There were insufficient numbers to run an analysis of variance at any particular stage of gestation. However, neonatal weights for a group of kids from the same population of animals were available. If there were differences due to sex and litter size, it should be more apparent at birth (150 days). There were no differences ($P>.05$) in birth weight for female singles, male twins and female twins. However, male singles were found to be significantly ($P<.05$) larger than the other three groups. Thus, the data was pooled into three groups for analysis: male singles, female singles and twins.

Eaton (3) did not find a significant influence of sex or litter size on fetal weight of Toggenberg goats. However, Lynset (6) found that males weighed 10% more than females at birth and that litter size also influenced birth weight. Fetuses of the same age and class may vary greatly in weight. This variation may be attributed to breed type, maternal influences or season of gestation. The genetic diversity of the present population may have disguised some effects of fetal sex and number of fetuses on fetal size.

All variables measured, as well as the log transformations of placental, fetal and caruncle weights were submitted to a stepwise regression analysis. Table 1 depicts variables selected at the .10 entry level for the three groups. Fetal weight, CCR, SCR, chest circumference, chest depth, femur and metacarpal length measures were submitted to a polynomial regression procedure for regression on age. The model included the assumption that weight and linear measures approached zero at conception. Length measures were shown to have a linear or quadratic relationship to age while the cubic model best fit most weight measures regressed on age. Figure 1 shows the regression lines and equations for two variables, fetal weight and CCR, for each of the three groups.

The pattern for total number and weight of visible caruncles during gestation is illustrated in Figure 2. The means ($\pm$ SE) for caruncle number at 7, 11, 15 and 19 $\pm$ 1 weeks of gestation were 41.2 $\pm$ 10.2, 112.5 $\pm$ 19.9, 118.2 $\pm$ 4.1 and 132. 5 $\pm$ 11.1, respectively. The means

(± SE) for caruncle weight at the corresponding intervals during gestation were 19.0 ± 6.7, 102.0 ± 20.4, 236.6 ± 31.3 and 340.5 ± 61.4 gm, respectively. Mean caruncle number increased from week 7 to week 11 and then remained relatively constant through week 19 of gestation. However, mean caruncle weight increased approximately three-fold between weeks 11 and 19 of gestation.

Although it appears that certain traits can be used as reliable criteria for estimating age, these traits may be estimating physiological rather than chronological age. Evans and Sach (4) suggest that ratios between dimensions may provide better estimates of age than do the absolute measures. Joubert (5) addressed the issue of differential maturation of the various fetal sheep dimensions. Head and body weight ratios were eliminated as a reliable indication of age because two fetuses of the same weight and chronological age may differ greatly in conformation.

It has been suggested that accuracy of age determination may be improved by using several variables in combination. This might reduce inaccuracies due to extreme variation of one variable. Multicolinearity among variables reduced the number of variables in the stepwise regression. The use of a less conservative entry level in this procedure may allow more variables to enter the model.

The results of this study should be useful for estimation of age in Spanish goat fetuses. Because the age prediction equations were generated from fetuses over 32 days of age and under 135 days, caution should be used when fetal age is predicted beyond this range.

LITERATURE CITED

1. Dhingra, L. D. and Tyagi. 1974. A study of the prenatal growth patterns of some long bones of the goat. Ceylon Vet. J. 22:21.

2. Dun, R. B. 1955. Aging the Merino foetus. Aust. Vet. J. 31: 153.

3. Eaton, O. N. 1952. Weight and length measurements of foetuses of Karakul sheep and goats. Growth 16:175.

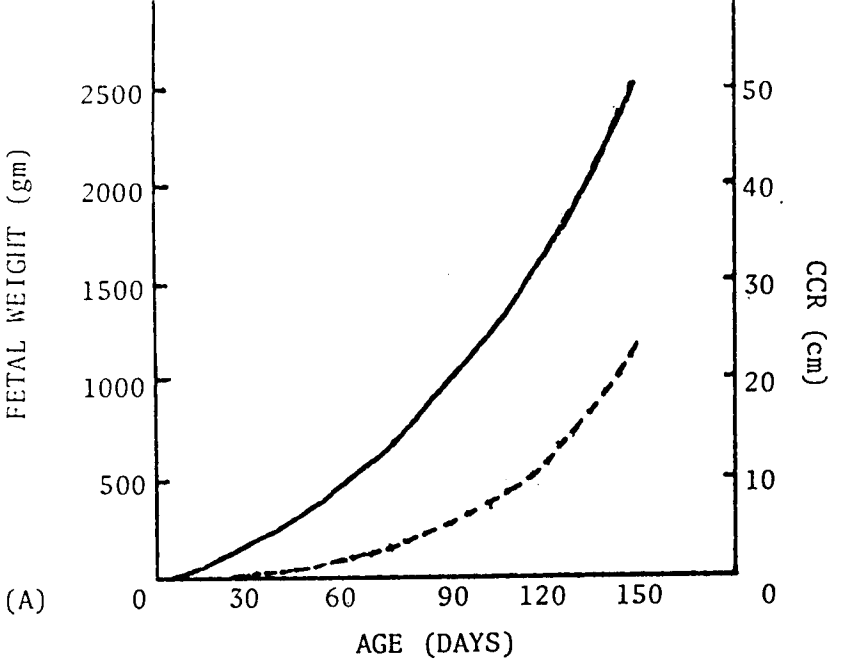
4. Evans, H. E. and W. W. Sach. 1973. Prenatal development of domestic and laboratory mammals. Growth curves, external features and selected references. Anat. Histol. Embryol. 2:11.

5. Joubert, D. M. 1956. A study of prenatal growth and development in the sheep. J. Agri. Sci. 47:382.

6. Lynset, O. 1971. Studies on reproduction in the goat. VII. Pregnancy and development of the foetus and the fetal accessories of the goat. Acta. Vet. Scand. 12:185.

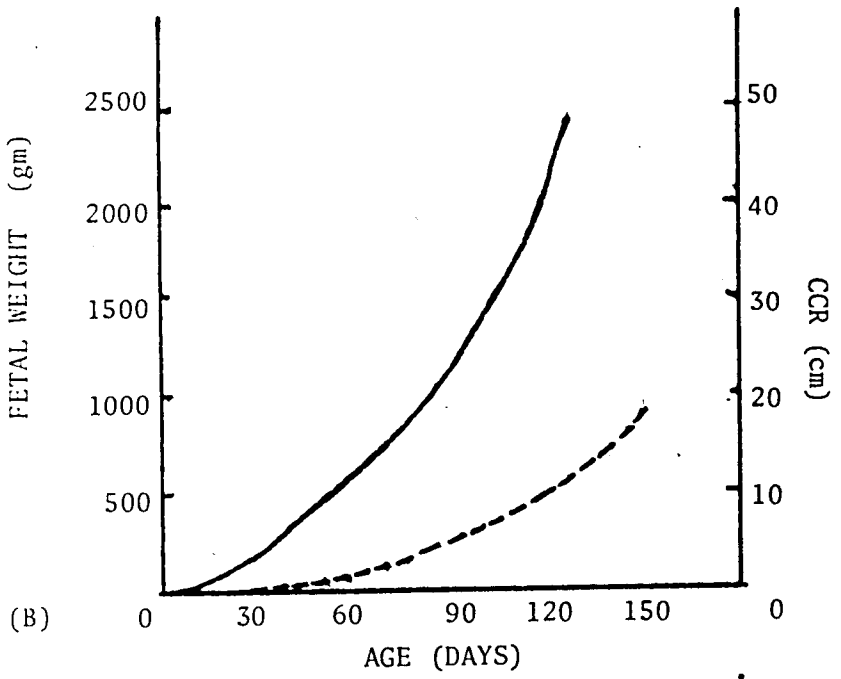
TABLE 1. STEPWISE REGRESSION BY FETAL GROUP FOR DEPENDENT VARIABLE, AGE (MODEL:AGE = ALL VARIABLES)

Male Singles	n= 17
Step 1	R^2 = .87
	Age = 32.0939 + 3.173 (SCR)
Step 2	R^2 = .90
	Age = 21.42 - 0.015 (Fetal wt.) + 4.175 (SCR)
Female Singles	n = 14
Step 1	R^2 = .83
	Age = 39.26 + 2.665 (SCR)
Step 2	R^2 = .88
	Age = 51.06 + .019 (Fetal wt.) + 1.50 (SCR)
Twins	n = 27
Step 1	R^2 = .79
	Age = 32.46 + 2.547 (CCR)



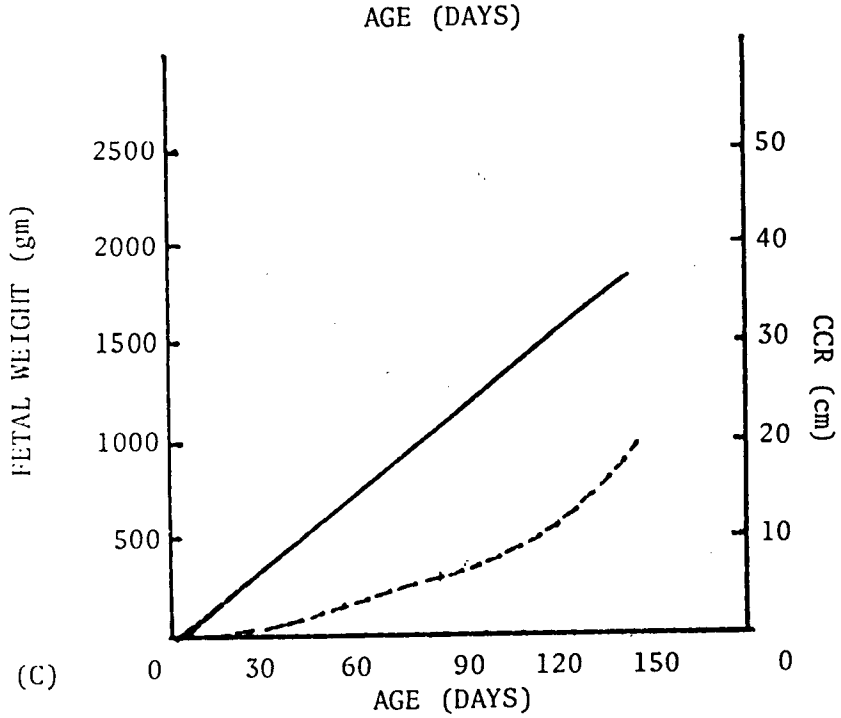
$$AGE = .3973\ (\text{Fetal wt}) - 0.000371\ (\text{Fetal wt})^2 + 1.005 \times 10^{-7}\ (\text{Fetal wt})^3$$

$$AGE = 5.45\ (CCR) - 0.05\ (CCR)^2$$



$$AGE = .452\ (\text{Fetal wt}) - 0.0005\ (\text{Fetal wt})^2 + 2.100 \times 10^{-7}\ (\text{Fetal wt})^3$$

$$AGE = 5.74\ (CCR) - 0.07\ (CCR)^2$$



$$AGE = .327\ (\text{Fetal wt}) - 0.00018\ (\text{Fetal wt})^2$$

$$AGE = 3.866\ (CCR)$$

Figure 1. Regression Lines for Fetal Weight (---) and CCR (—) on Fetal Age for Male Singles (A), Female Singles (B) and all Twins (C). Regression Equations for Fetal Weight and CCR are Included for A, B and C, Respectively.

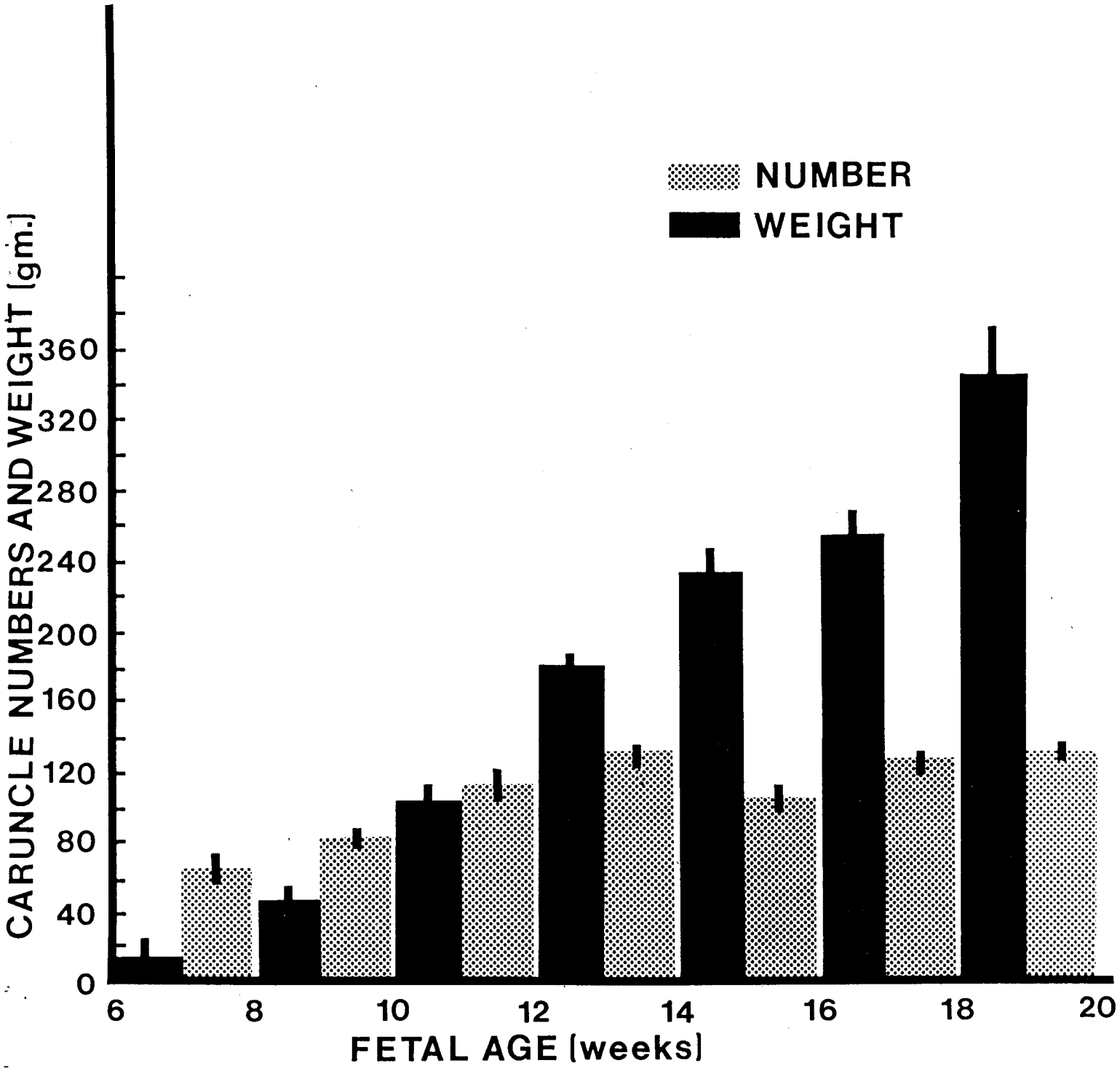


Figure 2. Relationship Between Fetal Age and Mean Caruncle Number or Caruncle Weight.

TESTOSTERONE-INDUCED PHENOTYPIC SEX REVERSAL IN SHEEP

Nat M. Kieffer, Maxine Stiles and Maurice Shelton

SUMMARY

Laparotomies were performed on pregnant ewes between 10 and 49 days post-breeding to facilitate the direct intrauterine injection of testosterone cypionate. Fifty-two of the 55 lambs born were phenotypic males. Of the 55, 21 were normal XY males, 3 were normal XX females, and 31 were virilized XX females (intersexes). The external genitalia of the intersexes consisted of a normal appearing penis and a small empty scrotum. They differed from normal males in that their teats were longer and thinner and their scrotums had a more narrow attachment to the abdominal surface. Internally the reproductive tract had differentiated along both male and female lines. Present were ovaries, well-developed epoophoron and paraepoophoron, oviducts, bicornuate uterus, anterior vagina, seminal vesicles, prostate and bulbourethral glands. The size of the prostate and bulbourethral glands increased with age and the presence of horns in some of the intersex lambs suggested that these genetic females were synthesizing testosterone. Also, radioimmunoassay of blood testosterone showed significantly higher levels for intersex animals than for normal controls. Testosterone is normally produced by the cells of Leydig. A variety of channels and cords, some closely resembling primitive medullary cords, were identified in tissues intimately associated with intersex ovaries. This observation suggests that testosterone may also play a role in maintaining the structure of the tubules and channels of the testis.

INTRODUCTION

In 1979 we completed a series of experiments designed to test the effects of testosterone on development of the sexual phenotype of female lambs when injected directly into the fetal membranes during the first 35 days of fetal life.

Our interest in these experiments was stimulated by the observation (3) of an unusual freemartin with gonads organized as testes and with a penis extruding from the perineal area. The outward phenotype of the usual freemartin is that of a normal female although the vulva may appear somewhat juvenile. The classical explanation of the freemartin condition (2, 4, 5) is that exchange of blood through anastomosed twin circulations subjects the female of male-female twin sets to the influence of hormones secreted by the fetal testes of her co-twin. The female is almost always masculinized and Lillie (5) suggested that the degree of masculinization was related to both the time at which circulatory anastomosis occured and the amount of male hormone reaching the tissues of the female co-twin.

During embryogenesis of the mammalian female reproductive system, there is a short critical stage when testicular hormones will irreversibly direct organogenesis of certain target tissues along male lines. Sex reversal of the freemartin referred to in the foregoing may have occured because of earlier than usual development of circulatory anastomosis between the freemartin and her male co-twin. For this freemartin, the mechanism whereby her target organs could receive testicular hormones from the male co-twin would have been in place at the time they were most sensitive to these hormones. It had not escaped our attention that studies by Jost (1) had suggested that possibly another substance, now known as the antimullerian hormone, was involved in the development of the normal male secondary sex characteristics. However, proof of the existence of the antimullerian hormone (AMH) at the time the experiments described here were begun was by inference only. It now seems clear that both testosterone and AMH are required for the embryo to become a male and in the absence of testosterone or AMH the embryo becomes a female or intersex, despite male genetic sex or gonadal sex. With the discovery in the 1970's that H-Y antigen might be the long sought after testis inducer, a central dogma of sex differentiation has emerged. This dogma has it that genes located on the Y chromosome control the production of a plasma membrane protein which induces the indifferent gonad to become a testis. The testis then secrete hormones which elicit the development of male secondary sex characteristics collectively known as the male phenotype. In XX embryos, i.e. in the absence of the Y chromosome, the indifferent gonad develops as an ovary and the secondary sex characteristics are those of the female phenotype.

This paper presents a definitive account of the effects of testosterone intervention on the differentiation of the mammalian female phenotype.

EXPERIMENTAL PROCEDURES

Laparotomies were performed on pregnant ewes between 10 and 49 days post-breeding (TABLE 1) to facilitate the direct intrauterine injection of testosterone cypionate. Stock solutions of Depo-Testosterone Cypionate (Upjohn) in concentrations of either 50 mg/ml, 100 mg/ml or 200 mg/ml were used in the preparation of hormone dosages. In most cases the predetermined concentrations of testosterone were contained in a total volume of 0.5 ml of sterile cottonseed oil. Hormone treatment levels ranged from 1.0 mg to 400 mg of testosterone cypionate (TABLE 2) with most ewes receiving the hormone at 22 or 23 days post-breeding.

The uterine horns and ovaries were lifted through a 7.0 - 10.0 cm abdominal incision. The ovaries were inspected for the presence of corpora lutea which would indicate that the ewe had ovulated. If the ewe was pregnant the location of the developing embryo was determined by comparing the two uterine horns. An obvious swelling was usually noted at the site of the developing embryo. In the early phases of this study the site of the pregnancy was specifically avoided when making the hormone injection as it was at that time unknown how traumatic this procedure would be on the pregnancy. Subsequently, however, the injection was made directly into the swollen area surrounding the embryo.

RESULTS AND DISCUSSION

Fifty-two of the 55 lambs born during this investigation were phenotypic males. Of these 55, 21 were normal XY males, 3 were normal XX females and 31 were virilized XX females (intersexes). The external genitalia of the intersexes consisted of a normal appearing penis and a small empty scrotum. They differed from normal males in that their teats were longer and thinner and their scrotums had a more narrow attachment to the abdominal surface. Testes could be palpated high in the scrotum of the normal males but were absent in intersex lambs.

The genetic sex was confirmed by examining the sex chromosomes of cultured lymphocytes. All lambs examined were found to have a normal compliment of chromosomes ($2n = 54$) with the sex chromosomes corresponding to the genetic sex assigned at birth.

Testosterone induced morphological changes in intersex lambs were quite similar regardless of hormone dosage and the time of gestation during which it was administered. The intersex lambs possessed a penis with a sigmoid flexure, retractor penis muscle, glans and filiform appendage. A disseminate prostate gland was positioned at the base of a blind vagina with seminal vesicles attached to the vaginal side. Bulbourethral glands were located at the root of the penis embedded in the bulbourethral muscle. The vagina opened into a normal bicornuate uterus via the cervix. The oviducts were tortuous and ended in a distinct fimbria partially covering the ovary-like gonads. The epoophoron and paraepoophoron, situated between the ovary and oviduct in the broad ligament, were very well developed and consisted of a mass of tissue equal in size to the gonad itself (PLATE 1).

Microscopic examination of gonads taken from intersex sheep revealed typical ovarian structures. Numerous follicles were observed in varying stages of development and atresia although no corpora lutea were discovered. The medulla of the ovary was seen to lead into the mass of tissue thought to be the epoophoron and paraepoophoron (PLATE 2-A). This tissue consisted of a variety of tubules and channels. There were tubules morphologically similar to the efferent ductules (PLATE 2-B and C), ductus epididymis (PLATE 3-A and B), straight tubules (PLATE 3-C) and rete testis of normal male sheep. Also located in this mass of tissue were smaller more tortuous cords, similar in appearance to the vestigial medullary cords (PLATE 3-D) sometimes seen in the medulla of a normal ovary. No Sertoli cells or Leydig cells were identified.

Tissue sections of the penis, seminal vesicles, prostate and bulbourethral glands were similar to that taken from normal male sheep.

The direct intra-uterine administration of testosterone to sheep fetuses facilitates a most effective method for documenting its role in the control of sexual development. The essential role of testosterone is the virilization of the Wolffian duct system. The external male genitalia develop under the influence of dihydrotestosterone, a derivative of testosterone (6). The experiments described here show that target tissues were most sensitive to testosterone and dihydrotestosterone between day 20 and day 25 of embryogenesis.

TABLE 1. Summary of Number of Days From Breeding to Hormone Treatment and Sex of Lambs for Experiments A, B, C and D

Days from breeding to treatment	No. of ewes	No. of lambs	Sex of lambs ♂	♀	⚥
10-14	2	2	0	0	2
15-19	4	5	1	0	4
19-24	15	18	5	0	13
25-29	13	19	9	0	10
30-34	4	5	1	2	2
35-39	3	4	4	0	0
40-44	1	1	0	1	0
45-49	1	1	1	0	0
Total	43	55	21	3	31

TABLE 2. Summary of Hormone Treatment Levels and Sex of Lambs for Experiments A, B, C and D (for Ewes Lambing)

Level of hormone (mg of testosterone cypionate)	No. of ewes	No. of lambs	Sex of lambs ♂	♀	⚥
1-14	20	25	10	2	13
15-29	8	12	5	1	6
30-44	2	2	1	0	1
45-59	5	6	2	0	4
60-74	2	2	0	0	2
75-89	-	-	-	-	-
90-104	3	4	2	1	2
200-250	2	2	0	0	2
400	1	2	1	0	1
Total	43	55	21	3	31

♂ = male ♀ = female ⚥ = intersex 21 male:34 female

PLATE 1. Diagrammatic representation of a typical intersex reproductive tract. A. Gonad. B. Epoophoron and paraepoophoron. C. Oviduct. D. Uterine horn. E. Cervix. F. Anterior vagina. G. Seminal vesicle. H. Prostate gland. I. Bulbourethral gland. J. Sigmoid flexure. K. Penis.

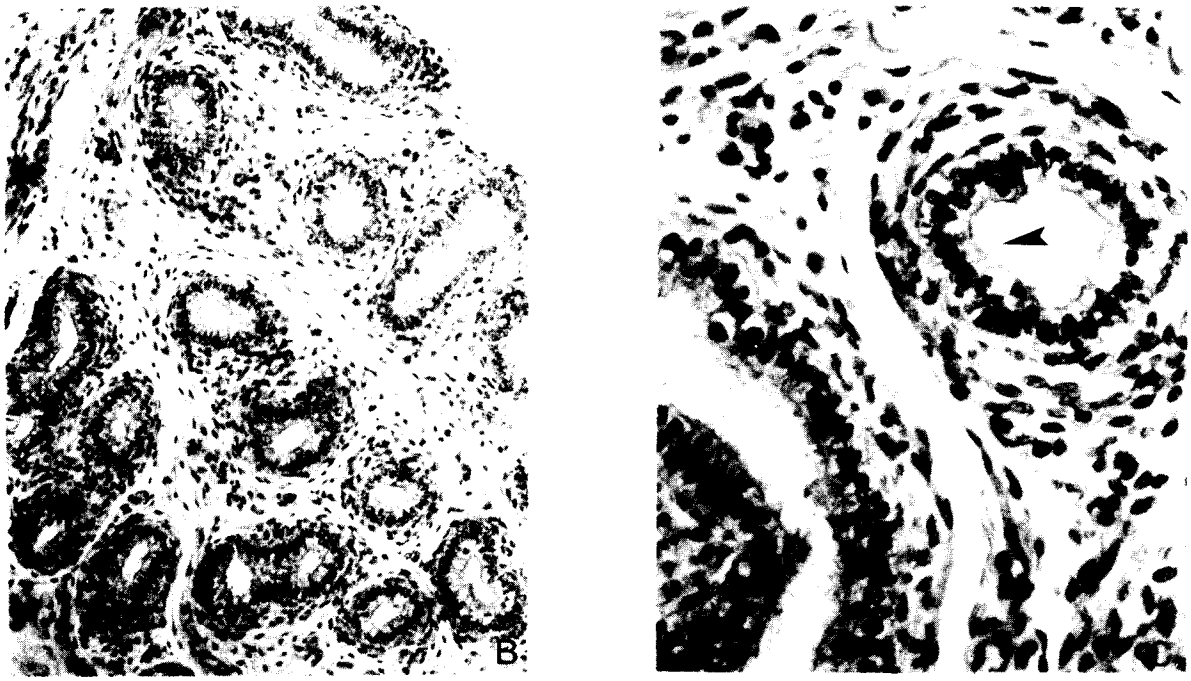


PLATE 2. Photomicrographs of a histological section through the gonad and epoophoron of sheep No. 109 at 5 months of age. The dam of this sheep received 16.0 mg of testosterone cypionate at 23 days post-breeding. A. Arrow points to unusually large follicle characteristic of intersex gonads. B and C. Efferent ducts showing steriocilia (arrow) and pseudo-stratified epithelium. (Lenses used - A., 1X; B. 10X and C. 25X)

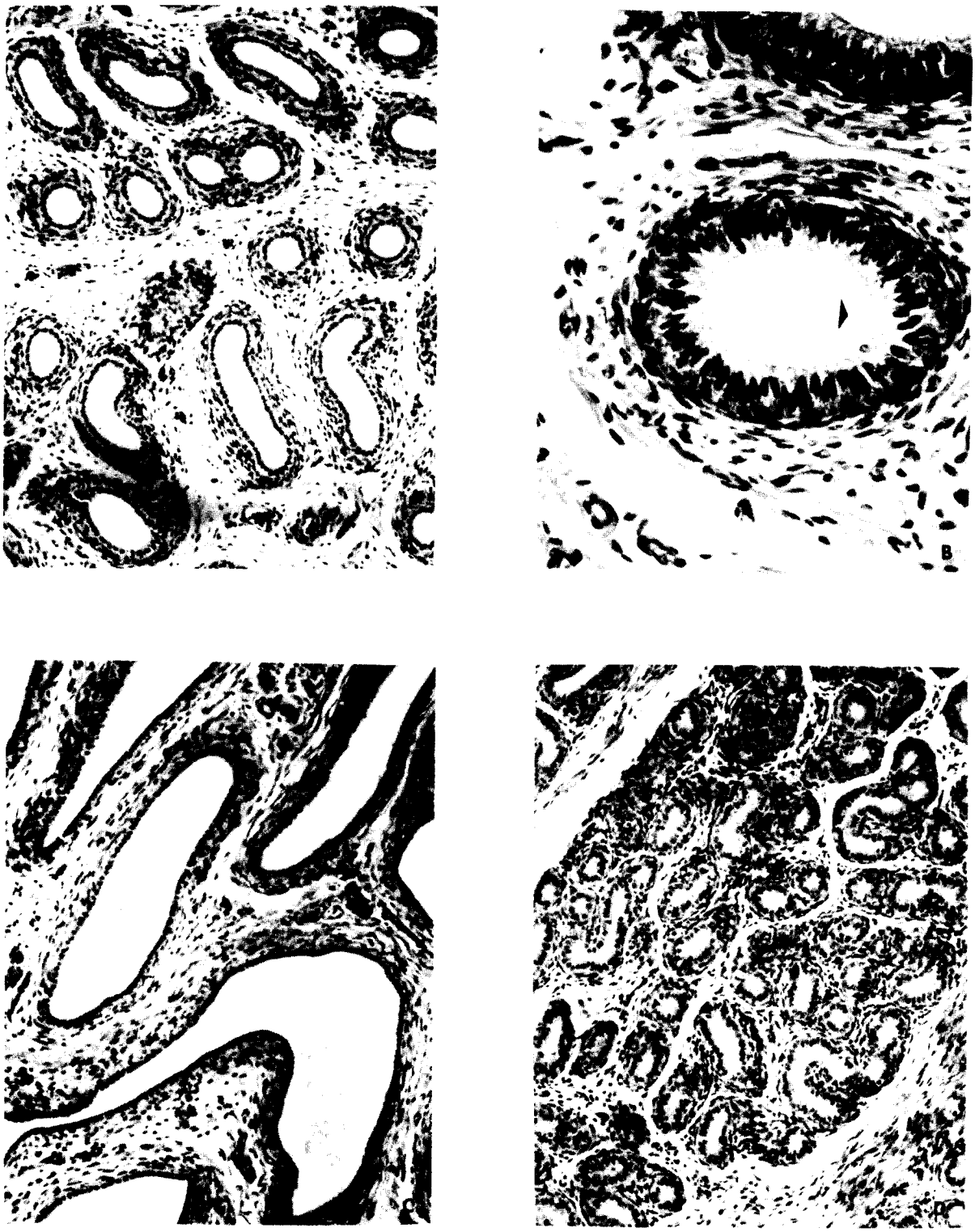


PLATE 3. A. and B. Ductus epididymis, showing pseudostratified columnar epithelium and stereocilia (arrow). C. Straight tubules lined with columnar cells. D. Small tubules resembling vestigial medullary cords. (Lenses used - A. and D., 10X; B. and C., 25X)

LITERATURE CITED

1. Jost, A. 1953. Problems of fetal endocrinology. The gonadal and hypophyseal hormones. Recent Prog. Hormone Res. 8:379.

2. Keller, K. and J. Tandler. 1916. Wein. Tierartzel. Wochschr. 3:513. As cited by Price, 1972. Am. Zoologist 12:179.

3. Kieffer, N. M. and A. M. Sorensen, Jr. 1971. Some cytogenetic aspects of intersexuality in the bovine. J. Anim. Sci. 32:1219.

4. Lillie, F. R. 1916. The theory of the freemartin. Science 43:611.

5. Lillie, F. R. 1917. The freemartin; a study of the action of sex hormones in the foetal life of cattle. J. Exp. Zool. 23:371.

6. Wilson, J. D., F. W. George and J. E. Griffin. 1981. The hormonal control of sexual development. Science 211:1278.

INFLUENCE OF EXOGENOUS PROGESTINS ON ENDOGENOUS PROGESTERONE PRODUCTION IN ANGORA GOATS

Maurice Shelton, Max Amoss and Ron Lewis

Abortion has long been recognized as a problem or source of loss in Angora goats. More recently it has been recognized that other types of goats are also subject to abortion losses. Although diseases can be shown to be a cause of abortion in goats, it is now generally recognized, at least with Angoras, that nutritional stress is primarily responsible for precipitating the problem. Nevertheless, it is often suggested that progesterone or progestins be considered as a control measure since endogenous progesterone exercises a function to maintain pregnancy. However, some problems are encountered in testing this possibility. Under Texas conditions breeding dates are generally unknown and thus, timing progesterone therapy to the pregnancy state of the individual animal is not feasible. Thus, it is necessary to know if exogenous progesterone interferes with endogenous progesterone production from a functional corpus luteum or if a given source of exogenous progesterone interferes with parturition at a normal term. Also, the source of progesterone presents some problem. Progesterone itself is a short acting drug and would require daily or frequent injections. Thus, this source could be ruled out in practice. Previous experience has shown that long acting drugs such as depo-provera used in injectible form interferes with parturition at term resulting in dystocia and elevated losses of both does and their kids. Orally active progestins offer a third alternative. One such potential drug is Melengesteral Acetate (MGA). However, before it could be studied on a flock basis, it seemed desirable to know how the apparently normal pregnant doe reacts to this exogenous progestin. Thirty-seven aged Angora does were used in a study to determine the influence of oral MGA on endogenous progesterone production, parturition at term or effect of its removal after a period of treatment. Treatments consisted of a control ration and two levels of MGA at 0.25 or 0.50 mg. per day fed in a complete ration. Animals were group fed in lots of 5 head; thus, intake values are based on group feeding and it is not possible to be sure of the intake of each individual animal. Within the groups receiving MGA, some received the drug throughout the experiment; whereas, with others the drug was removed after 15 or 30 days. Data collected included weekly progesterone levels as well as birth dates and weights of kids born. This drug, at the levels used, did not result in marked reductions in endogenous progesterone production. Withdrawal of the drug did not precipitate abortion at the time of removal. Also, the presence of the drug in the ration did not interfere with normal parturition at term. It may be significant to note that it also did not prevent abortion as two losses were recorded among does receiving the drug. These preliminary data indicate that further studies using larger numbers under field conditions might be undertaken without the treatments themselves precipitating losses. However, these preliminary data do not provide much encouragement that this approach will prove a solution to the problem.

EFFECT OF SUCKLING MANIPULATION ON REPRODUCTIVE EFFICIENCY IN SPANISH GOATS

J. L. Lawson, D. W. Forrest and J. M. Shelton

Results of numerous studies with sheep have indicated that removal of the suckling stimulus may promote early postpartum rebreeding. However, possible beneficial effects appear only when the regimin is initiated during the normal breeding season. Thus, in the northern hemisphere, such a treatment would be useful only with fall lambing ewes. Previous studies involving the early weaning of kids from Spanish does failed to affect the postpartum interval. However, the early weaning treatments used were not drastic, since weaning was at approximately 3-4 months following parturition. Early weaning or short-term calf removal has been reported to shorten the interval to conception in lactating cows. Consequently, manipulation of the suckling stimulus by limiting hours of nursing per day or weaning earlier than 3 months might also prove useful with meat goats, particularly in certain months of the year. Over the past 10 years, nearly 19% of the does managed at the Texas Agricultural Experiment Station at Sonora kidded during the fall (September through December). Of these, approximately 45% kidded from breeding that occurred before the start of the anestrus period. Thus, the aim of the present study was to determine if suckling treatments on fall and early winter kidding does would promote early return to estrus and out-of-season kidding. A group of 45 does located at College Station kidded between December 2 and December 20. All animals were maintained as one group until the kids reached 30 days of age. At that time, does and kids were randomly allotted to one of the following groups: 1) limited suckling (LS), suckling 1 hour per day from 5:00 - 6:00 p.m.; 2) early weaning (EW), placed on a pelleted ration; 3) control (CO), unlimited nursing. Does were assigned so that each group had an approximately equal number of twin- and single-bearing does with approximately the same kidding dates. Each group had one mature, fertile male equipped with a marking harness for estrus detection. The males were rotated at least twice weekly upon initiation of the suckling treatments. Sixty kids were born to 45 does: 25 singles, 16 sets of twins and 1 set of triplets. After initiation of the treatments, 70% of both EW and LS does came into estrus within an average of 6 days and 11 days, respectively. Only 15% of the CO does were observed in estrus before the end of the experiment (98 days after the start of kidding). Thirty percent of the EW does were noted to short cycle at least once (mean cycle length 4.8 days, range = 3-10 days). Kid mortality was 16% in the EW group with no losses occurring in the other treatments. Percent kid crop for each treatment will be determined during the summer of 1982.

MILK YIELD RECORDS FOR DAIRY GOATS

Michael A. Tomaszewski and Robert W. Blake

Texas dairy goat owners have resurgent interest in production testing. A number of provisions were made by the Dairy Herd Improvement Association (DHIA) to calculate lactation records for dairy goats for use in herd management. In addition, the capture and analysis of milk yield data will permit estimation of genetic and other herd management parameters useful in dairy goat improvement programs.

DHIA records have been a boon to dairy cattle production because accurate records are the basis for sound decision making. Genetic estimates calculated from DHIA data were instrumental in doubling the yield capacity of dairy cattle in the last 20 years. This same phenomenon is beginning in the dairy goat population because breeders are deciding to production test their animals. The Texas dairy goat testing program was initiated 4 years ago. Currently, 48 Texas herds have 505 goats (one-third of the total) enrolled in DHIA at the Dairy Records Processing Center at Raleigh, North Carolina. For the 1981 official testing year, 250 does in 19 herds had annual yields averaging 1342 pounds of milk, 4.2% milkfat and 56 pounds of milkfat.

Special herd management training courses are at off-campus locations to serve Texas' growing goat industry. Training courses in 1981 were at New Braunfels and Jacksboro and were attended by about 85 breeders.

MILK PRODUCTION OF CROSSBRED EWES

L. H. Ripley, J. W. Campbell and J. W. Bassett

Milk production was measured on 18 crossbred ewes, eleven ewes had single lambs and seven ewes had twin lambs. Ewes lambed between January 26 and March 16, 1982 and milk production was measured for the first eight weeks of lactation for each ewe. Ewes were group-fed an average of two pounds of a 14% crude protein, 61% total digestible nutrients pelleted ration per day and had access to bermuda grass pasture. Milk production was estimated by separating ewes from their lambs for a 24-hour period each week. Lambs were allowed to nurse at four hour intervals and the difference between a lamb's weight before suckling and after suckling was attributed to the weight of the milk consumed. In general, ewes with twin lambs gave more milk than the ewes with single lambs. Differences in production between ewes with twin and single lambs tended to decrease as lactation progressed.

EFFECT OF ENVIRONMENTAL FACTORS AND STAGE OF MATURITY ON HYMENOXON CONTENT OF BITTERWEED (HYMENOXYS ODORATA)

F. A. Pfeiffer and M. C. Calhoun

SUMMARY

Bitterweed plants growing at different locations but under similar moisture conditions and temperatures, when sampled at approximately the same stage of maturity, varied widely in hymenoxon content. Since the toxicity of bitterweed has been shown to be related to its hymenoxon level, this suggests a wide difference in toxicity of bitterweed plants growing at different locations. In general, bitterweed growing south and west of San Angelo, Texas is more toxic than that growing north of San Angelo. Hymenoxon levels ranged from 0 to 4.7% (dry matter basis) with the highest values measured in bitterweed seedlings and the lowest in mature, desiccated plants. Sampling sites within ranch locations that had the lowest soil moistures and highest soil temperatures also had bitterweed with the highest hymenoxon content. During a short dry period hymenoxon content of bitterweed increased at 7 of the 8 sampling sites. This suggests bitterweed may be more toxic under drought conditions.

INTRODUCTION

Bitterweed (Hymenoxys odorata) is a member of the Compositae (Sunflower) family. The plant is a winter growing annual which thrives in overgrazed and disturbed areas of the Edwards Plateau and Trans-Pecos range areas of Texas. However, its range extends from south Kansas into Mexico and from central Texas to California (5).

Bitterweed is the most serious poisonous plant problem affecting sheep production in the range areas of Texas; one which has plagued the industry since the early 1920's (1,5). Poisoning usually occurs from late fall through early spring. The severity of the problem depends on rainfall patterns and availability of other forage. Signs of poisoning include loss of appetite, salivation, cessation of rumination and depression. An occasional animal will vomit rumen contents and exhibit a green nasal discharge (6).

The factors which determine the toxicity of growing bitterweed plants are not completely understood. Ranchers have reported that plants growing in some areas are more toxic than others. However it was not known whether this was due to actual differences in the level of toxin in the weed or to an increased consumption of the plant by sheep. Early studies, in which fresh, green bitterweed was harvested

at different stages of maturity and force-fed to sheep, showed there was a slight increase in toxicity as the weed matured (1). In contrast, Rowe et al. (6) reported seedling bitterweed was more toxic than mature weed. It has also been reported that bitterweed growing during a drouth year was more toxic than weed growing during a year of normal rainfall and range vegetation (1).

In the preceeding studies estimates of the relative toxicity of plant material were based on LD_{50} values determined in acute feeding studies with sheep. Such estimates are less precise than actual measurements of the chemical toxin (hymenoxon) which has been shown to be the major toxic component of bitterweed (2,4,8). An assay for hymenoxon, developed by Hill et al. (4), provided a means for more accurately assessing the factors affecting the toxicity of bitterweed. The purpose of this research was to determine the effect of location, stage of maturity and environmental factors on the hymenoxon content (toxicity) of bitterweed.

EXPERIMENTAL PROCEDURE

The hymenoxon content of bitterweed plants collected bi-weekly from four ranches, during the 1980-81 growing season (Dec.-June), was determined by gas-liquid chromatography (4). The four ranches were H and H Cattle Company Ranch located 3.2 km northeast of Sterling City, Texas in the northeastern portion of Sterling county; Oglesby Ranch located 37 km west of Eldorado, Texas in the northeastern portion of Crockett county; Pfluger ranch located 35 km southeast of San Angelo, Texas in the southeastern portion of Tom Green county and Sonora experiment Station Ranch located 45 km south-southeast of Sonora, Texas in the northwestern portion of Edwards county.

The sampling procedure consisted of collecting bitterweed from three 1/4 m quadrates selected at random from two sites at each ranch. Each time bitterweed was sampled, the phenological stage of the population was recorded. The bitterweed was oven dried at 60°C for 48 hr. to determine water content, and then ground through a 1 mm screen and stored for subsequent hymenoxon, crude protein and phosphorus analyses. Other observations taken at the time of sampling were soil temperature and cumulative rainfall. Also soil samples were collected and used for determinations of soil moisture.

RESULTS AND DISCUSSION

The growth of bitterweed throughout the year was similar at all four locations. In early December bitterweed plants were mostly 2.5 to 7.6 cm tall. Some seedlings < 2.5 cm were present as were a few plants > 7.6 cm. By the end of January plants were mostly in the range of 2.5 to 12.7 cm

tall and some blooms were present on the more mature plants. Germination continued throughout the winter months whenever conditions were favorable as many seedling bitterweed plants were observed in February and March. Rapid growth occurred in March and most plants were 20.3 to 30.5 cm tall and beginning to flower by March 25. By the middle of April plants were in full bloom and by the end of April seed heads were forming. Some plants in full bloom were observed in May, but most had seed heads and were beginning to dry out. Plants collected the first week in June were mostly desiccated.

Figure 1 shows the hymenoxon content of bitterweed summarized by months for each of the ranches. Hymenoxon was highest in December and levels decreased as the plants matured; approaching zero in desiccated plants collected during the first week of June. Bitterweed collected at the Pfluger and Sonora ranches was consistently higher in hymenoxon than was bitterweed from H&H Cattle Co.; whereas, plants harvested at the Oglesby ranch tended to be intermediate in hymenoxon value. There were also consistent differences in hymenoxon content of bitterweed between sampling sites at both the Oglesby and Pfluger ranches. These differences corresponded with consistent differences in soil moisture and soil temperature measurements for these sites. The sampling sites on each of these ranches with the lowest soil moistures and highest soil temperatures contained bitterweed with the highest hymenoxon, even though the sampling sites on each ranch were less than 5 km apart. With the exception of a short dry period during the last half of January and the first half of February, rainfall was above average at all locations during this study. The dry period coincided with an increase in hymenoxon content of bitterweed at 7 of the 8 sampling sites even though the general trend was for hymenoxon to decrease as plants matured. This limited evidence that bitterweed may be more toxic under drought conditions is consistent with observations reported by Boughton and Hardy (1) and is supported by measurements of hymenoxon in bitterweed harvested from the Pfluger Ranch during a dry spring. Whole bitterweed plants (including roots) collected on April 16, 1982 averaged 2.87 ± .50% hymenoxon compared with 1.40 ± .11% hymenoxon in the above ground portion of plants collected from the Pfluger ranch during April 1981. Since roots contain only traces of hymenoxon and make up about 9.5% of the dry weight of the plant, the above ground portion of the plants collected in April 1982 actually contained about 3.0% hymenoxon.

The crude protein (Nx6.25) content of bitterweed samples (composited by months for each ranch) are shown in Figure 2. December values ranged from 13.1 to 22.6% for Pfluger and H&H Cattle Co. ranches, respectively. These levels decreased as the bitterweed matured and in June the respective values for the two ranches were 6.7 and 10.2%. Values for the crude protein content of bitterweed collected at the Oglesby and Sonora ranch locations were intermediate between values for bitterweed at the H&H Cattle Co. and Pfluger ranch locations.

Phosphorus levels of bitterweed plants (composite samples) collected from the four locations were quite similar throughout the year. Values ranged from .15 to .27% and there was little difference between locations and, with the exception of an increased phosphorus content of plants from all four location's which occurred in May, no effect of stage of maturity on phosphorus levels.

This study has demonstrated that bitterweed plants growing at different locations on the Edwards Plateau differ in hymenoxon and crude protein content even when growing under similar environmental conditions and when collected at the same phenological stage. It is also interesting to note the inverse relationship which exists between crude protein content of bitterweed and its hymenoxon level. At any given sampling time bitterweed with the highest crude protein tended to have the lowest hymenoxon (Figures 1 and 2). For example, during the month of December crude protein content of bitterweed from Pfluger ranch was 13.1% and hymenoxon was 3.1%, whereas plants collected at the H&H Cattle Co. location, which contained 22.6% crude protein, had only 1.6% hymenoxon. Whether these differences are due to genetic differences in these plant populations or to geographical differences is unknown. However, variation in chromosome numbers from N=11 to N=15 have been reported for Hymenoxys odorata (7). These are found in orderly geographic distribution with N=15 found in the highland area of north central Mexico, N=14 near Laredo, Tx., and N=12 near Del Rio, Tx. Populations of N=11 are the most widespread and extend northward and westward from the Del Rio area. Unfortunately these races are essentially indistinguishable in the field and have never been distinguished taxonomically (7).

The bitterweed used in this study was dried in a forced-draft oven at 60°C for 48 hr. It was assumed, when these conditions were decided upon, that hymenoxon would be fairly stable under moderate drying conditions. However, recent observations indicate time and temperature in the drying oven both adversely affect hymenoxon content of bitterweed (Deere and Calhoun, unpublished data). For example, the hymenoxon content of a bitterweed sample was 1.76% when freeze-dried prior to analysis, however when dried at 50°C for 48 hr. hymenoxon was 1.31% and at 75°C for 48 hr., 1.14%. Because of these effects it can be assumed that the hymenoxon values reported in this paper are about one-third less than the actual values that existed in the field when the bitterweed was harvested.

LITERATURE CITED

1. Boughton, I.B. and W.T. Hardy. 1937. Toxicity of bitterweed (Actinea odorata) for sheep. Tex. Agr. Exp. Sta. Bull. 552.

2. Calhoun, M.C., D.N. Ueckert, C.W. Livingston, Jr. and B.C. Baldwin, Jr. 1981. Association between bitterweed dose, voluntary feed intake and some blood serum constituents of sheep. Am. J. Vet. Res. 42:1713.

3. Hardy, W.T., V.L. Cory, H. Schmidt and W.H. Dameron. 1931. Bitterweed poisoning in sheep. Tex. Agr. Exp. Sta. Bull. 433.

4. Hill, D.W., H.L. Kim and B.J. Camp. 1979. Quantitative analysis of hymenoxon in plant tissue. J. Agr. Food Chem. 27:885.

5. James, L.F., R.E. Keeler, A.E. Johnson, M.C. Williams, E.H. Cronin and J.D. Olsen. 1980. Plants poisonous to livestock in the western states. U.S.D.A. Agr. Info. Bull. 415. pp 8-9.

6. Rowe, L.D., J.W. Dollahite, H.L. Kim and B.J. Camp. 1973. Hymenoxys odorata (bitterweed) poisoning in sheep. Southwest. Vet. 26:287.

7. Sanderson, S.C. and J.L. Strother. 1973. The origin of aneuploidy in Hymenoxys odorata. Nature New Biol. 242:220.

8. Terry, M.K., H.L. Kim, D.E. Corrier and E.M. Bailey, Jr. 1981. The acute oral toxicity of hymenoxon in sheep. Res. Commun. Chem. Pathol. Pharmacol. 31:181.

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FIGURE 1

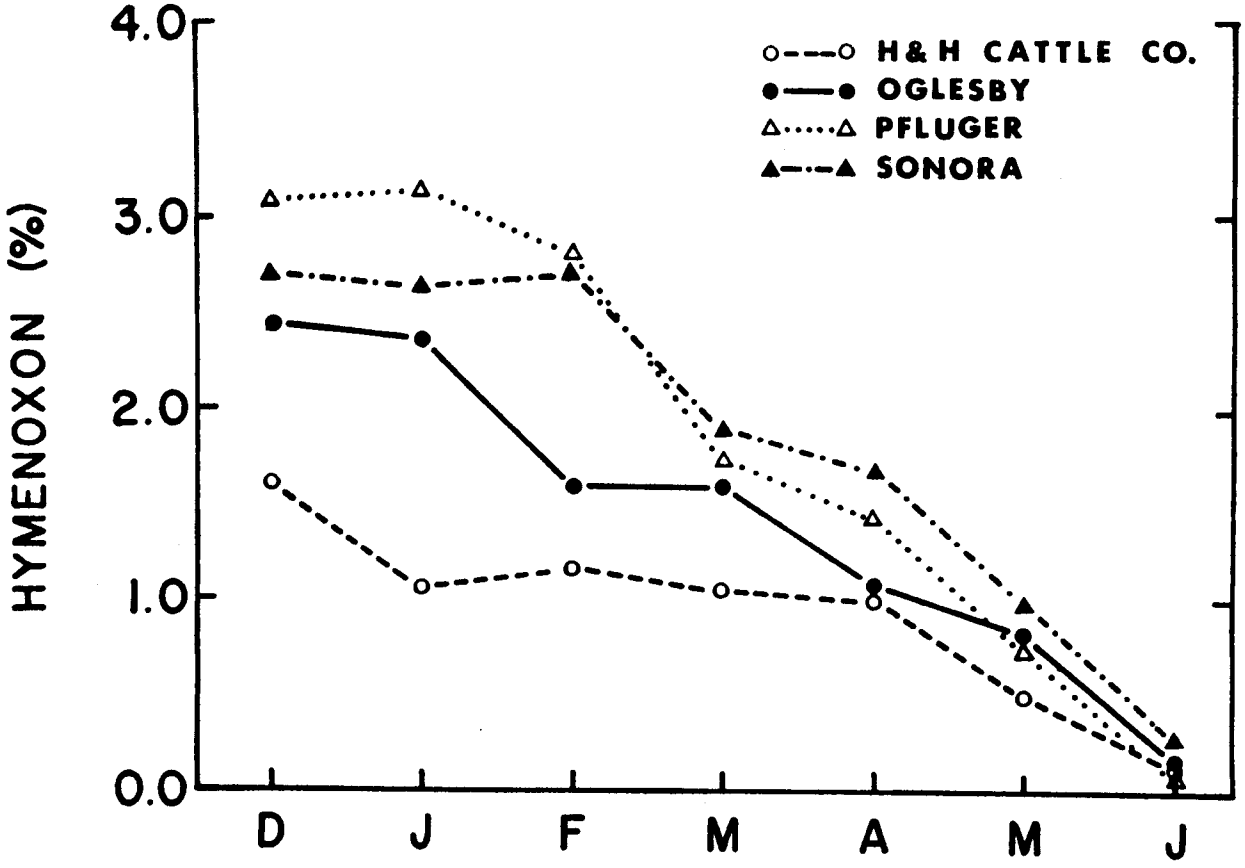
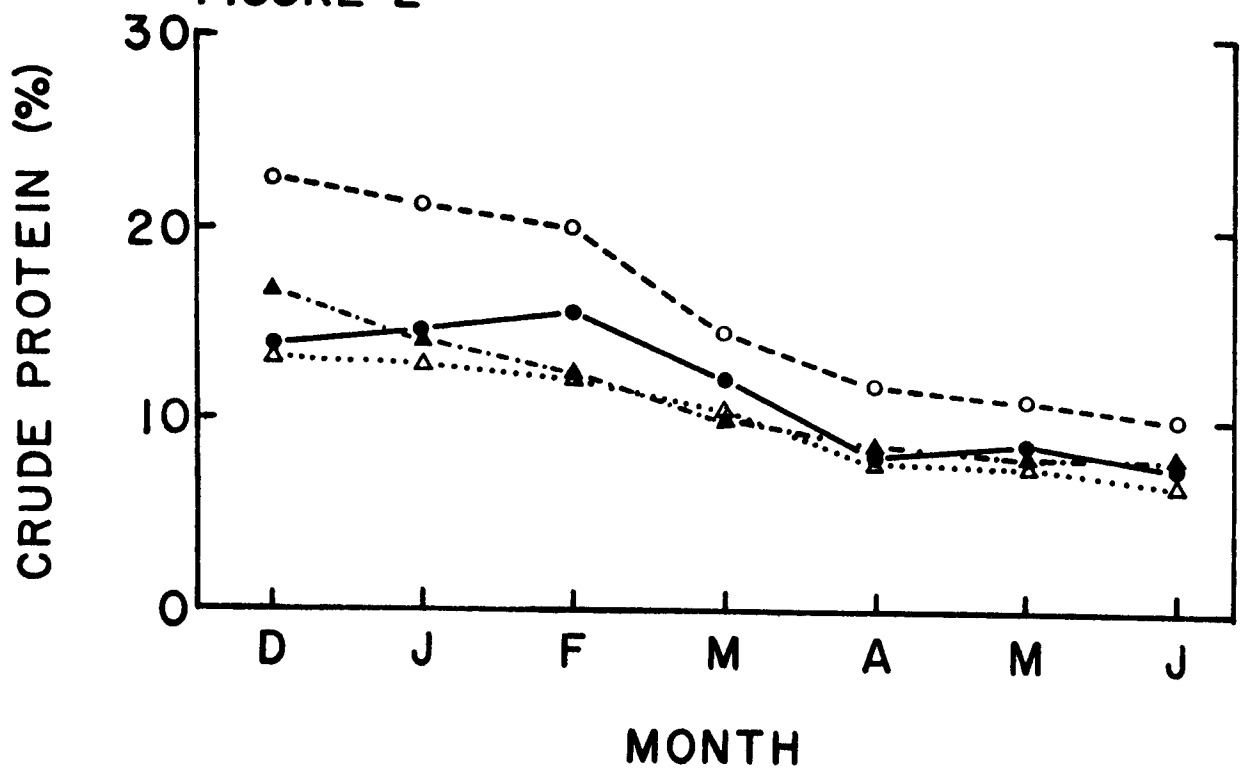


FIGURE 2



EFFECTS OF DRYING TEMPERATURES AND TIMES ON HYMENOXON CONCENTRATIONS IN BITTERWEED SAMPLES

B. F. Deere, F. A. Pfeiffer and M. C. Calhoun

SUMMARY

Bitterweed plants, collected from a uniform population, were used to determine the effects of post-harvest drying times and temperatures on hymenoxon concentrations. Drying conditions studied were 50, 75 and 100°C, for 24 and 48 hr. A bitterweed sample packed immediately (when harvested) in dry ice and then freeze dried was used as the control. The hymenoxon content of the freeze dried sample was 1.8 ± .03%. Time in the oven and drying temperatures had significant effects and all treatment combinations reduced hymenoxon ($P<.01$) relative to the control. Hymenoxon losses ranged from 17.4% for 24 hr at 50°C to 67.3% for 48 hr at 100°C.

INTRODUCTION

Bitterweed (Hymenoxys odorata) is one of the major poisonous plants in Texas and the most important poisonous plant problem for sheep production in the state (2). Staggering losses have been experienced in the past (3) and significant losses still occur (8).

Until recently the toxic principle remained unidentified (2). However, in 1974, a poisonous sesquiterpene lactone was isolated which was named hymenoxon (6). At present it appears that the hymenoxon content of bitterweed is the major factor governing its toxicity (1,9).

Hymenovin (a mixture of epimers of hymenoxon) has been reported to be lethal to sheep at oral dosages of 100 mg/kg live weight and non-toxic at 50 mg/kg live weight (5). Terry et al. (9) reported that the acute oral LD_{50} of hymenoxon for sheep was approximately 75 mg/kg live weight. Published values for the hymenoxon content of bitterweed range from 0 to 4.7% (dry matter basis), but little information is available on losses of hymenoxon which might occur while processing the plant for analyses. Knowledge of such losses is essential to relate laboratory measurements of hymenoxon to the actual toxicity of the growing plant.

The procedure used for hymenoxon determination involves harvesting, drying (air or oven), grinding, solvent extraction and analysis by gas chromatography (4). Although care must be exercised throughout this procedure, the drying process possibly offers the greatest potential for loss of hymenoxon. According to Ivie et al. (5) bitterweed retains full toxicity upon drying. However, Dollahite et al. (2) stated that toxicity

varied with how the plant was collected and handled. The purpose of this research was to better define the effects of drying times and temperatures on hymenoxon content of bitterweed.

EXPERIMENTAL PROCEDURE

From a single population, 105 uniform bitterweed plants (approximately 8 cm tall) were collected. These were randomly divided into 21 samples of 5 plants/sample. Three samples were packed immediately in dry ice and then freeze dried. The remaining samples were subjected to each of the following treatments; dried in a forced-draft oven at 50, 75 and 100°C for either 24 or 48 hr. Three samples were randomly assigned to each treatment. When the samples were dry they were ground to pass a 1 mm screen. Subsequently hymenoxon analysis was carried out using the gas chromatographic procedure described by Hill et al. (4).

RESULTS AND DISCUSSION

The bitterweed plants used in this study were collected on Dec. 29, 1980 at the H&H Cattle Co. Ranch located 3.2 km northeast of Sterling City, Texas in the northeastern portion of Sterling county. Soil moisture was adequate and the plants were robust and in an early vegetative growth stage about 8 cm tall.

The effects of drying times and temperatures on hymenoxon content of bitterweed are shown in Figure 1. The freeze dried samples averaged 1.8 ± .03% hymenoxon (dry basis). Time spent in the forced-draft ovens, as well as, drying temperatures had significant negative effects on hymenoxon content and all treatment combinations reduced hymenoxon relative to the control ($P<.01$). Losses of hymenoxon ranged from 17.4% (24 hrs at 50°C) to 67.3% (48 hr at 100°C). The effect of temperatures was linear. For each 10°C increase in drying temperature above 50°C there was a decrease in the actual hymenoxon content of .14%. The effect of increasing the drying time from 24 to 48 hr, when averaged across all temperatures was to decrease the hymenoxon content by .18%.

Drying bitterweed for 48 hr at 60°C, in a forced-draft oven, has been routine in our research. Based on results obtained in this study, these conditions could result in a 33% loss of hymenoxon. Since values up to 4.7% of the dry weight of the above ground portion of bitterweed plants have been measured in our studies (7), hymenoxon levels as high as 7.0% of the dry weight may have existed in the growing plant. Considering that hymenoxon is concentrated primarily in the leaves of the growing plant (leaves contain about 10 times the level found in stems), then selective eating by sheep could result in intakes of material containing more than 7.0% hymenoxon (on a dry matter basis).

LITERATURE CITED

1. Calhoun, M.C., D.N. Ueckert, C.W. Livingston, Jr., and B.C. Baldwin, Jr. 1981. Association between bitterweed dose, voluntary feed intake and some blood serum constituents of sheep. Am. J. Vet. Res. 42:1713.

2. Dollahite, J.W., L.D. Rowe, H.L. Kim and B.J. Camp. 1973. Control of bitterweed (Hymenoxys odorata) poisoning in sheep. Tex. Agr. Exp. Sta. Prog. Rpt. 3149.

3. Hardy, W.T., V.L. Cory, H. Schmidt and W.H. Dameron. 1931. Bitterweed poisoning in sheep. Tex. Agr. Exp. Sta. Bull. 433.

4. Hill, D.W., H.L. Kim and B.J. Camp. 1979. Quantitative analysis of hymenoxon in plant tissue. J. Agr. Food Chem. 27:885.

5. Ivie, G.W., D.A. Witzel, W. Herz, R. Kannan, J.O. Norman, D.D. Rushing, J.H. Johnson, L.D. Rowe and J.A. Veech. 1975. Hymenovin. Major toxic constituent of western bitterweed (Hymenoxys odorata DC). J. Agr. Food Chem. 23:841.

6. Kim, H.L., L.D. Rowe and B.J. Camp. 1975. Hymenoxon, a poisonous sesquiterpene lactone from Hymenoxys odorata DC. (bitterweed). Res. Commun. Chem. Pathol. Pharmacol. 11:647.

7. Pfeiffer, F.A. and M.C. Calhoun. 1982. Effects of environmental factors and stage of maturity on hymenoxon content of bitterweed (Hymenoxys odorata). Tex. Agr. Exp. Sta. Prog. Rpt. .

8. Rowe, L.D., J.W. Dollahite, H.L. Kim and B.J. Camp. 1973. Hymenoxys odorata (bitterweed) poisoning in sheep. Southwest. Vet. 26:287.

9. Terry, M.K., H.L. Kim, D.E. Corrier and E.M. Bailey, Jr. 1981. The acute oral toxicity of hymenoxon in sheep. Res. Commun. Chem. Pathol. Pharmacol. 31:181.

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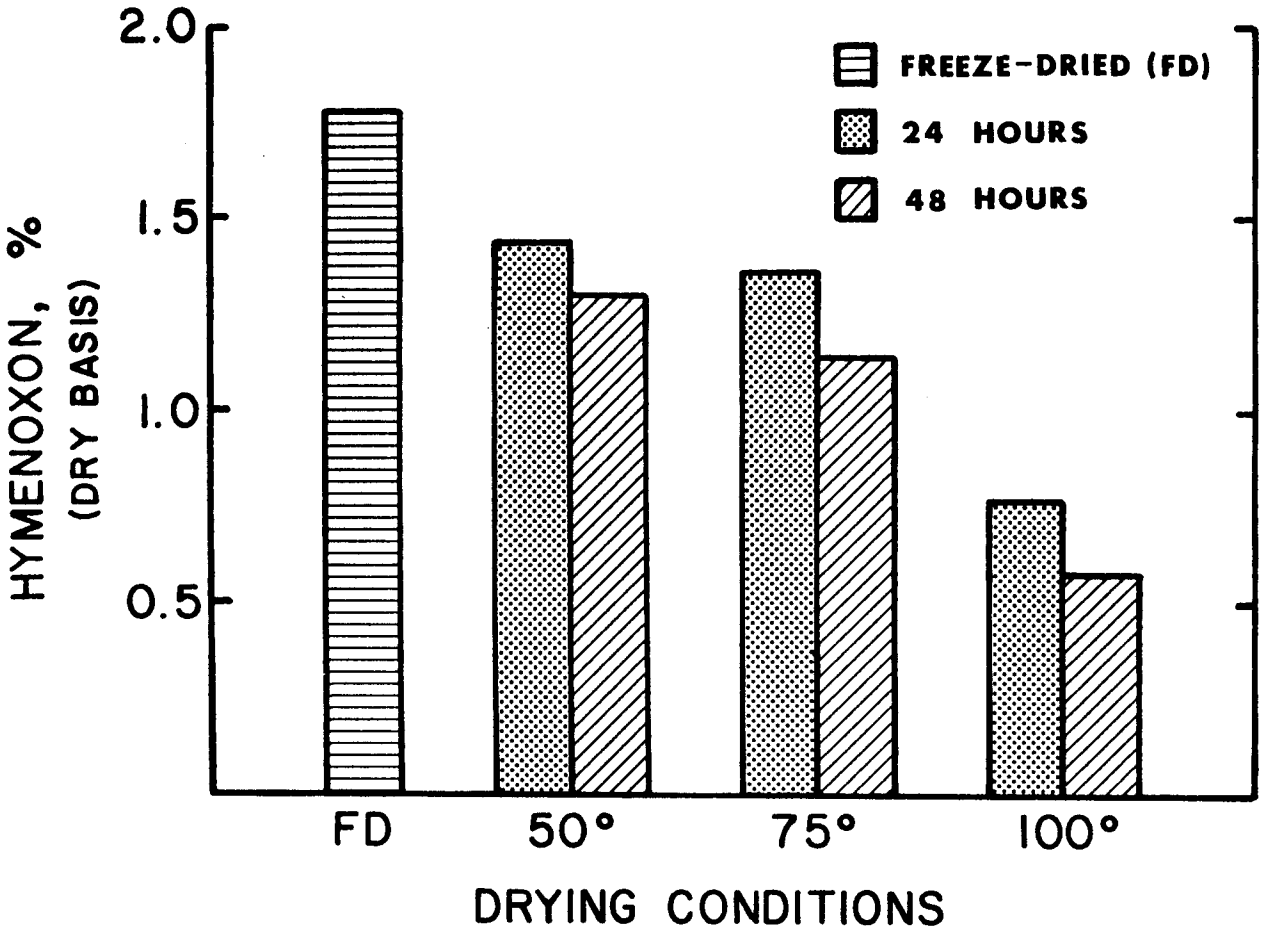
Appreciation is expressed to Stanley Horwood, owner of H&H Cattle Co. ranch for allowing us to collect bitterweed on his ranch. Appreciation is also expressed to Dr. H.L. Kim for providing a pure sample of hymenoxon and to Estelle Hejtmancik for her helpful assistance with the hymenoxon assays.

FIGURE 1. EFFECT OF DRYING TIMES AND TEMPERATURES ON HYMENOXON CONTENT OF BITTERWEED (HYMENOXYS ODORATA).



PREVENTION OF BITTERWEED POISONING

H. L. Kim

Hymenoxon a toxicant isolated from bitterweed has been shown in sheep to possess toxicity essentially identical to that of bitterweed. The toxicity of hymenoxon is reduced when cysteine, a sulfur containing essential amino acid, is administered intravenously either simultaneously or immediately following intraperitoneal administration of hymenoxon. However, this treatment is impractical in field cases since most of the orally administered cysteine is destroyed in the rumen. It has also been found that hymenoxon is converted into several less toxic compounds when exposed to an alkaline solution. Therefore, a practical and field applicable preventive means for bitterweed poisoning might be to; 1) make the rumen fluid alkaline, and/or 2) feed a non-toxic additive which can induce cysteine-like compounds(s) in the rumen and/or in the liver. The former is not practical but the latter seems attractive if there are such additives available. Butylated hydroxyanisole (BHA) and ethoxyquin (EQ) appear to be such additives. They are presently used for the preservation of essential oils and other nutrients in food and feed. Furthermore, oral administration of these antioxidants in the diet has been known to induce hepatic glutathione, an intracellular reducing agent containing cysteine, in mice. These additives have likewise been proven to be protective in mice against hymenoxon. The protective effect of BHA and EQ have been evaluated in sheep; EQ prevented the toxic actions of bitterweed but BHA failed. However, feeding studies using EQ have revealed several adverse effects in laboratory animals especially at high doses. Investigation is continuing to eliminate the undesirable effects of EQ and to identify other effective propylactic agents with field application potential.

THE EFFECT OF DIETARY SUPPLEMENTS ON CHRONIC BITTERWEED (HYMENOXYS ODORATA) POISONING IN SHEEP

Lynn O. Post and E. M. Bailey

Two experiments were designed to establish a chronic bitterweed dose in sheep and to prevent chronic bitterweed poisoning with dietary supplements of high protein (20% crude protein) and sodium sulfate. The toxicity trial consisted of five lambs in each of three groups. One group received no bitterweed, the low dose group received up to 0.5 g/kg/day of bitterweed (10 mg/kg of hymenoxon), and the high dose group received a maximum dose of 1 g/kg/day (20 mg/kg of hymenoxon). The high dose group developed clinical signs of intoxication after an average of 47 days compared to an average of 83 days for the low dose group. The diet was 13% crude protein. After the initial onset of clinical signs in the high dose lambs, a tolerance to bitterweed became apparent. Approximately twice as much bitterweed was required to re-induce signs. The prophylactic trial consisted of five groups of four sheep each. One group received a basal (13% crude protein) diet plus bitterweed; the second group received bitterweed, a basal diet and urea; the third group received bitterweed and the basal diet plus soybean meal; the fourth group received bitterweed, the basal diet, urea and sodium sulfate; and the fifth group received bitterweed, the basal diet, soybean meal, and sodium sulfate. The soybean meal and urea were used to adjust the ration to a 20% crude protein equivalent and each animal received 1.2 g/kg/day of bitterweed. The soybean meal-sodium sulfate combination had its greatest effect on reduction of bitterweed toxicity. Urea appeared to potentiate the toxic effects of bitterweed in this study. The urea group developed signs of bitterweed intoxication after 14 days while the urea-sodium sulfate group developed signs within 27 days. The sheep receiving the soybean meal and soybean meal-sodium sulfate diets developed signs after 57 days. The control group receiving the basal diet plus bitterweed developed signs after 38 days.

PHOMOPSIS SPP. ISOLATED FROM TOBOSA GRASS PRODUCED MYCOTOXIN (RORIDIN A)

Daniel R. Samples, Dennis Hill, Charles Bridges

and Bennie J. Camp

A toxic species of Phomopsis (fungus) was isolated from tobosa grass obtained from a ranch in Runnels County, Texas. The fungus was cultivated to investigate the possible role of the organism in the induction of the hard yellow liver disease in sheep as this disease has affected sheep in Runnels County and adjacent counties. Phomopsis species are known to produce metabolites (mycotoxins) that produce liver damage in sheep. A mycotoxin (Roridin A) was isolated from the fungus, but the mycotoxin did not produce clinical signs of hard yellow liver when the compound was given to animals.

USE OF THE 1080 TOXIC COLLAR TO REDUCE COYOTE PREDATION ON SHEEP AND GOATS

S.L. Beasom, T.L. Blankenship, and J.H. Scrivner

SUMMARY

Data were collected on targeting strategies and collar effectiveness on 9 ranches scattered throughout 3 eco-regions of Texas. Targeting attacks toward small, young stock was most effective but only where most of the animals in that size or age class were collared. During 46,511 collar days, 60 collared animals were killed and/or attacked by predators and 33 collars were punctured. Problems reducing the effectiveness of the toxic collar include targeting "sacrificial" animals, coyotes which kill elsewhere than at the throat, and coyotes which attack at the throat but miss the collar. Despite these and other problems the toxic collar appears to have potential as a supplemental tool to aid producers in reducing predation.

INTRODUCTION

Predation, primarily by coyotes, has been identified as a major problem confronting the sheep and goat industries in North America. During 1978, producers in Texas lost an estimated $13 million due to sheep and goat losses attributable to predators. Predator control efforts by private individuals and Federal and State agencies have long been conducted in an attempt to reduce these losses.

In late 1980 the Texas A&M University System entered into a cooperative research program with the U.S. Fish and Wildlife Service and the Texas Department of Agriculture to test the effectiveness of the 1080 toxic collar at reducing depredation by coyotes on domestic livestock. Another important aspect of the research was to evaluate the impact of this relatively new predator control technique on nontarget wildlife.

EXPERIMENTAL PROCEDURE

Data were collected on targeting strategies and collar effectiveness on 9 ranches scattered throughout the Cross Timbers and Prairies, Edwards Plateau, and Rolling Plains regions of Texas. Eight of the ranches served as extensive study areas where the individual landowners were responsible for the day to day collaring and husbandry activities

for their sheep and/or goats. TDA personnel collected pertinent information from these individuals by biweekly personal interviews. The information subsequently was summarized and evaluated by TAMUS. The other ranch, which was comprised of 9 management units, served as an intensive study area where TAMUS personnel carried out most of the field activities associated with livestock collaring.

RESULTS AND DISCUSSION

Of the 4 general types of targeting strategies used [(1.) collar all individuals of a small flock and place in pasture prior to stocking, (2.) collar the smallest animals in a flock, (3.) collar young animals and their dams and place among uncollared adults, and (4.) collar as many individuals as practical and place among groups of the same sex or age classes] some proved effective and some did not. In general, targeting success depended upon the ratio of collared to uncollared animals in a flock. Where collared animals comprised only a small proportion of a flock, the chances of targeting an attack to a collared animal was remote. Targeting attacks toward small, young stock was relatively effective, but again, only where most of the animals in that size or age class were collared.

From August 1980 through December 1981 animals were collared for a total of 46,511 collar days (lambs - 11,622; Angora nannies - 5,465; Angora kids - 25,248; Angora wethers - 3,032; and Spanish goat kids - 1,144). A total of 60 collared animals was killed or attacked by coyotes or dogs, and 33 toxic collars were punctured, presumably killing that many predators. In addition, 116 uncollared animals were killed or attacked in the target pastures.

In most cases depredations ceased after a collar was punctured, but usually only temporarily. Several problems were encountered in the logistics of collar use which probably added to the problem of temporary effectiveness. Aside from the obvious difficulty associated with targeting "sacrificial" animals, coyotes occasionally killed or damaged sheep or goats by attacking other body areas besides the throat which carried the lethal collar pouches. Furthermore, about 30% of the collared animals killed were killed by throat attack in front of or behind the collar which failed to puncture the pouches.

Despite these problems and others that we encountered in the use of the toxic collar, it curtailed depredations on some occasions and has potential as a supplemental tool to aid producers in reducing overall losses of sheep or goats. Research will be continuing in order to answer questions concerning present techniques of application of the toxic collar to improve its overall effectiveness.

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THE ECONOMIC EFFECTS OF PREDATION ON ANGORA GOAT RANCHES

Jerry H. Scrivner

SUMMARY

This report discusses preliminary results of a study assessing the economic impact of coyote predation on past and present Angora goat ranches in three counties of Texas. Direct costs resulting from predation and the fear of losing goats to predators included: lost revenues associated with animal deaths, costs associated with predator control, and costs associated with management procedures used to reduce predation. Indirect costs included: costs resulting from unusual confinement, costs associated with the inability to effectively utilize available forage resources, and costs associated with brush encroachment and reduced water yields.

INTRODUCTION

The Angora goat industry is an important part of the agricultural economy of Texas. In addition to producing such cash crops as kids and mohair, goats are well adapted to use steep, rugged terrain and ranges with limited livestock water; they also utilize a greater proportion of browse and other plant species less acceptable to cattle (1, 6, 7). Though goat numbers in Texas have varied during the past 60 years, numbers have steadily declined since 1965.

A significant factor contributing to the decline of the Texas goat industry has been predation. Goat and kid losses during 1978 due to predators amounted to 72% of all deaths, as compared to 45% in 1967 (11). The magnitude and economic impact of goat losses to predators has not been thoroughly examined, although some recent assessments have been made (10). In general, most studies on predation costs have calculated only the loss of animals and/or animal products. The purpose of this study was to identify and determine these and other costs of predation to Angora goat producers. These costs generally have been overlooked.

EXPERIMENTAL PROCEDURES

Past (pre-1980) and present (1980) Angora goat producers residing in three Texas counties (Bosque, Coryell, and Hamilton) were personally contacted and interviewed. Questions were designed to assess direct

and indirect costs associated with predation on Angora goats. Direct costs are expenses immediately attributable to predators. Indirect costs are more general. They represent costs of management techniques used to decrease predation and loss of income resulting from the inability to manage livestock in an optimum fashion because of expected or real predation.

RESULTS AND DISCUSSION

The data are presently being analyzed and therefore all results are preliminary and discussed only in general terms. A total of 207 past and present Angora goat ranchers were surveyed. This represents most of the present producers in the three counties and an unknown proportion of past producers.

Both past and present producers indicated predation on goats was the greatest problem they faced. Past producers, however, generally had greater losses than did present producers. Kid goats were more often killed than adults. As a result, many present producers manage only wether goats, though these ranchers often felt nanny-kid operations were more profitable.

Ranchers also incur substantial costs resulting from efforts made to reduce predator numbers. They often spend personal time and money on fuel and equipment (i.e. traps, snares, M-44's) for predator control. In addition, ranchers also may have regular expenses sustaining a full or part-time government and/or private trapper.

Ranchers also have costs associated with management procedures used to protect goats from predators. This includes such techniques as shed-kidding, penning goats at night, moving goats from problem areas to safer pasture, and the use of guard dogs and scare devices. Costs associated with these and other husbandry techniques include: fuel, feed, labor, and supplies such as fencing materials and lights. Generally present producers were using more of these techniques to protect goats from predators than did past producers, thus increasing relative costs of production for these factors.

Generally, it was difficult to gather specific information by means of the survey regarding most indirect costs. Discussion of these costs is based primarily on a synthesis from pertinent literature.

Wade and Connolly (10) reported that on one Texas goat ranch it was necessary to crowd 800 goats onto a 24 acre Sudan-grass field. Such "unusual confinement" resulted in large losses from internal parasites and tetanus, additional veterinarian and drug costs, forced sale of goats at a loss, and reduced mohair production from surviving goats. Thus, when ranchers are forced into this management strategy it can be very costly.

The inability to effectively utilize available forage resources may be the single greatest cost due to predation. Most past producers indicated they would like to have goats if predation or the fear of losing goats to predators were not so great. This is particularly true since goat and mohair prices are more favorable now than when many ranchers went out of business. Many past producers indicated that even if goat and mohair prices were not favorable they would like to have goats to help reduce brush encroachment. Often past producers said their pastures were in the best condition when they had goats.

Brush encroachment is a major problem on Texas grasslands. A 1963 survey of the brush problem by the Soil Conservation Service (9) showed that 50% of all Texas rangelands are so densely covered with brush and the grass so suppressed that little improvement can be accomplished without reduction of the brush competition. In addition, about 10 million acre-feet of water could be saved annually by controlling a major portion of the undesireable brush in Texas (8). Johnston (4) estimated that non-economic plants use 10.1 inches of the average annual precipitation of 27.1 inches.

Goats can be used effectively to control low-growing brush or as a follow-up maintenance control of sprouts on brush that has been treated for initial control (2, 3, 5). The use of goats may not only save money otherwise spent on mechanical and chemical brush control methods, but also may be a significant source of income to the landowner and/or livestock operator.

LITERATURE CITED

1. Bowns, J.E. 1980. Testimony at public hearing on Animal Damage Control Act of 1980. Subcommittee on Dep. Investigations, Oversight and Research of the Committee in Agriculture. Wash., D.C. April 17. Serial No. 96-BBB.

2. du Toit, P.F. 1979. Brush encroachment: a curse or a blessing? Boerbok Nuus. 1:7-9.

3. Green, L.R., C.L. Hughes, and W.L. Graves. 1979. Goat control of brush regrowth on southern California fuelbreaks. Rangelands 1:117-119.

4. Johnston, J.R. 1957. The significance of a water budget for Texas. Proceedings 3rd Ann. Water for Texas Conf., Texas A&M Univ., College Station. pp. 7-10.

5. Magee, A.C. 1957. Goats pay for clearing Grand Prairie rangelands. Texas Agric. Exp. Sta. 8 pp.

6. Martin, J.A., and D.L. Huss. 1981. Goats much maligned but necessary. Rangelands 3:199-201.

7. Merrill, L.B., and C.A. Taylor. 1976. Take note of the versatile goat. Rangelands 3:74-76.

8. Rechenthin, C.A., and H.N. Smith. 1967. Grasslands restoration: effect on water yield and supply. U.S. Dep. Agric. Soil Conserv. Serv., Texas. 46 pp.

9. Smith, H.N., and C.A. Rechenthin. 1964. Grassland restoration: the Texas brush problem. U.S. Dep. Agric. Soil Conserv. Serv., Texas. 17 pp.

10. Wade, D.A., and G.E. Connolly. 1980. Coyote predation on a Texas goat ranch. Texas Agric. Prog. 26:12-16.

11. Walther, W.H., P.M. Williamson, M.D. Humphrey, and E.L. Johnson. 1979. Texas sheep and goat losses and marketing practices. Texas Crop and Livestock Reporting Serv., Texas Dep. Agric. 12 pp.

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EFFECTS OF SUPPLEMENTAL FEEDING DURING FALL AND WINTER ON WEIGHT CHANGES AND BLOOD GLUCOSE IN EWES ON RANGELAND

J.E. Huston and B.S. Engdahl

SUMMARY

Selected finewool ewes, either dry or pregnant, were observed between November 23 and April 1 to determine the effects of supplemental energy on weight and blood glucose concentration. Treatments included an unfed group (Control) and three fed groups given equal supplemental protein and increasing supplemental energy (Low, Medium and High) between November 23 and April 1. Weight changes in dry ewes showed a patterned response to supplemental feed. Weight changes in ewes rearing lambs were similar across feeding treatments. Glucose levels dipped during midwinter in all groups, but increasing supplemental energy tended to maintain higher blood glucose. Ewes which lost lambs had lower midwinter glucose concentrations than either dry ewes or ewes rearing lambs. The data suggests a possible role of supplemental feeding in maintaining a higher blood glucose concentration during late pregnancy thereby reducing the risk of pregnancy toxemia in ewes and perinatal death of lambs.

INTRODUCTION

Supplemental feeding has not consistently increased lamb production under experimental conditions. Yet, reports from sheep producers indicate the importance of feeding during the winter period. Studies on the nutritional value of range forage (2) show that range forage dips to a low point in late fall and winter, a period corresponding to late pregnancy in fall bred ewes. The dependency of the fetus, especially twin fetuses, on circulating glucose for an energy supply can impose a glucose shortage on the ewe resulting in pregnancy toxemia and death. A study was conducted to determine the effects of supplemental feed on blood glucose during late pregnancy in fall bred ewes on rangeland.

EXPERIMENTAL PROCEDURE

Fall bred finewool ewes were assigned to four treatment groups during the fall. Treatments were: no feed (Control) and three levels of supplemental feed (Table 1). Feeding began on November 23

and continued through April 1. Ewes were grazing in a common pasture, penned three times each week and individually fed one-third of their weekly allowance. Otherwise, the ewes were treated identically. Weights were taken at the beginning of the study, prelambing and at discontinuation of feeding. Blood was taken for glucose analysis at the beginning and end of the feeding period and at midwinter (January 18) during heavy pregnancy.

RESULTS AND DISCUSSION

Weight change in the dry ewes follows an expected pattern if ewes are consuming an energy deficient diet of range forage (Table 2). Control ewes lost weight throughout the study and fed ewes showed a stepwise response to increasing supplemental feed. Pregnant ewes gained considerable weight prelambing (approximately equal to weights of conceptus and maternal tissues). Weight losses at birth and following were similar across feed treatments. Ewes that lost lambs at birth had smaller weight losses between prelambing and termination of the study compared with ewes rearing lambs. This indicates either a recovery of weight loss in the ewes losing lambs or a continuation of weight loss in ewes rearing lambs. The similarity in weight change across treatments in ewes rearing lambs indicates that increasing levels of supplemental feed were displacing forage consumption in the diet and is consistent with previously reported results (1).

Blood glucose levels showed a midwinter dip across all treatments but a strong indication of supplemental feed effect (Table 3). Fall and spring values were rather uniform across feed treatments and for both dry ewes and ewes rearing lambs. Midwinter values showed a stepwise increase with increasing supplemental feed. There were no detected cases of pregnancy toxemia but the data suggests that supplemental feeding reduced the risk of the disease. Three ewes in the unfed group and two ewes in the low feed group lost lambs. Causes of death losses were not determined. Blood glucose levels in these ewes were lower than in other individuals of the treatment group.

Results of this study suggest the possible importance of supplemental feed in maintaining sufficiently high blood glucose to prevent pregnancy toxemia. Associated data from this study, which included forage intake and blood ketones, are being completed.

LITERATURE CITED

1. Huston, J.E. and B.S. Rector. 1978. Effect of supplemental feed on voluntary forage consumption by pregnant and lactating ewes. Tex. Agr. Exp. Sta. PR-3501.

2. Huston, J.E., B.S. Rector, L.B. Merrill and B.S. Engdahl. 1981. Nutritional value of range plants in the Edwards Plateau region of Texas. Tex. Agr. Exp. Sta. Bull. 1357.

TABLE 1. SUPPLEMENTAL FEED AND NUTRIENTS SUPPLIED DURING WINTER TO EWES ON RANGELAND

	Experimental Feeding Treatment			
	Control	Low	Medium	High
Ration ingredients, %				
Cottonseed meal	-	100	32	0
Sorghum grain	-	0	68	100
TOTAL	-	100	100	100
Feeding level, g/day	0	125	250	500
Nutrients supplied/day	0			
Crude protein, g	0	50	50	50
Digestible energy, Kcal	0	350	825	1750

TABLE 2. EFFECTS OF SUPPLEMENTAL FEED ON WEIGHT CHANGES IN FINEWOOL EWES

	Treatment Group			
	Control	Low Feed	Medium Feed	High Feed
Dry ewes				
Number of ewes	6	6	6	6
Weight changes, lb				
Fall to prelambing	- 3	4	4	11
Prelambing to spring	- 8	- 4	- 2	0
	-11	0	2	11
Ewes rearing lambs				
Number of ewes	5	2	8	4
Weight changes, lb				
Fall to prelambing	12	19	18	20
Prelambing to spring	-23	-23	-24	-26
	-11	- 4	- 6	- 6
Ewes losing lambs				
Number of ewes	3	2	0	0[a]
Weight changes, lb				
Fall to prelambing	9	22	-	-
Prelambing to spring	-11	-15	-	-
	- 2	7	-	-

[a]One ewe from the high feed group lost twin lambs and died at birth. Data were incomplete, thus, were not reported.

TABLE 3. EFFECTS OF SUPPLEMENTAL FEED ON BLOOD GLUCOSE CONCENTRATION IN FINEWOOL EWES

	Treatment Group			
	Control	Low Feed	Medium Feed	High Feed
Dry ewes				
Number of ewes	6	6	6	6
Blood glucose, mg/dl				
Fall 11/23	40.6	41.5	42.3	42.5
Midwinter 1/18	35.9	37.6	38.4	38.6
Spring 4/1	45.9	43.8	48.4	45.3
Ewes rearing lambs				
Number of ewes	5	2	8	4
Blood glucose, mg/dl				
Fall	42.1	41.8	42.2	42.9
Midwinter	35.6	37.8	39.1	39.5
Spring	48.7	51.2	47.8	47.6
Ewes losing lambs				
Number of ewes	3	2	0	0[a]
Blood glucose, mg/dl				
Fall	40.6	40.3	-	-
Midwinter	31.1	36.2	-	-
Spring	43.5	45.2	-	-

[a]One ewe from the high feed group lost twin lambs and died at birth. Data were incomplete, thus, were not reported.

EFFECTS OF SUPPLEMENTAL ENERGY AND PERIOD OF SUPPLEMENTATION ON WEIGHT CHANGE AND LAMB PRODUCTION IN FINEWOOL EWES

J.E. Huston

SUMMARY

A study to determine the effects of supplemental energy and time of supplementation on weight change and lamb production in finewool ewes indicated that supplemental feeding did not increase productivity. Ewes which were not fed during winter appeared to make compensatory gain during spring and summer and, by the subsequent breeding season, were actually heavier than fed ewes. Among the fed groups, ewe weight changes reflected period of feeding, but period of feeding had no detectable effects on lamb production. Lamb production increased with level of supplemental energy, but only those fed the high level of energy exceeded the unfed control group in lamb production. Weight changes and lamb production in dry ewes, ewes nursing single lambs and ewes nursing twins were compared. Weight change was in the order of dry ewes > ewes nursing single lambs > ewes nursing twins. Ewes nursing twins weaned 45% more weight of lamb than ewes nursing single lambs. These data are evidence that finewool ewes will not necessarily respond to supplemental feed with increased productivity.

INTRODUCTION

The nutritional value of range forage in Texas dips to its lowest average level during late fall and winter (2). This period corresponds with late pregnancy and early lactation in fall bred ewes. However, supplemental feeding during winter has not shown consistent benefit in improving productivity, presumably because under some conditions supplemental feed displaces forage in the diet and does not necessarily improve total nutrition (1). A study was conducted to determine the effects of time of supplementation and level of supplemental energy on ewe weight changes and level of lamb production.

EXPERIMENTAL PROCEDURE

Adult Rambouillet ewes were bred during September-October and were assigned to ten treatment groups (Table 1). Supplemental feeds were formulated to provide equal protein but increasing levels of energy (Table 2). The ewes were gathered and fed individually one-third of the weekly allowance three times per week. Weights were

recorded during late fall (12/12), prelambing (2/13), at the end of winter feeding period (3/26), and at the beginning and end of the subsequent breeding season (9/1 and 11/17, respectively). Weaning weights of lambs were recorded on June 3.

RESULTS AND DISCUSSION

Supplemental feeding resulted in slightly less weight loss during the treatment periods (Table 3), but subsequent gain by the control ewes exceeded those of the fed ewes. The control ewes were slightly heavier than all fed groups by the end of the subsequent breeding season. Although there was an apparent linear response in lamb production to supplemental energy, only the high-fed group averaged more weaned lamb than the control group. As has been suggested in earlier reports, supplemental feeding tends to decrease forage consumption and under some conditions, may decrease the net nutrition consumed in the diet of the animal. Whether this is a result of altered animal behavior (decreased grazing time while awaiting supplementation) or some metabolic change which alters the nutritional value of consumed feeds is not known.

Period of supplementation affected pattern of weight change, but had minimal effect on total weight change or lamb production (Table 4). Ewes which were fed early gained more weight during period 1 but lost more during periods 2 and 3. Again, the control group showed a strong tendency to make compensatory gains during periods 3 and 4.

Weight change and lamb production were compared for dry ewes, ewes nursing single lambs and ewes nursing twins as an indication of an association between weight and productivity (Table 5). Weight changes in dry ewes reflect forage quality and body demands. The slight weight loss during late fall and early winter corresponded to the low point in forage quality. The early growth of cool season annual grasses and forbs promoted rapid gains during period 2. Period 3 included both spring and summer and included the shearing date. Thus, weight gain approximated the wool clip (approximately 8 pounds). Period 4, again, promoted a good gain. Ewes nursing single and twin lambs gained 3 and 7.1 pounds, respectively, during period 1. These gains are less than the weights of reproductive tissues (fetus, fluid, membranes) thus represent net losses in ewe weights. Likewise, since losses during period 2 included losses at birth, they do not represent net losses in ewe weights and perhaps indicate a slight gain (especially in ewes with single lambs). However, the burden of milk production does not allow weight gains to parallel that of dry ewes. In subsequent periods, gains are in reverse order of previous losses.

These data fail to clarify the importance of ewe weight fluctuation and supplemental feeding on productivity. But the data add evidence that supplemental feed will not necessarily improve winter nutrition in ewes. Research efforts to identify the critical periods

in ewe nutrition and means to alleviate nutritional stress are continuing.

LITERATURE CITED

1. Huston, J.E. and B.S. Rector. 1978. Effect of supplemental feed on voluntary forage consumption by pregnant and lactating ewes. Tex. Agr. Exp. Sta. PR-3501.

2. Huston, J.E., B.S. Rector, L.B. Merrill and B.S. Engdahl. 1981. Nutritional value of range plants in the Edwards Plateau region of Texas. Tex. Agr. Exp. Sta. Bull. 1357.

TABLE 1. GROUP ASSIGNMENTS FOR WINTER FEEDING EXPERIMENT WITH FINEWOOL EWES

Group Number	Group Code[a]	Feeding Level	Feeding Period		
			1/5 - 2/1	2/2 - 3/1	3/2 - 3/29
1	C---	0	-	-	-
2	L++-	Low	+	+	-
3	L-++	Low	-	+	+
4	L+++	Low	+	+	+
5	M++-	Medium	+	+	-
6	M-++	Medium	-	+	+
7	M+++	Medium	+	+	+
8	H++-	High	+	+	-
9	H-++	High	-	+	+
10	H+++	High	+	+	+

[a] Symbols denote fed, "+", and unfed "-", during the respective periods.

TABLE 2. SUPPLEMENTAL FEED AND NUTRIENTS SUPPLIED DURING WINTER TO FINEWOOL EWES

Item	Supplemental Feeding Treatment			
	Control	Low	Medium	High
Feed ingredients, %				
Sorghum grain	-	31	78	96
Cottonseed meal	-	69	22	4
TOTAL	-	100	100	100
Feeding levels, g/day	0	242	444	650
Nutrients supplied/day				
Crude protein, g	0	80	80	80
Digestible energy, Kcal	0	750	1500	2250

TABLE 3. EFFECTS OF LEVEL OF FEEDING DURING WINTER ON WEIGHT CHANGE AND LAMB PRODUCTION IN FINEWOOL EWES

Item	Supplemental Feed Treatments			
	Control	Low	Medium	High
Number of ewes	8	18	15	16
Weight changes (lb)				
Period 1 (12/12-2/13)	4.1	4.9	5.0	6.2
Period 2 (2/13-3/26)	-13.5	- 9.8	-11.3	-10.9
Period 3 (3/26-9/1)	5.2	- 1.4	- 5.2	- 2.4
Period 4 (9/1-11/17)	12.6	9.8	12.2	7.6
TOTAL	8.4	3.5	0.7	0.5
Weight of weaned lamb/ewe (lb)	91.8	73.2	82.8	95.0

TABLE 4. EFFECTS OF LENGTH AND TIMING OF FEEDING PERIOD ON WEIGHT CHANGE AND LAMB PRODUCTION IN FINEWOOL EWES

Item	Supplemental Feeding Periods			
	---	++-	-++	+++
Number of ewes	8	19	12	18
Weight changes (lb)				
Period 1 (12/12-2/13)	4.1	10.1	- 1.4	9.0
Period 2 (2/13-3/26)	-13.5	-13.6	- 8.6	-10.4
Period 3 (3/26-9/1)	5.2	- 4.9	0.6	- 5.4
Period 4 (9/1-11/17)	12.6	10.0	9.2	10.3
TOTAL	8.4	1.6	- 0.2	3.5
Weight of weaned lamb/ewe (lb)	91.8	88.6	80.2	81.8

TABLE 5. EFFECTS OF LEVEL OF REPRODUCTION ON WEIGHT CHANGE AND LAMB PRODUCTION IN FINEWOOL EWES

Item	Reproductive Level		
	Dry Ewes	Ewes Weaning Single Lambs	Ewes Weaning Twin Lambs
Number of ewes	7	38	19
Weight changes (lb)			
Period 1 (12/12-2/13)	- 2.8	3.0	7.1
Period 2 (2/13-3/26)	12.6	- 4.0	-19.0
Period 3 (3/26-9/1)	- 0.3	- 2.2	- 0.4
Period 4 (9/1-11/17)	5.4	8.3	12.7
TOTAL	14.9	5.1	0.4
Weight of weaned lamb/ewe (lb)	-	69.9	101.6

A RE-EVALUATION OF THE MINIMUM VITAMIN A REQUIREMENT OF GROWING-FINISHING LAMBS

B. J. May, M. C. Calhoun, and G. R. Engdah

SUMMARY

The minimum vitamin A requirement of growing-finishing lambs appears to be between 8 and 16 µg of vitamin A (alcohol equivalent)/kg live weight/day. Evidence which supports this is the lack of liver storage of vitamin A and increased cerebrospinal fluid pressures observed in sheep getting 8 µg vitamin A/kg live weight per day; whereas, sheep on the 16 µg level of vitamin A intake had increased levels of vitamin A in their livers and "normal" cerebrospinal fluid pressures. On the basis of these results, it appears that the value (5.1 µg) used by the National Research Council to establish their current recommendations for the vitamin A requirements of sheep is too low.

INTRODUCTION

The earliest reported experiments conducted to determine vitamin A requirements for livestock were done by Guilbert et al. (2). In their experiments cattle, sheep and swine were fed varying levels of vitamin A and carotene. Incidence of night blindness and liver stores of vitamin A were the criteria used for determining vitamin A requirements. Results showed minimum carotene requirements for all species studied to be 25 to 30 micrograms (µg) daily per kilogram body weight. Minimum vitamin A requirements for these species ranged from 6 to 8 µg per kilogram body weight per day.

The NRC (4) revised edition for sheep used results from Guilbert et al. (3) as the basis for calculating the minimum vitamin A and carotene requirements. These amounts (5.1 µg of vitamin A alcohol per kilogram of body weight for vitamin A and 25 µg per kilogram of body weight for carotene) were the minimum levels found to prevent night blindness. These minimums were then multiplied by appropriate factors to give the carotene and vitamin A requirements for growth, pregnancy and lactation. More recent studies have demonstrated that elevated

cerebrospinal fluid (CSF) pressure is the earliest physiological change specific for vitamin A deficiency (1). Night blindness is much less sensitive to vitamin A status. For example, to prevent night blindness, the minimum vitamin A requirements for calves are 24 to 35 µg of carotene and 5.1 to 6.4 µg of vitamin A per kilogram of live weight per day; whereas, for prevention of elevated CSF pressure, the values are 66.1 to 72.8 µg for carotene and 14.1 µg for vitamin A.

Because of the differences in estimates of minimum vitamin A requirements depending on whether night blindness or CSF pressure was used as a response criteria, a re-evaluation of the vitamin A requirements of sheep was believed to be desirable. The purpose of this research was to use changes in CSF pressure to determine the minimum vitamin A requirements of growing-finishing lambs.

EXPERIMENTAL PROCEDURE

Twenty-four white-faced lambs were obtained and placed in a single large pen and fed a vitamin A depletion diet (Table 1). This diet was fed ad libitum until blood plasma vitamin A levels decreased to less than or equal to 12 µg per 100 ml. After plasma vitamin A levels reached this point, each lamb was assigned at random to one of six dietary vitamin A levels. The six levels were 2, 4, 8, 16, 32 and 64 µg of vitamin A (alcohol equivalent) per kilogram of live weight per day.

The daily vitamin A allowance was fed mixed with 100 g of a vitamin A depletion finishing ration (Table 1). This was fed first each morning. The remainder of the finishing ration was fed after the supplement was eaten. Feeding level was set to allow an estimated gain of .181 kg per day.

Lamb live weights were obtained weekly. Blood samples (30 ml citrated) were collected bi-weekly during the depletion period and monthly during vitamin A supplementation and used for determination of plasma carotenoids and vitamin A levels. Cisternal cerebrospinal fluid pressures were measured at the end of the 12th and 16th weeks of supplementation. Xylazine[3/] was used to sedate the sheep for cerebrospinal fluid pressure measurements which were taken with the animal in lateral recumbency. Upon completion of the 16 week supplementative period, lambs were slaughtered and livers removed and stored frozen until carotene and vitamin A concentrations were determined.

3/ .83 mg of xylazine per kg of live weight was used for sedation prior to CSFP measurement (Haver-Lockert, Bayvet Division, Cutter Laboratories Inc. Rompun ®).

RESULTS AND DISCUSSION

The lambs used in this study were obtained on May 13, 1981 and started immediately on the vitamin A depletion diet. The depletion period lasted 19 wk. Initial live weights were 14.9 ± .5 kg and gains during the depletion period were .145 ± .009 kg/day. The first blood samples, for vitamin A analysis, were collected on June 16. On that date, concentrations of plasma carotenoids and vitamin A (alcohol) respectively, were 8.4 ± .82 and 32.4 ± 2.7 µg/100 ml. There was a linear decrease in plasma vitamin A with time during the depletion period. The equation describing this relationship was $Y = 32.1-.309X$ ($r^2 = .81$, $P<.01$), where X = days on the depletion ration and Y = micrograms of vitamin A alcohol per 100 ml of plasma. Plasma vitamin A concentrations at the end of the depletion period averaged 6.1 ± .52 µg/100 ml.

A summary of the performance data and plasma vitamin A values during the 16 wk vitamin A supplementation period are presented in Table 2. Four lambs were lost during the supplementation period, one each from the 8 and 64 µg treatment levels and two from the 32 µg level. None of the deaths were attributable to the vitamin A treatments imposed in this study. Lambs receiving the 2 µg level of vitamin A had the lowest gains and feed intakes of any treatment and consequently the poorest efficiency; however, because of the large variations that existed between lambs on the same treatments, these differences were not significant. There was a curvilinear relationship between final plasma vitamin A concentrations and vitamin A intake. The relationship is described by the equation $Y = 1.53 + 2.08X - .015X^2$ ($r^2 = .97$, $P<.01$) where X = µg vitamin A alcohol/kg live weight/day and Y = µg vitamin A alcohol/100 ml plasma.

Total liver vitamin A levels in µg vitamin A alcohol/liver remained constant through vitamin A intakes of 2, 4 and 8 µg/kg live weight/day and increased at vitamin A intakes of 16 µg and above. Based simply on storage of vitamin A in the liver, the requirement for vitamin A would appear to be between 8 and 16 µg/kg live weight/day.

Xylazine proved to be a satisfactory sedative for measuring CSF pressures in most sheep. An occasional sheep exhibited irregular and labored respiration which made it impossible to obtain a stable CSF pressure measurement. Also one lamb died when intravenous administration was used. The procedure that worked best was intramuscular injection of .83 mg xylazine/kg live weight about 15 min. prior to CSF pressure measurements, followed by a supplementary dose of 1/3 to 1/2 this amount when the desired degree of sedation was not achieved. Using this procedure, lambs laid quietly on their sides and CSF pressures were stable.

Cerebrospinal fluid pressures were elevated at vitamin A intakes of 2, 4 and 8 µg/kg live weight/day indicating that these levels were not adequate to meet the lambs vitamin A requirements (Table 2). At vitamin A intakes of 16 µg and above, CSF pressures were fairly constant, averaging 168 ± 4 mm of saline. This value is assumed to represent the

"normal" CSF pressure of lambs weighing about 31 kg when measured with the animals in lateral recumbency.

Although the data obtained in this study are not adequate to closely define the minimum vitamin A requirements of growing-finishing lambs, it is apparent the actual requirement is greater than 8 and less than 16 µg of vitamin A (alcohol equivalent)/kg live weight/day. Evidence which indicates the 8 µg vitamin A intake level is not adequate is the lack of liver storage of vitamin A and increased CSF pressures observed in sheep getting this level; whereas, CSF pressures in the normal range indicates the 16 µg level of vitamin A intake is adequate.

It is not unreasonable to assume that a vitamin A intake of 12 µg/kg live weight/day would closely approximate the minimum vitamin A requirements of growing-finishing lambs. This level is considerably greater than the value of 5.1 µg used by the National Research Council to establish their current recommendations for the vitamin A requirements of sheep. However, it is similar to the value of 14.1 µg reported to be the minimum vitamin A intake required to prevent elevated CSF pressures in growing calves.

LITERATURE CITED

1. Eaton, H.D. 1969. Chronic bovine hypo- and hypervitaminosis A and cerebrospinal fluid pressure. Am. J. Clin. Nutr. 22:1070.

2. Guilbert, H.R., R.F. Miller and E.H. Hughes. 1937. The minimum vitamin A and carotene requirement of cattle, sheep and swine. J. Nutr. 13:543.

3. Guilbert, H.R., C.E. Howell and G.H. Hart. 1940. Minimum vitamin A and carotene requirements of mammalian species. J. Nutr. 19:91.

4. National Research Council. 1975. Nutrient Requirements of Domestic Animal No. 5. Nutrient Requirements of Sheep. 5th revised edition. National Academy of Sciences. Wash., D.C.

ACKNOWLEDGEMENT

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TABLE 1. INGREDIENT COMPOSITION AND CHEMICAL ANALYSES OF DIETS USED DURING THE VITAMIN A DEPLETION AND SUPPLEMENTATION PERIODS

Ingredient	Depletion diet	Supplementation diet
	%	%
Oats	20.00	20.00
Barley	44.85	45.00
Cottonseed meal	12.50	7.50
Cottonseed hulls	15.00	20.00
Molasses	5.00	5.00
Calcium carbonate	1.65	1.50
Salt, mineral[a/]	1.00	1.00
Chemical analyses[b/]		
Crude protein, %	17.2	12.9
Acid detergent fiber, %	19.4	21.9
Calcium, %	1.00	.77
Phosphorus, %	.41	.22
Potassium, %	.85	.77
Sulfur, %	.29	.24
Copper, mg/kg	6.0	5.0
Manganese, mg/kg	29.9	28.8
Zinc, mg/kg	37.7	34.3

a/ Zinc sulfate was added at a level to provide 10 mg Zn/kg feed in the complete diet.

b/ 100% dry matter basis.

TABLE 2. FEEDLOT PERFORMANCE, PLASMA AND LIVER VITAMIN A LEVELS AND CEREBROSPINAL FLUID PRESSURES OF LAMBS FED FIXED INTAKES OF VITAMIN A

Criteria	Vitamin A Treatments µg Vitamin A Alcohol/kg Live Weight/Day					
	2	4	8	16	32	64
Lambs starting exp., No.	4	4	4	4	4	4
Lambs lost, no.	0	0	1	0	2	1
Initial live weight, kg	31.2	34.6	32.2	31.0	30.8	31.1
Live weight gain, kg/day	.070	.142	.140	.097	.138	.121
Feed intake, kg/day	.98	1.37	1.29	1.15	1.22	1.28
Feed/gain, kg/kg	14.0	9.6	9.2	11.8	8.8	10.6
Plasma vitamin A, µg/100 ml						
Initial	5.7	6.2	4.8	6.5	5.9	6.9
Final	5.3	13.4	14.7	23.4	57.6	70.5
Average	5.5	9.8	9.8	14.9	32.0	38.7
Total liver vitamin A, mg	.22	.25	.25	1.33	2.45	11.06
Cerebrospinal fluid pressure, mm saline	297	209	207	150	188	155[a/]

[a/] Only one observation was obtained at this level.

EFFECT OF LENGTH OF WINTER FEEDING PERIOD ON BLOOD GLUCOSE CONCENTRATION IN ANGORA FEMALES

J.E. Huston and B.S. Engdahl

SUMMARY

Angora females were either unfed or fed from November 16, January 5 or February 1 until April 1 to determine effect of length of feeding period on reproduction. Glucose concentration was determined in individuals in each group during fall, midwinter and prekidding. Feeding had positive effects on weight change in both nonpregnant and pregnant does. Glucose concentration was increased by feeding in nonpregnant does but not in pregnant does. Implication of these results will be determined following completion of data on forage intake and blood ketones.

INTRODUCTION

The low reproductive rate in Angora goats has been attributed at least in part to nutritional stress during pregnancy causing a fall in blood glucose leading to abortion (2). Results of a recent study indicated that feeding during late gestation was more important than during either breeding or early pregnancy (1). A study was conducted to determine effects of length of the feeding period on forage intake, blood glucose, blood ketones and reproductive rate. The completed data on blood glucose are reported.

EXPERIMENTAL PROCEDURE

Angora females were bred during the fall of 1981 and assigned to treatment groups for late fall and winter supplementation according to treatment plan (Table 1). Feeding was by period, i.e., early gestation, mid-gestation, and late gestation-early lactation. Group 1 (---) was not fed, group 2 (--+) fed during final period only, group 3 (-++) fed during the last two periods and group 4 (+++) fed during the entire study. The does were grazed in a common pasture, penned three times per week, and individually fed 700 g (equivalent to 300 g per day) of the experimental ration (454 grams equals one pound). Blood samples were drawn once during each of the three periods for glucose analysis. Weights were recorded at the beginning of the study (11/16), midwinter (1/22) and after termination (4/8).

RESULTS AND DISCUSSION

Body weight changes reflected the length of the feeding periods in both nonpregnant and pregnant goats (Table 2). Whereas the pregnant goats gained more weight prior to kidding (Period 1), they lost considerable weight during Period 2, which included loss of weight at kidding.

Glucose concentrations were inconsistent but tended to increase with feeding in nonpregnant does but not in pregnant does (Tables 3 and 4). Implications of these data are unclear. Since there were no observed abortions during this study, it is possible that conditions were not sufficiently severe to show a response to feeding. Glucose tended to be lower in pregnant does but never dropped to a critical level (below 40 mg/dl). Results of the forage intake and blood ketone analyses will contribute to further interpretation of these results.

LITERATURE CITED

1. Huston, J.E. 1981. Effect of supplemental feeding on reproductive rate in yearling Angora females. Tex. Agr. Exp. Sta. PR-3895.

2. Wentzel, D., Marita M. LeRoux and L.J.J. Botha. 1976. Effect of level of nutrition on blood glucose concentration and reproductive performance of pregnant Angora goats. Agroanimalia. 8:59-62.

TABLE 1. EXPERIMENTAL RATION AND FEEDING SCHEME IN SUPPLEMENTAL FEEDING STUDY IN ANGORA FEMALES

Experimental ration:				
Ingredients		%		
Cottonseed meal		41		
Sorghum grain		57		
Molasses		2		
		100		
Treatment assignments:				
Group number	1	2	3	4
Treatment codes	---	--+	-++	+++
Feeding period	0	Feb.-Apr. 1	Jan.-Apr. 1	Nov.16-Apr. 1
Feeding level:				
Three times weekly		700 g (1.54 lb)		
Daily equivalent		300 g (.66 lb)		

TABLE 2. BODY WEIGHT CHANGES IN ANGORA FEMALES DURING A FALL-WINTER SUPPLEMENTAL FEEDING STUDY

Item	Supplemental Feed Treatment			
	---	--+	-++	+++
Nonpregnant does				
Number of does	3	2	6	4
Weight change, lb				
Period 1	-1.0	- .5	3.4	3.2
Period 2	- .3	1.6	3.3	5.8
TOTAL	-1.3	1.1	6.7	9.0
Pregnant does				
Number of does	8	6	7	8
Weight change, lb				
Period 1	5.9	4.7	8.0	12.8
Period 2	-10.8	-6.2	-7.1	- 8.2
TOTAL	- 4.9	-1.5	0.9	4.6

TABLE 3. GLUCOSE CONCENTRATIONS IN ANGORA FEMALE IN A FALL-WINTER SUPPLEMENTAL FEEDING STUDY

Item	Supplemental Feed Treatment				Average of Treatments
	---	--+	-++	+++	
Nonpregnant does					
Number of does	3	2	6	4	
Blood glucose, mg/dl[a]					
Fall	44.3	50.1	48.6	50.2	48.3
Midwinter	45.6	55.0	50.5	50.8	50.5
Prekidding	41.9	45.9	49.4	55.8	48.2
Average	43.9	50.3	49.5	52.3	49.0
Pregnant does					
Number of does	8	6	7	8	
Blood glucose, mg/dl[a]					
Fall	46.8	47.5	45.7	45.3	46.3
Midwinter	45.8	44.3	50.3	47.2	46.9
Prekidding	44.8	42.9	43.7	44.0	43.8
Average	45.8	44.9	46.6	45.5	45.7

[a]Blood glucose concentration expressed as milligrams per decaliter (100 milliliters).

TABLE 4. EFFECT OF FEEDING ON GLUCOSE CONCENTRATION IN ANGORA FEMALES IRRESPECTIVE OF TREATMENT DURING OTHER PERIODS

Item	Reproductive Stage			
	Nonpregnant		Pregnant	
Period treatment	-	+	-	+
Fall period				
Number of does	11	4	21	8
Blood glucose, mg/dl[a]	47.7	50.2	46.6	45.3
Midwinter period				
Number of does	5	10	14	15
Blood glucose, mg/dl[a]	49.4	50.6	45.2	48.6
Prekidding period				
Number of does	3	12	8	21
Blood glucose, mg/dl[a]	41.9	51.0	44.8	43.6

[a]Blood glucose concentrations expressed as milligrams per decaliter (100 milliliters).

STUDIES ON ANGORA GOAT AND MOHAIR PRODUCTION ON VASEY SHIN OAK

Maurice Shelton, Phil Thompson, Ron Lewis and D. N. Ueckert

SUMMARY

Annual net income from mohair production on untreated rangeland dominated by Vasey shin oak on the Edwards Plateau averaged $41/acre over a 3-year period. Mechanical shredding of shin oak to a 1-m height did not increase mohair production nor did supplementation with various sources of sulfate or protein.

INTRODUCTION

Vasey shin oak (Quercus pungens var. Vaseyana), a relatively low growing, deciduous shrub or small tree, occurs on dry limestone hills in the Edwards Plateau. A substantial amount of work has been done on methods of control or removal of shin oak (4). However, Vasey shin oak is readily browsed by goats and to some degree by cattle. In the bud stage it is toxic to livestock due to the tannic acid content (1). Losses of goats browsing on oaks have occasionally been observed. Not only is the tannic acid a potential toxic principle, the presence of tannins may lower the digestibility of forage and can contribute to protein and sulfur deficiencies (2,3).

A series of studies were initiated in 1979 on the H. D. Winters Ranch near Brady, Texas to quantify production of mohair from shin oak rangeland and to investigate potential management alternatives which might increase the mohair production from this resource.

MATERIALS AND METHODS

A series of 5-acre plots was fenced in an 800-acre pasture dominated by shin oak. During the growing seasons of 1979, 1980, and 1981, four of these plots were stocked with Angora muttons or billies.

In each year one of the 5-acre plots served as a control in which the goats received only salt. A second plot was shredded to a 1-m height on July 31, 1979. The animals in the shredded plot were treated the same as the control. In the other two plots the goats were provided sulfur in the form of sodium or calcium sulfate and/or protein as cottonseed meal or a urea-molasses mixture. These supplements, except for the urea molasses, were fed ad libitum in various salt

mixtures. The choice of the supplements used were based on the premise that shin oak forage is not high in protein and that which is present may be complexed with tannins to the extent that it is unavailable and may result in protein and/or sulfur deficiency.

RESULTS AND DISCUSSION

In the first year adjusted gross income from the shredded plot was slightly less than that from the control, but in the 2nd or 3rd year there appeared to be a tendency for increased production (Table 1). This may reflect damage to shin oak in the first year, but increased forage availability in subsequent years. Providing supplemental protein in the form of cottonseed meal or urea molasses provided a small response, but not an economic one. Providing sulfur as sodium or calcium sulfate tended to increase mohair production in 1980 but not in 1979.

The most significant results were not the responses to treatments, but rather the overall income realized from mohair production on shin oak dominated rangeland. Realizing that the first year (1979) values are somewhat inflated, it is obvious that the gross income was in the range of $30 to $50/acre with net income ranging upward from $22/acre. These data suggest that for ranchers who are able and willing to run goats, especially Angoras, Vasey shin oak should be considered a valuable resource to be exploited rather than controlled. Providing winter feed or grazing for goats presents problems in areas dominated by shin oak. On many ranches live oak is available in winter months for browsing. Other alternatives are dry grass and protein supplements, or use of small grain pastures in years when mohair prices are favorable.

LITERATURE CITED

1. Dollahite, J. W., G. T. Housholder and B. J. Camp. Oak poisoning in livestock. Texas Agri. Expt. Sta. Bu. 1049.

2. Gartner, R.F.W. and D. R. Niven. 1978. Studies on the supplementary feeding of sheep consuming mulga (Acacia aneura) 4. Effect of sulphur on intake and digestibility and growth and sulphur content of wool. Australian Journal of Experimental Agriculture and Animal Husbandry 18:768-772.

3. Gartner, R.J.W. and I. S. Hurwood. 1976. The tannin and oxalic acid content of Acacia aneura (mulga) and their possible effect on sulphur and calcium availability. Australian Veterinary Journal 52:194-195.

4. Wiedemann, H. T., C. H. Meadors, Jr., and C. E. Fisher. 1980. Bigelow shin oak control. Pages 28-29 In D. N. Ueckert and J. E. Huston (ed.) Rangeland Resources Research, Texas Agri. Exp. Sta. Consol. P.R. 3665.

TABLE 1. MOHAIR PRODUCTION AND INCOME FROM ANGORA MALES (WETHERS OR BILLIES) GRAZING ON SHIN OAK IN THE EDWARDS PLATEAU

Year	Treatment	Stocking Rate Goats per Acre	Ave. Daily Gain	Actual Fleece Weight	Adjusted Fleece Weight (180-day basis)	Actual Gross Income Per acre	Adjusted Gross Income Per acre (less cash costs)
1979[1]	Control	2.8	0.02	8.7	7.3	$98.66	$73.56
	Shredded	2.6	0.05	8.1	6.8	84.97	62.54
	18% $NaSO_4$	2.6	0.06	8.3	7.1	87.16	50.12
	18% $NaSO_4$ + 18% C.P. from CSMeal	2.8	0.06	8.4	7.1	95.01	57.88
1980	Control	2.0	0.01	4.8	4.0	42.64	27.20
	Shredded	2.0	0.02	5.4	4.6	43.52	29.14
	$CaSO_4$	2.4	0.01	5.5	4.6	52.48	31.72
	$CaSO_4$ + CSMeal	1.8	0.05	6.8	5.7	48.64	25.98
1981	Control	2.0	--	6.2	5.6	32.61	22.33
	Shredded	1.8	--	6.9	6.2	32.61	22.87
	CSMeal + Salt	2.0	--	6.5	5.9	34.34	11.09
	Molasses 32% C.P.	1.8	--	7.1	6.4	33.92	12.31

[1] Production and income values for 1979 appear to be inflated. In this year, yearling Angora billies were used. The shearing period extended beyond that of shinnery growth, and the goats had been on a highly favorable nutritional regime before being placed in the experimental pastures. Although the fleece weights were adjusted for growth period, there was no doubt a carryover effect of the favorable growth period earlier.

GLUCOSE AND THREONINE INCORPORATION INTO THE MILK OF LACTATING DAIRY GOATS

Dale C. Kenison, G.T. Schelling, W.C. Ellis and L.W. Greene

SUMMARY

Measurements of the percentage of glucose and threonine incorporated into milk were made in lactating dairy goats producing either a high (3.9 liters/day) or a low (1.2 liters/day) level of milk. Single pulse doses of radioactive (^{14}C) threonine or glucose were intravenously injected and the radioactivity in milk was monitored for three days. Essentially all of the radioactivity secreted in the milk was recovered within one day. Of the total glucose turnover, the percentage glucose secretion into milk when milk production was high was approximately twice that with low milk production (65% vs 32%). Comparable values with threonine indicated approximately 1.5 times greater incorporation (29% vs 20%) with high milk production. This work indicates the general magnitude of the incorporation of these nutrients into milk as well as the relative influence of the level of milk production.

INTRODUCTION

The ruminant, as well as all other mammals, has a metabolic requirement for glucose. Since rumen fermentation converts most of the digestible dietary carbohydrate into volatile fatty acids, the ruminant must synthesize much of its glucose requirement under most nutritional situations. The physiological status of the animal plays an important role in determining its glucose requirement. The added demand for glucose due to lactation places a severe strain on the ruminants gluconeogenic machinery. Glucose, absorbed from the blood stream by the mammary gland, is the substrate for milk lactose synthesis (Young, 1977). Bickenstaffe (1974) reported in dairy cattle that 60% of the total glucose entry rate (total metabolism) was used to synthesize lactose for milk.

Although propionate is the major glucose precursor, amino acids can contribute up to 30% of the carbon used in glucose synthesis (Wolf and Bergman, 1972). Threonine, an essential amino acid, is metabolized to a significant extent in dairy cattle (Black, 1968). Beede (1979) reported that only 1.74% of total threonine turnover was used for glucose synthesis in growing goats. Egan (1977) and Morton et al. (1977) concluded that threonine did not contribute significantly to glucose carbon. The extent of incorporation is dependent upon the dietary situation and physiological demands placed upon the animal.

The present study was undertaken to assess the demand for glucose and threonine by daily milk secretion and as a preliminary work for subsequent studies.

EXPERIMENTAL PROCEDURE

Lactating dairy goats representing a low level of milk production and a high level of milk production were housed in individual metabolism cages and fed a diet of alfalfa hay and concentrate. Alfalfa was fed ad libitum, while the concentrate was fed, at milking time, according to level of production. The animals were milked twice daily. The animals were given seven days to adjust to the cages and stabilize their intake and milk production.

A dose of uniformly labelled ^{14}C-glucose (25 μCi) was administered via jugular cannula immediately after the morning milking. Blood and milk samples were taken every 2 hours for 24 hours and then at 12 hour intervals up to 72 hours. Milk samples were collected by milking each animal out completely. The entire procedure was repeated for each animal after seven days.

The threonine portion of the experiment was performed in the exact same manner as described above, except a dose of uniformly labelled ^{14}C threonine (25 μCi) was administered.

RESULTS & DISCUSSION

The results of the glucose portion of the experiment are listed in Table 1. Total radioactivity per individual sample was determined and the total radioactivity recovered in 24 hours calculated. The percent of total dose recovered in 24 hours in the milk was taken to be the percent of body glucose pool secreted in the milk per day. The high level of milk production was 3.23 times that of the low production level (3702 vs 1145 ml/day) and the percent of blood glucose used for milk synthesis was 2.04 times that of the low milk production treatment. These data demonstrate the quantitative aspects of the higher demand for glucose by milk secretion with increased milk production. Fractionation of milk samples and subsequent ratioactive counting will indicate the milk component which contains the radioactivity.

Data from the threonine study are listed in Table 2. The high level of milk production was 3.12 times that of the low production level and the percent of blood threonine used for milk synthesis was 1.44 times that of the low milk production treatment (29% vs 20%). The greater demand for threonine due to higher milk production would be expected, but it is of considerable interest that even with high milk production only 29% of the threonine pool is used for milk synthesis.

TABLE 1. PERCENTAGE OF TOTAL GLUCOSE TURNOVER SECRETED IN MILK

Treatment		Milk Production	Recovery of Blood Dose in Milk
		ml/day	%
Low Production,	rep. 1	1182	33.1
	rep. 2	1107	30.4
	mean	1145	31.8
High Production,	rep. 1	3241	66.8
	rep. 2	4164	62.4
	mean	3702	64.8

TABLE 2. PERCENTAGE OF TOTAL THREONINE TURNOVER SECRETED IN MILK

Treatment		Milk Production	Recovery of Blood Dose in Milk
		ml/day	%
Low Production,	rep. 1	1190	18.7
	rep. 2	1417	21.8
	mean	1304	20.3
High Production,	rep. 1	4258	32.6
	rep. 2	3869	25.8
	mean	4064	29.3

LITERATURE CITED

1. Bickenstaffe, R., E.F. Annison and J.L. Linzell. 1974. The metabolism of glucose, acetate, lipids and amino acids in lactating cows. J. Agr. Sci. 82:71.

2. Black, A.L., A.R. Egan, R.S. Anand and T.E. Chapman. 1968. The role of amino acids in gluconeogenesis in lactating ruminants. In: Isotope Studies on the Nitrogen Chain, IAEA, Vienna. p. 427.

3. Egan, A.R. 1977. The contribution of threonine to the glucose economy of hill sheep. Proc. Nutr. Soc. 37, 15A.

4. Morton, J.L., D.B. Lindsay and P.J. Buttery. 1977. Gluconeogenesis from threonine in adult sheep. Proc. Nutr. Soc. 37, 7A.

5. Wolff, J.E. and E.N. Bergman. 1972. Gluconeogenesis from amino acids in fed sheep. Am. J. Physiol. 223:455.

6. Young, J.W. 1977. Gluconeogenesis in cattle: Significance and methodology. J. Dairy Sci. 60:1.

MANAGEMENT OF ANGORA GOATS IN A 14-PASTURE SHORT DURATION GRAZING SYSTEM

Charles A. Taylor, Jr.

Vegetative composition most desirable for goats varies for different soils and climatic conditions. However, goats have a wide grazing spectrum, and in a mixed vegetative complex their inclusion in the grazing system increases efficiency of utilization of the vegetation. Based on research results, it is evident that with mixed vegetation types and comparable rates of grazing, goats spread their grazing pressure more evenly over all kinds of vegetation than cattle or sheep. This results in light utilization of grasses which is beneficial both for vigor and seedling establishment, and improves the diets of other ruminants. When Angora goats are grazed on rangelands, careful consideration should be given to development and maintenance of the ultimate vegetative complex. Compared to other domestic ruminants, Angora goats have higher nutritional requirements. Because of this, when goats are grazed in combination with other kinds of livestock, it would be beneficial to place them on a higher plane of nutrition by strategically locating them in pastures with the highest quality vegetation.

The proper managment of Angora goats in a short duration grazing system (SDG) is being studied at the Sonora Experiment Station. One objective of this study is being done through the use of esophageal cannulated goats in a 14-pasture, one herd SDG system. Three kinds of livestock are used in the grazing system with a stocking ratio of 45, 27.5 and 27.5% for cattle, sheep and goats, respectively. Pastures in the SDG system are alternately grazed 3 and 4 days and rested for approximately 42 days. A grazing cycle consists of 49 days. Diet samples collected from the esophageally cannulated goats will be analyzed for protein and energy content. Diet quality from these samples will help determine where goats should be placed in the SDG rotation sequence in relation to cattle and sheep.

EFFECT OF CREEP FEEDING ON RATE OF GAIN IN CROSSBRED LAMBS

L. H. Ripley, J. W. Campbell and J. W. Bassett

Lambs born in the 1981-82 lambing season at the Sheep Center in College Station were divided into two groups. One group had 21 lambs and was creep fed from birth. The other group had 23 lambs and received no supplemental feed. The creep feed was a pelleted formulation with 14% crude protein and 1.18 Mcal/lb. While differences in average daily gain and actual weight between the two groups were small up to 60 days of age, the lambs on creep feed gained more consistently than the lambs which were not supplemented. After 60 days, however, the weight and gain differences between the two groups increased with the creep fed lambs averaging 17 pounds heavier than the unsupplemented lambs at 120 days of age.

DEVELOPMENT OF A QUADRIVALENT BLUETONGUE VACCINE

C. W. Livingston, Jr., S. McConnell, G. Cummings and B. B. Gauer

SUMMARY

A quadrivalent bluetongue vaccine developed by the Texas Agricultural Experiment Station was safe and effective when tested under laboratory and field conditions using sheep, cattle, and goats. A patent has been applied for this vaccine and commercial production is anticipated within 2 years.

INTRODUCTION

Bluetongue disease is endemic in Texas livestock. Severe outbreaks involving large numbers of animals occur at 3 to 4 year intervals. Four distinct serotypes or strains of bluetongue virus have been identified in Texas and the United States. The bluetongue vaccine available commercially today contains only a single serotype of bluetongue virus (Bluetongue virus international type (BTVIT) 10). This monovalent vaccine has not been effective in preventing bluetongue outbreaks in susceptible animals because it does not protect against the other three serotypes (BTVIT 11, 13, and 17).

EXPERIMENTAL PROCEDURE

The four serotypes of bluetongue virus were attenuated by rapid subpassages in cell cultures. The attenuated virus was used to vaccinate sheep, goats and cattle under laboratory and field conditions. Vaccinates and unvaccinated controls were challenged with the appropriate fully virulent bluetongue virus. The reisolation of the attenuated and the fully virulent virus was attempted on selected groups of animals. Agar gel diffusion and serum neutralization techniques were employed to monitor the antibody response to vaccination and challenge bluetongue virus. Known bluetongue-susceptible sheep and goats were raised in confinement to prevent contact with the natural vector of bluetongue, the Culicoides sp.

RESULTS AND DISCUSSION

Attenuated strains of bluetongue virus were developed which produced immunity to bluetongue virus but did not produce overt signs of bluetongue in susceptible animals. Animals vaccinated with the attenuated bluetongue

vaccines demonstrated protection to challenge by virus of the appropriate bluetongue serotype. The quadrivalent vaccine apparently did not produce severe or adverse reactions in the vaccinated animals. All serotypes of the bluetongue vaccine virus appeared to be stable especially after rapid subpassages in susceptible sheep. The duration of immunity established by the quadrivalent bluetongue vaccine has not been determined. However, immunity has been demonstrated to be protective up to one year after vaccination with this product. Commercial quadrivalent bluetongue vaccine may be available within 2 years. An agreement for the production and distribution of this vaccine has been made with International Minerals Corp., Terra Haute, Ind.

MYCOPLASMA BIOTYPE 2D--A MYCOPLASMA ISOLATED FROM TEXAS SHEEP

C. W. Livingston, Jr. and B. B. Gauer

SUMMARY

Mycoplasma biotype 2D was isolated from the reproductive tract of sheep in four separate flocks.

INTRODUCTION

A mycoplasma designated as biotype 2D was isolated from the reproductive tract of sheep in Australia by Carmichael et al. in 1972 (1). Cottew, also in Australia, isolated biotype 2D from ewes with vulvovaginitis (2). These 2D isolates were serologically distinct from all ovine mycoplasma species with the exception of Mycoplasma mycoides subsp. mycoides which on occasion did show a serologic similarity to certain isolates of biotype 2D.

EXPERIMENTAL PROCEDURE

Vaginal and prepucial swabs were obtained from sheep located in four Texas flocks. Semen was collected from the rams by electroejaculation. The swabs were cultured in Hayflick's medium and pure cultures obtained by single colony cloning procedures. The cloned mycoplasmal cultures were identified using biochemical and growth inhibition tests. Antiserum specific for the Australian isolate of biotype 2D was provided by Dr. Cottew.[a/]

RESULTS AND DISCUSSION

Selected mycoplasmas isolated from the reproductive tract of sheep from each flock were identified as Mycoplasma sp. biotype 2D using biochemical reactions and serological tests. This biotype has been reported

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only in Australia and apparently this is the first reported isolation of biotype 2D outside of Australia. The pathogenic properties of this mycoplasma is questionable. Carmichael et al. isolated biotype 2D from the reproductive tracts of sheep with no apparent reproductive problems.[1/] However Cottew isolated this biotype from ewes with vulvovaginitis.[2/] Two of the Texas isolates of biotype 2D were obtained from flocks experiencing reproductive problems while the two other flocks appeared to be normal. Additional research must be undertaken before the significance of this mycoplasma can be determined.

LITERATURE CITED

1. Carmichael, L. E., St. George T. D., Sullivan N. D., Horsfall N.: Isolation, propagation, and characterization studies of an ovine Mycoplasma responsible for proliferative interstitical pneumonia. Cornell Vet 62:654-679, 1972.

2. Cottew, G.S., Lloyd L.C., Parsonson, I.M.: Isolation of a mycoplasma from vulvovaginitis of sheep. Aust Vet J 50:576-577, 1974.

DELAYED TYPE HYPERSENSITIVITY TEST OF GOATS WITH CASEOUS LYMPHADENITIS INFECTION

T.Y. Hsu, H.W. Renshaw, C.W. Livingston, Jr., and E.J. Browder

SUMMARY

Delayed type hypersensitivity tests were conducted using five preparations from Corynebacterium pseudotuberculosis. The animals responded best to the autoclaved sonicate antigen and the cell wall preparation. The purified protein derivative-like antigen and toxoid were poor antigens in detecting cellular response after artificial infection.

INTRODUCTION

Corynebacterium pseudotuberculosis, the etiologic agent of caseous lymphadenitis, is a facultative intracellular bacterium. A delayed type hypersensitivity test is effective in detecting Mycobacterium tuberculosis infection which is also an intracellular bacterium. An attempt for detecting caseous lymphadenitis infection was made by conducting a delayed type hypersensitivity test with different preparations from C. pseudotuberculosis on field goats.

EXPERIMENTAL PROCEDURE

Five antigens were prepared from C. pseudotuberculosis by different methods in order to identify the best antigen. A toxoid preparation from the culture supernatant, a purified protein derivative-like preparation from autoclaved culture supernatant[1], a sonicate preparation, an autoclaved sonicate antigen preparation, and a cell wall preparation were used.[2]

Thirty male Spanish goats were inoculated with C. pseudotuberculosis. Two weeks before inoculation, and ten and twenty-four weeks after, 0.2 ml of each antigen preparation was injected intradermally at sites 1.5 inches apart in the neck area of each goat. Saline injections of 0.2 ml were made to achieve control values for skin thickness for each goat. The skin thickness was measured with skin calipers at 48 and 72 hours after inoculation.

RESULTS AND DISCUSSION

All the animals showed very low responses to all antigen preparations before infection. Infection or establishment of disease was determined based on the presence of abcess formation in inoculated animals. All 30 animals had clinical evidence of abcessation (Table 1). After infection responses were better to autoclaved sonicate, sonicate antigen and cell wall preparation than to toxoid and purified protein derivative-like antigen.

The purified protein derivative has been shown to be a very effective reagent for detecting tuberculosis. However, it apparently is not a good antigen for detecting caseous lymphadenitis although there are some similarities between C. pseudotuberculosis and M. tuberculosis. Based on preliminary data presented here further investigation using the autoclaved sonicate antigen could provide valuable information leading to a practical method of testing for caseous lymphadenitis.

LITERATURE CITED

1. Angus, R.D. (1978). Production of reference PPD tuberculins for veterinary use in the United States. J. Biol. Standarization 6. 221-227.

2. Shen, D.T., Jen, L.W. and Gorham, J.R. (1982). The detection of C. pseudotuberculosis antibody in goats by the enzyme-linked immunosorbent assay. Proceedings of the third international conference on goat production and disease. 445-448.

ACKNOWLEDGEMENT

We appreciate Dr. Caesar Kuo for data analysis.

Table 1. The mean skin thickness of experimentally infected goats

skin * thickness in mm.	2 wks before		10 wks after		24 wks after	
	48 hr	72 hr	48 hr	72 hr	48 hr	72 hr
PPD-like	0.30±0.61**	0.00±0.60	0.24±0.62	0.26±0.54	0.55±0.68	0.36±0.93
Toxoid	0.43±0.89	0.29±0.42	0.46±0.83	0.51±0.73	0.58±0.98	0.42±1.10
Sonicate	0.67±0.94	0.57±0.70	2.58±1.10	2.55±1.35	1.04±1.40	0.76±1.43
Autoclaved sonicate	0.57±0.66	0.26±0.57	5.55±2.36	5.09±2.28	3.95±2.34	5.01±3.32
Cell wall	NA	NA	NA	NA	3.73±2.61	4.50±3.69

* The data have been transformed by subtracting control measurements from each skin thickness measurement.

** Mean ± S.D.

PROPERTIES OF CORYNEBACTERIUM PSEUDOTUBERCULOSIS EXOTOXIN

T.Y. Hsu, H.W. Renshaw, C.W. Livingston, Jr., and E.J. Browder

SUMMARY

The exotoxin of C. pseudotuberculosis was purified by column chromatography. The isoelectric point was identified at pH 9.2-9.4 and the molecular weight was found to be 31,000. Newborn lambs and kids died within 48 hours of intravenous exotoxin injection. Generalized hemolysis was present in all blood samples collected at that time. The exotoxin also hemolysed bovine red blood cells which had been sensitized with a C. equi extract. The role of this exotoxin in natural infection of caseous lymphadenitis is unknown.

INTRODUCTION

Several properties of the exotoxin produced by C. pseudotuberculosis have been reported using different methods of extraction (1, 2, 3, 4, 5). The purpose of this experiment is to evaluate whether or not exotoxin obtained from a single method has all of the properties described. Properties to be evaluated include isoelectric point, molecular weight, hemolytic activity, and lethal effect in lambs and kids.

EXPERIMENTAL PROCEDURE

Culture supernatants of C. pseudotuberculosis were pooled, and proteins were separated by ammonium sulfate precipitation. The precipitate was redissolved and partially purified through column chromatography. The physical and biological properties of the exotoxin obtained by this method were examined by isoelectrofocusing, sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS PAGE), hemolysin assay, and intravenous injection into newborn lambs and kids.

RESULTS AND DISCUSSION

The exotoxin exhibited an isoelectric point at pH 9.2-9.4. The molecular weight obtained from the SDS PAGE was about 31,000. The exotoxin caused hemolysis of C. equi extract sensitized bovine red blood cells and the hemolytic activity was rather stable to heat treatment. The exotoxin killed kids and lambs within 48 hours of intravenous administration and all animals showed generalized hemolysis.

In its natural form caseous lymphadenitis is a chronic disease. Acute death and generalized hemolysis are not seen in naturally infected animals. There is likely to be an important factor other than the exotoxin playing a major role in C. pseudotuberculosis infection.

LITERATURE CITED

1. Jolly, R.D. (1965). The pathogenic action of exotoxin of C. ovis. J. Comp. Pathol. 75, 417-431.

2. Souck, A. & Souckova, A. (1974). Toxicity of bacterial sphingomyelinases D. J. Hyg. Epidemiol. Microbiol. Immunol. 18, 327-335.

3. Knight, H.D. (1978). A serologic method for the detection of Corynebacterium pseudotuberculosis infection in horses. Cornell Vet. 68, 220-237.

4. Linder, R. and Bernheimer, A.W. (1978). Effect on sphingomyelin containing liposomes of phospholipase D from Corynebacterium ovis and the cytodysin from Stoichactis helianthus.

5. Onon, E.O. (1979). Purification and partial characterization of the exotoxin of Corynebacterium ovis. Biochem. J. 177, 181-186.

ACKNOWLEDGEMENT

We appreciate the valuable assistance of Bobbie Boyd and Betty Gauer.

LONGEVITY OF CORYNEBACTERIUM PSEUDOTUBERCULOSIS IN SIX TEXAS SOILS

J. L. Augustine and H. W. Renshaw

SUMMARY

These studies show that Corynebacterium pseudotuberculosis may be a greater environmental hazard to production stock than previously thought. Data presented in this paper shows that this pathogen in its natural form (purulent exudate from infected animals) persists longer than a year in sterile soils. More importantly however, C. pseudotuberculosis could be isolated from unsterile soil samples for more than a month.

INTRODUCTION

The concern over caseous lymphadenitis and its infectious agent Corynebacterium pseudotuberculosis has increased dramatically in recent years. Little data however is available as to the ability of C. pseudotuberculosis to survive outside the host. Zaki and co-workers showed that sterile bedding, feed, soil, wood and metal surfaces may harbor artifically cultured and washed C. pseudotuberculosis for as long as 8 days[2]. Evidence given by Augustine and Renshaw indicate that C. pseudotuberculosis in the form of an axenic purulent exudate remains viable on rusty nails, hay, straw, and wool shavings for as long as two months.[1] The following study has been designed to shed light on the survival of C. pseudotuberculosis in contaminated soils using the axenic purulent exudate of infected goats.

EXPERIMENTAL PROCEDURE

Five soils, common in Texas, were sterilized and inoculated with axenic purulent exudate containing C. pseudotuberculosis from an infected lymph node of a goat. Each inoculated sample which contained 1 gram of purulent material to every 9 grams of soil (10:1) was then mixed with a table top blender and added in 25 gram portions to sterile plastic covered dishes (petri plates). Three separate samples of the Bub, Silsted, Norwood and Houston Black Clay soil samples were mixed 1:1 with either Brazos River water, tap water or distilled deionized water. A fourth series of samples had no water added. Each group of samples was incubated at either 98°F, 72°F, 40°F, or incubated outside to simulate the various average Texas seasonal as well as actual ambient temperatures. The fifth soil sample, an unsterile silt loam taken from a pasture at the Sheep and Goat Center, Texas Ag. Exp. Sta., San Angelo, Texas was inoculated and incubated at 98°F, 72°F, 40°F and outside. The last soil sample, a sandy loam collected from a pasture in the San Antonio area, was sterilized before inoculation and incubated at 98°F, 72°F, and 40°F. All soil samples were tested for viable C. pseudotuberculosis monthly in soil samples 1 to 5, and daily in soil sample 6.

RESULTS AND DISCUSSION

In Norwood and Bub soils, viability ranged from 57 days to more than 323 days. C. pseudotuberculosis cells were viable in Silsted soils from 130 days to more than 323 days. Houston Black Clay contained live bacteria up to 323 days. The bacteria remained viable in soil sample 5, the sandy loam, longer than the other soil samples ranging from 289 days to 387 days. In sample 6, the unsterile silt loam, C. pseudotuberculosis survived from 21 days to more than 44 days.

Statistical analysis of the data indicates that C. pseudotuberculosis survived in Houston Black Clay and sandy loam soil samples significantly longer than in the other soil types ($P>0.0001$). The higher temperatures (98°F and 72°F) were also shown to be a significant factor in increasing the survival time of the bacteria ($P>0.0002$). Though incubation outside was not significantly different from 98°F and 72°F in survival advantages, the mean survival time was the highest of the temperature groups. This is most interesting since the C. pseudotuberculosis cells were subjected to temperatures ranging from 100°F in the summer to 18°F in the winter with about a 20°F change per day. The water type added did not apparently affect bacterial survival to a significant extent.

While warm temperatures and particular soil types may increase the survival times of C. pseudotuberculosis outside the host, all samples showed a longer persistence than previously reported[2]. The relationship between viability of bacteria and temperature appears the same for the unsterilized silt loam as for the other soil samples. Although the unsterilized silt loam sample did not sustain C. pseudotuberculosis as long as the other soils, it does simulate more closely the natural conditions for survival. These data suggest that long term survival of C. pseudotuberculosis in its natural form (purulent exudate from lesions) is possible. This information may be important in management practices of the disease problem. Measures such as proper isolation of infected stock, disposal of contaminated bedding, and handling of infective purulent material during treatment should be undertaken to lessen the chance of further infections or soil contamination.

LITERATURE CITED

1. Augustine, J. L. and Renshaw, H. W. 1982. Corynebacterium Pseudotuberculosis survival in soil samples amended with water. Proceedings of the 3rd International Goat Prod. and Disease Conf. p. 576.

2. Zaki, M. M. and Y. M. A. Hamid. 1972. Viability of C. Pseduotuberculosis Ovis in animal dwellings in different seasons. J. of the Egyptian Vet. Med. Ass. 32, p. 180-193.

PERSISTENCE OF CORYNEBACTERIUM PSEUDOTUBERCULOSIS IN WATER FROM VARIOUS SOURCES

J.L. Augustine, A.B. Richards and H.W. Renshaw

SUMMARY

The survival of Corynebacterium pseudotuberculosis outside the host was assayed by inoculating water samples from various sources with axenic purulent exudate and comparing their longevity to that of samples inoculated with cultured and washed cells. The inoculated water samples were incubated at temperatures which attempted to simulate the four Texas seasons. Cells remained viable from less than 3 hours in chlorinated tap water to 70 hours in distilled deionized water.

INTRODUCTION

Corynebacterium pseudotuberculosis, the causative agent of caseous lymphadenitis in sheep and goats, when grown on artificial media and washed has been shown to persist from 1 to 8 days in water from various sources.[3] Preliminary data indicates that C. pseudotuberculosis in its natural state, the purulent exudate of infected animals, may survive much greater lengths of time outside the host than cultured and washed bacteria. The purpose of this study is to compare the longevity of cultured and washed bacterial cells to cells obtained in the pure purulent exudate from infected animals.

EXPERIMENTAL PROCEDURE

Persistence of Cultured and Washed C. pseudotuberculosis

C. pseudotuberculosis was grown 48 hours in beef heart infusion broth (BHI) and harvested by centrifugation at 2000xg. The pellet was resuspended in a phosphate buffer solution and recentrifuged, a procedure which was repeated three times. One gram of the harvested cells was added to 50 ml of either tap water, Brazos River water, or distilled deionized water. A sample of each was incubated at 98°F, 72°F and 40°F. Every 3 to 6 hours, a 1 ml sample was assayed for viable C. pseudotuberculosis with artificial media pour plates.

Persistence of C. pseudotuberculosis from Axenic (pure culture) Purulent Exudate:

Purulent exudate samples of C. pseudotuberculosis were added to similar sterile 50 ml samples of water and shaken until the bacteria were dispersed. Every three hours samples were taken and assayed as previously described. The results were compared by statistical analysis.

RESULTS AND DISCUSSION

In river water samples cultured and washed C. pseudotuberculosis was retrieved 24, 54 and 60 hours after inoculation while cells from purulent exudate survived 9, 48 and 60 hours after inoculation at 98°, 72° and 40°F,

respectively (Table 1). The bacteria survived somewhat longer periods in deionized distilled water. Tap water was the most inhospitable environment for C. pseudotuberculosis with all bacterial samples dying in less than 6 hours.

Though a comparison of the persistence of C. pseudotuberculosis in purulent exudate, and cultures and washed bacteria in the water samples was not significantly different, the temperature was found to be a significant factor ($P > .0001$). With decreases in incubation temperature there were significant increases in bacterial survival times. In addition, both bacterial samples survived in river and distilled deionized water significantly longer than in tap water ($P > .0002$).

Although no significant differences were observed between the 2 types of bacterial cells used in this study it was apparent that C. pseudotuberculosis is able to survive for extended periods of time in river or distilled deionized water. Tap water with normal levels of chlorination effectively kills the bacteria, however, C. pseudotuberculosis in purulent lesional material did survive up to 6 hours. Temperature dependent variations in bacterial survival of this pathogen indicate that there may be a seasonal effect on longevity. When summer conditions were simulated ($98^{o}F$) the survival of C. pseudotuberculosis was consistently less than in spring or fall conditions ($72^{o}F$). Bacterial survival in water appears more favorable at temperatures approximating a Texas winter ($40^{o}F$).

The data indicates a greater probability of transmission of C. pseudotuberculosis by water during cooler months of the year.[1] One group of researchers however reported a higher incidence of caseous lymphadenitis during the spring and fall than during the winter. The increased incidence in these seasons may be influenced more by the shearing and lambing schedules than by numbers of bacteria in the environment.[2] Fortunately, in the U.S., much of the drinking water is chlorinated. Since chlorination appears to effectively kill C. pseudotuberculosis in contaminated water, its use in sheep and goat operations should be encouraged. Since the use of chlorinated water may not be possible in many operations, there is a chance of large scale contamination. Although C. pseudotuberculosis apparently survives for longer periods of time on or in fomites other than water it still appears likely that water may be a major vehicle for disease transmission.

LITERATURE CITED

1. Nadin, A. M., Farid, A. and Mahmoud, A. H. 1966. Caseous lymphadenitis in sheep in Egypt. I. Incidence of infection of the causative micro-organisms. J. Arab Vet Med Asso, 26, p. 67.

2. Renshaw, H. W., Graff, V. P. and Gates, N. L. 1978. Visceral caseous lymphadenitis in thin ewe syndrome: Isolation of Corynebacterium, Staphylococcus and Moraxella spp from internal abscesses in emaciated ewes. Am J. Vet Res, 40, p. 1110.

3. Zaki, M. M. and Hamid, Y. M. A. 1972. Viability of Corynebacterium ovis in animal dwellings in different seasons. J Egypt Vet Med Asso, 32, p. 189.

TABLE 1. Survival[1] of C. pseudotuberculosis in Water

WATER TYPE	BACTERIA SAMPLE	98°F	72°F	40°F
River Water	Cultured and Washed Bacteria	24	54	60
	Purulent Exudate	9	48	60
Distilled Deionized Water	Cultured and Washed Bacteria	9	42	70
	Purulent Exudate	18	42	66
Tap Water	Cultured and Washed Bacteria	0	0	0
	Purulent Exudate	3	6	6

[1]Survival time given in hours

LONGEVITY OF CORYNEBACTERIUM PSEUDOTUBERCULOSIS CONTAINED IN AXENIC PURULENT EXUDATE ON FOMITES

J. L. Augustine, A. B. Richards and H. W. Renshaw

SUMMARY

Several sterile farm fomites were inoculated with Corynebacterium pseudotuberculosis in axenic purulent exudate taken from goats having lymphadenitis. Each fomite was inoculated and then incubated at temperatures which simulate the seasonal norms in Texas. Viable cells were isolated from the fomites one week to two months after inoculation depending on the temperature and fomite.

INTRODUCTION

The spread of caseous lymphadenitis in sheep and goats has been a major concern to that industry. Contamination of wounds by infected instruments or dust during such operations as docking, and shearing has been cited as a cause of the spread of caseous lymphadenitis. Zaki indicates that cultured and washed Corynebacterium pseudotuberculosis, the proported causative agent of caseous lymphadenitis, survives outside the host in the environment from 1 to 8 days, depending on the fomite.[1] The present experiment was designed to demonstrate the longevity of C. pseudotuberculosis cells from purulent lesional material.

EXPERIMENTAL PROCEDURE

Sterile wood shavings, goat manure, hay, straw, white pine chips, white pine shavings and rusty nails were inoculated with purulent exudate containing a pure culture of C. pseudotuberculosis (axenic) from goats with caseous lymphadenitis. Control samples consisted of sterile covered plastic dishes (petri plates) containing the purulent material. The wood chips and rusty nails were coated with a thin layer of the purulent material, while the other fomites were inoculated by mixing them with the purulent exudate (10:1 w/w) in a table top blender. Each fomite was then incubated in a sterile petri plate at 98°F, 72°F and 40°F to stimulate summer, spring/fall and winters in Texas.

RESULTS AND DISCUSSION

Bacteria from the purulent exudate samples were found to survive up to 27, 72 and 96 hours at 98°, 72° and 40°F respectively, on petri plates. Wood chips yielded live cells at times ranging from 51 hours at 98°F to 129 hours at 40°F after inoculation. Bacteria from rusty nail surfaces were viable for 39 hours to 192 hours depending on incubation temperature (Table 1). Bacterial survival in the particulate fomites was greater than when spread on surfaces. Wood shavings, goat manure, hay and straw yielded viable cells from 7 days up to 55 days after inoculation.

The data shows that C. pseudotuberculosis survives much longer when inoculated onto fomites as an axenic purulent exudate than as an artificially cultured and washed inoculum.[1] More importantly, when mixed with finely chopped bedding such as hay or wood shavings, the pathogen appears to survive longer than when exposed on surfaces. Upon mixing, the purulent exudate is coated with the particulate matter to form small particles or micelles which may be a significant factor in bacterial survival. This potentially extended period of survival outside the host provides long-term opportunities for infection of healthy animals.

Several measures are therefore suggested which may reduce the hazards of infection. First, infected animals should be separated from the healthy ones. Second, the bedding used by infected animals should be changed frequently and disposed of. Third, wood surfaces should be cleansed where the infected animals are kept. Fourth, when new animals are added to the herd they should be kept separated for observation. Fifth, special care should be taken to use sterile instruments when vaccinating, shearing or docking the animals.

LITERATURE CITED

1. Zaki, M. M., and Hamid, Y. M. A. 1972. Viability of Corynebacterium ovis in animal dwellings in different seasons. J. Egypt Vet Med Ass, 32, p. 189.

TABLE 1. PERIODS OF SURVIVAL ON FOMITES BY CORYNEBACTERIUM PSEUDOTUBERCULOSIS

Fomite	98°F	72°F	40°F
Control	27[1]	72	99
Rusty nails	39	99	192
Wood chips	51	99	129
Wood shavings	11[2]	24	55
Goat manure	10	55	38
Hay	7	24	55
Straw	19	23	24

[1]Time is given in hours

[2]Time is given in days

A TOXIC AGENT DERIVED FROM PASTEURELLA HAEMOLYTICA

Y-F Chang, A. B. Richards, E. J. Browder and H. W. Renshaw

SUMMARY

A toxin was liberated from Pasteurella haemolytica into culture supernatant. This toxic agent was stable (when incubated for 60 minutes) at 39.2°F and 98.6°F, and lost its activity at 122.0°F and 132.8°F. Cultures containing live P. haemolytica with supernatants incubated at 39.2°F generated a high level of luminol-dependent chemiluminescence (LDCL). This LDCL declined rapidly to below control levels and approximately equal to absolute background levels. When cultures containing heat-killed P. haemolytica with supernatant incubated at 122.0°F and 132.6°F were tested, the LDCL values obtained were above the control levels at all sampling times. The toxic agent appears to be heat-sensitive and to halt the production of bacteria killing oxygen molecules. Therefore the toxin may play an important role in the pathogenesis of caprine pneumonia.

INTRODUCTION

Pasteurella haemolytica has long been known for producing a high incidence of morbidity and mortality in cattle and sheep (1, 2). This agent is also an important pathogen in caprine pneumonia (3). The pathogenesis and normal host defense mechanisms against the bacteria are poorly understood. Preliminary data from this laboratory have shown a possible toxic factor associated with P. haemolytica. The bacterial product has been shown to kill bovine alveolar macrophages and bovine white blood cells (leukocytes; 4, 5). The toxic factor may possibly be an important agent of virulence and pathogenicity in pneumonic pasteurellosis.

Luminol-dependent chemiluminescence (LDCL) occurs as a result of engulfment of bacteria by phagocytic cells (alveolar macrophages, monocytes, neutrophils). The LDCL indicates the generation of highly reactive oxygen containing molecules (6). These reactive oxygen molecules have been shown to be active in bacterial killing (7).

EXPERIMENTAL PROCEDURE

Pasteurella haemolytica was cultured in McCoy's solution with 10% fetal calf serum for 9 hours and centrifuged at 9,000xg. The pellet was adjusted to an optical density of 0.1 at 541 nm. Samples of supernatant were incubated at 39.2°F, 98.6°F, 122.0°F, 132.8°F for 60 minutes.

Goat blood was collected in heparin and the red blood cells were removed by treatment with ammonium chloride. The leukocytes were washed two times with saline. The concentration of the neutrophils was adjusted to 5 x 10^6 neutrophils/ml.

The LDCL assay was performed in polyethylene scintillation vials containing 5 ml of a buffered salt solution, 1 ml of a luminol fetal calf serum suspension mixture, 0.15 ml of a standardized bacterial suspension, 0.2 ml of goat neutrophils, and 0.2 ml of one of the heat treated supernatants. Experimental controls contained 5 ml of buffered salt solution, 1 ml of a luminol fetal calf serum suspension mixture, and 0.2 ml of goat neutrophils. Triplicate samples were incubated in a shaking water bath at 98.6°F. The LDCL counts were made at 0, 8, 16. 24, 48, 56 minutes after the addition of all reactants to the culture mixture. LDCL was monitored using a Beckman LS-3133 T Scintillation Counter and the LDCL was recorded as counts per minute (CPM). Samples were counted for six seconds per sampling time. CPM were reported as the average of the triplicate cultures.

RESULTS

LDCL values for cultures containing live P. haemolytica peaked at 16 minutes and were approximately seven times higher than neutrophil control samples. Counts rapidly declined until at the 32 minute reading they were below control values and equal to absolute background levels. Cultures containing heat-killed bacteria without supernatant displayed only a slight elevation in LDCL values above control levels at all sample times (Fig. 1). Heat-killed P. haemolytica cultures with supernatant incubated at 122.0°F and 132.8°F stimulated a high LDCL response, peaking at 24 minutes and remaining elevated through the experimental period (Fig. 1). Cultures containing supernatant incubated at 39.2°F and 98.6°F stimulated the neutrophils to produce LDCL levels thirteen times higher than control samples at 8 minutes. At 32 and 48 minutes the heat-killed bacterial cultures with supernatant incubated at 39.2°F and 98.6°F, respectively, had declined to control levels and by 56 minutes were at absolute background levels (Fig. 2).

DISCUSSION

The chemiluminescent response of goat neutrophils was much greater when the cells were exposed to live P. haemolytica. Also, the LDCL values of cultures containing live P. haemolytica rapidly declined below control values, but the cultures containing heat-killed P. haemolytica did not. The simplest explanation of this phenomenon is that the live P. haemolytica contains a toxic agent that has been destroyed in the heat-killed bacterial suspensions.

Heat-killed P. haemolytica cultures with supernatant incubated at 122.0°F and 132.8°F stimulated high LDCL values which remained elevated throughout the experimental period, while heat-killed P. haemolytica cultures with supernatant incubated at 39.2°F and 98.6°F stimulated the neutrophils to high LDCL values but then declined to below control levels. These results suggest that the heat labile toxic agent of P. haemolytica is secreted into the media.

In order to determine whether this toxic agent plays a role in the pathogenesis of caprine pneumonia, further isolation, purification, and identification of this toxic agent is necessary.

LITERATURE CITED

1. Friend, S.C.E., Wilkie, B.N., Thomson, R.G., and Barnum, D.A. 1977. Bovine pneumonic pasteurellosis: Experimental induction in vaccinated and nonvaccinated calves. Can. J. Comp. Med. 41:77-83.

2. Gilmour, N.J.L. 1978. Pasteurellosis in sheep. Vet. Rec. 102:100-102.

3. Ojo, M.O. 1977. Caprine pneumonia. Vet. Bulletin. 47:573-578.

4. Markham, R.J.F., and Wilkie, B.N. 1980. Interaction between Pasteurella haemolytica and bovine alveolar macrophages: Cytotoxic effect on macrophages and impaired phagocytosis. Am. J. Vet. Res. 41:18-22.

5. Bergren, K.A., Baluyut, C.S., Simonson, R.R., Bernrick, W.J., and Maheswaran, S.K. 1981. Cytotoxic effects of Pasteurella haemolytica on bovine neutrophils. Am. J. Vet. Res. 42:1383-1388.

6. Trush, M.A., Wilson, M.E., and Van Dyke, K. 1978. The generation of chemiluminescence by phagocytic cells. Methods Enzymol. 57:462-494.

7. Allen, R.C., and Loose, L.D., 1976. Phagocytic activation of a luminol-dependent chemiluminescence in rabbit alveolar and peritoneal macrophages. Biochem. Biophy. Res. Commu. 69:245-252.

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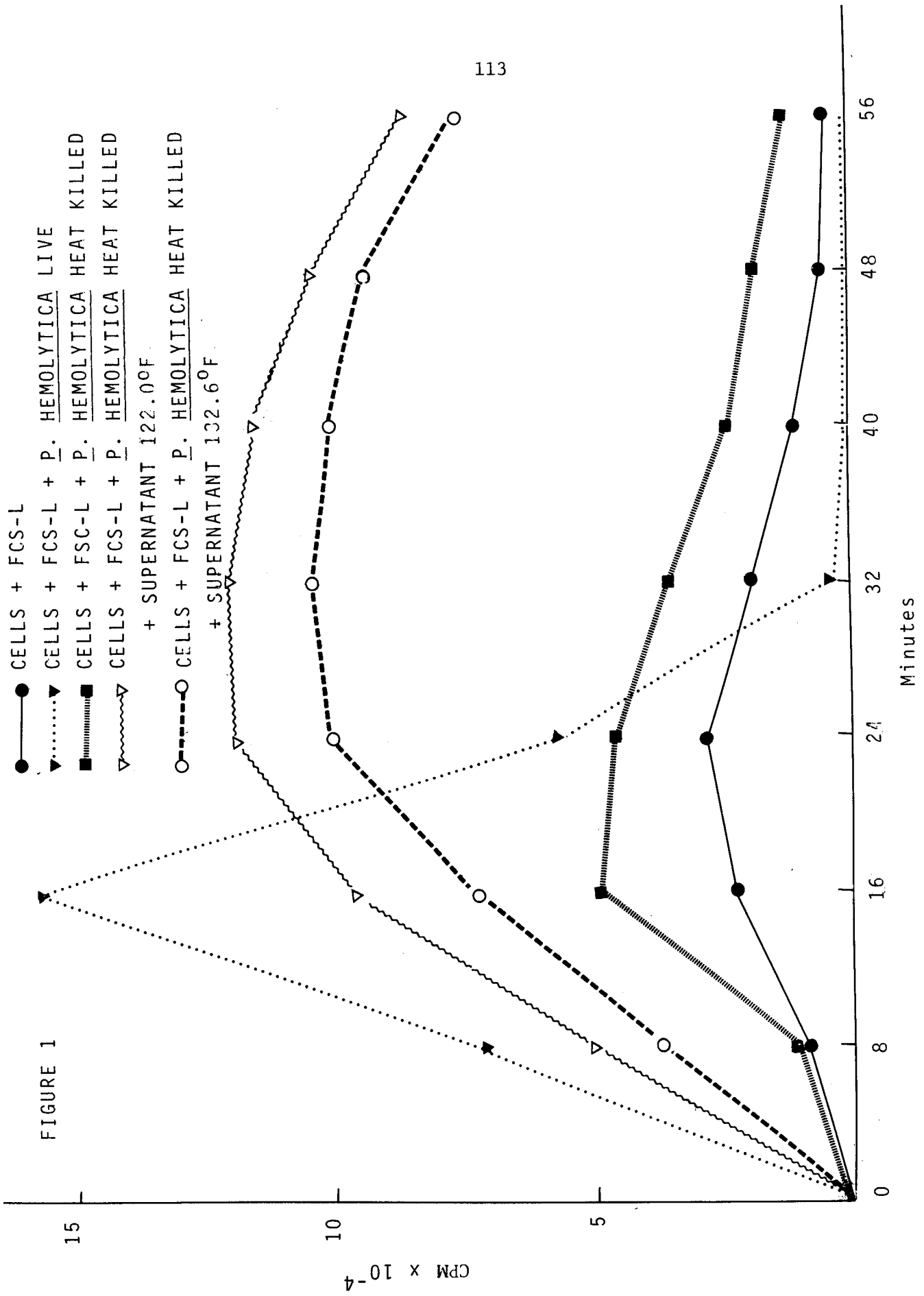
CELLS + FCS-L
CELLS + FCS-L + P. HEMOLYTICA LIVE
CELLS + FSC-L + P. HEMOLYTICA HEAT KILLED
CELLS + FCS-L + P. HEMOLYTICA HEAT KILLED
+ SUPERNATANT 122.0°F
CELLS + FCS-L + P. HEMOLYTICA HEAT KILLED
+ SUPERNATANT 132.6°F
CPM x 10-4
15
10
5
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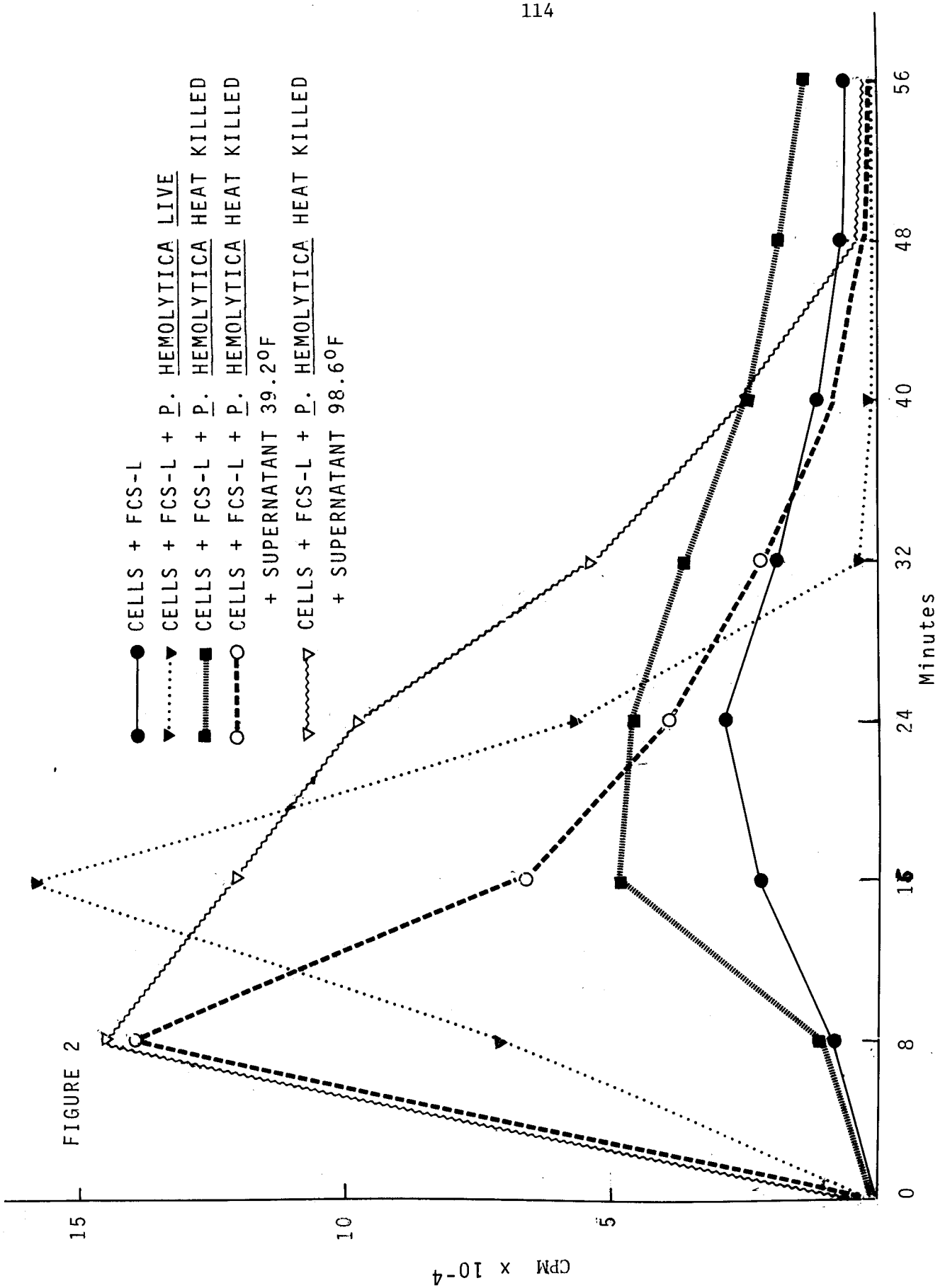
Minutes

FIGURE 1


CELLS + FCS-L
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+ SUPERNATANT 39.2°F
CELLS + FCS-L + P. HEMOLYTICA HEAT KILLED
+ SUPERNATANT 98.6°F
CPM x 10-4
15
10
5
0
8
16
24
32
40
48
56
Minutes

FIGURE 2

ASSAY FOR THE CONCENTRATION OF CORYNEBACTERIUM PSEUDOTUBERCULOSIS FROM LESIONS OF CASEOUS LYMPHADENITIS

J.L. Augustine, A.B. Richards and H.W. Renshaw

A total of 100 purulent exudate samples were collected from 17 sheep and 83 goats with caseous lymphadenitis. Samples were examined for the type of bacteria present and number of colony forming units per gram of purulent material. 37 of the samples yielded no viable bacteria. The remaining 63 samples contained Corynebacterium pseudotuberculosis, and in 31 samples the bacteria was present in pure culture. In addition to C. pseudotuberculosis , 32 samples contained one or more of the following bacteria: Moraxella spp, Staphylococcus aureus, epidermatis and pyogenes, Pasteurella aerogenes and multocida, Enterobacter spp, and Corynebacterium equi and pyogenes. The concentration of bacteria isolated from each sample ranged from one hundred thousand to one hundred million cells per gram of lesion exudate. Statistical analysis showed no difference in numbers of bacteria between sheep and goats. Although the populations of bacteria seemed higher in mixed infections, no statistical differences were observed. The average concentration of C. pseudotuberculosis per gram of lesional purulent material was approximately thirty-nine million.

SERUM NEUTRALIZATION OF A TOXIC FACTOR ASSOCIATED WITH PASTEURELLA HAEMOLYTICA

A. B. Richards and H. W. Renshaw

Pneumonic pasteurellosis continues to inflict severe economic losses on the cattle, sheep, and goat industries. Recent information suggests that a toxin associated with Pasteurella haemolytica can kill ruminant white blood cells (leukocytes) as well as other host defense cells. Using a luminol-dependent chemiluminescence (LDCL) test system it is possible to detect the presence of this toxic factor in P. haemolytic in extremely low concentrations. Studies presently underway use the LDCL test system to observe whether heat stable serum factors (antibodies) can neutralize the toxic factor as well as aid in the normal function of processing and killing the bacteria. Initial data has shown that serum obtained from several adult goats and pooled together can both neutralize the effects of the toxic factor and aid in the processing of the bacteria. Further tests are designed to compare the serums of goats vaccinated with several different vaccine preparations for anti-P. haemolytica properties. The purpose of these studies is directed at understanding the apparently consistent failure of vaccines to prevent respiratory diseases caused by P. haemolytica. This data will be examined in relation to recent information concerning the toxic substance.

LIMB DEFORMITY IN LAMBS

K. G. Thompson, M. C. Calhoun, C. H. Bridges, J. M. Shelton

For many years limb deformities have been recognized in rapidly growing young lambs, especially rams in testing stations. As many as 15 percent of rams in a group may be affected. The defect arises most frequently in the distal radius but can also involve the hind legs and may be either unilateral or bilateral. There may be either lateral or medial deviation producing a "calf kneed" or "bowlegged" appearance respectively. In sheep examined by us at necropsy, obvious abnormalities were present in the growth plate of the distal radius. The cause of the condition is unknown but is most likely multifactorial. Deformities occur mainly in the most rapidly growing rams on high energy rations, suggesting a nutritional cause possibly superimposed on a genetic potential for rapid growth. Similar lesions have been described in association with dietary phosphorus deficiency in sheep, but in our cases the dietary phosphorus levels were adequate and many affected rams in fact had elevated serum phosphorus concentrations. In an effort to resolve the cause and pathogenesis of this disorder, we plan to characterize more fully the microscopic lesions and serum biochemical alterations in spontaneous cases. Futhermore, we will attempt to reproduce the defect by modifying the dietary concentrations of minerals such as calcium, phosphorus, and zinc while closely monitoring biochemical alterations in serum and urine. This condition has resulted in financial loss of sheep breeders in Texas and several other states for many years. We are hopeful that this study will lead to a greater understanding of the pathogenesis of limb deformity in growing rams and to recommendations for preventing its occurrence.

TOXOPLASMOSIS ASSOCIATED WITH OVINE AND CAPRINE ABORTIONS IN TEXAS

R.A. Crandell and A.B. Angulo

Toxoplasma gondii has recently been associated with abortions in sheep in the states of Connecticut, Iowa and Oregon. The disease, toxoplasmosis, has also occurred in association with abortions in goats in Connecticut and Montana. Infection with Toxoplasma gondii has been known to be a major cause of ovine abortions in New Zealand and England. Since T. gondii cysts have been shown to persist in the liver and other tissues of goats as long as 441 days, Toxoplasma infections are of public health concern. TVMDL has very recently (1982) demonstrated significant antibody titers against the organism in two Texas herds of sheep with abortion problems. All 10 serums tested were positive with titers ranging between 16 and > 256. Seven serums had titers of 128 or greater. The results indicate a high prevalence of infection in these two herds. All samples were serologically negative for brucellosis, leptospirosis and chlamydiosis. The purpose of this study is to further develop our diagnostic capability for this disease and to determine the frequency of infection in Texas goat herds. A blood serum, acute and convalescent if possible, from all of the animals that abort and the rams will be tested. Fresh fetal placenta with cotyledons, heart blood, liver, heart, thymus, lung, kidney, spleen, diaphragm, mesenteric lymph nodes and portions of each of these tissues fixed in 10% buffered neutral formalin will be collected from all aborted fetuses and weak kids and lambs. A complete history of the herd including breed, size, sex, age and health status will be recorded. The antibody titers to T. gondii will be determined by the indirect fluorescent antibody test. Homogenates of tissues will be inoculated into mice intraperitoneally. Hematoxylin and eosin stained sections of the fixed tissues will be prepared by standard histologic techniques. Knowledge of the distribution and significance of T. gondii infection in Texas goat and sheep population will assist in the recommendations for the control of this disease and prevention of human infections.

THE INFLUENCE OF PERFORMANCE TRAITS ON SALE PRICE OF PERFORMANCE-TESTED RAMBOUILLET RAMS

Gary Snowder and Maurice Shelton

SUMMARY

The relation of sale prices received for performance-tested Rambouillet rams sold at public auction have been compared to their performance records. A total of 258 rams tested over a six-year period (1976-1981) were included. Body weight or final weight showed the highest correlation with sale price followed by index value. Other traits significantly correlated with price were rate of gain, wool production, staple length, face cover (negative), and body folds (negative). Significant differences existed in the prices paid for rams of different breeders or consignors, even when adjusted for index value. Attempts to predict sale prices based on performance data yielded R^2 values of 0.39 to 0.66 for various years.

INTRODUCTION

A public auction sale of the top indexing Rambouillet rams has followed the conclusion of the Sonora, Texas Experiment Station ram performance-testing program since 1976. The purpose of this study was to identify those traits which can be shown to have influenced the selling price of a Rambouillet ram. James (1) reported that performance-tested traits of boars were highly correlated to their selling price.

EXPERIMENTAL PROCEDURE

Data were collected from six annual auction sales of a total of 257 performance-tested Rambouillet rams. During each test period of approximately 140 days, rams were evaluated for daily gain (ADG), grease and clean wool production, yield, staple length and fiber diameter. Subjective scores for face covering, amount of belly wool, and degree of skin fold were assigned on a 1 to 4 basis with lower values as more desirable.

The rams were ranked according to the Registry of Merit (ROM) Index which is recognized by the American Rambouillet Sheep Breeders Association. The index is based upon important economic and production traits, characteristic to the Rambouillet breed. (I = 60 x

ADG in lbs. + 4 x staple length in inches + 4 x clean wool in lbs. - 3.0 x face cover score - 4.0 x skin fold score). The top 40% (30% in 1981) of all tested rams based on index, and which met certain independent culling levels were eligible for sale.

A second index used by Texas A&M University (TAMU) makes statistical adjustment for the relationship of body size to wool production, and places some emphasis on ewe fertility (I = 60 x ADG in lbs. + 4 x staple length in inches + 4 x adjusted clean wool in lbs. - 5 x face cover score - 4 x skin fold score + 2.5 for twin rams + 1.5 for twin rams out of 2-year old ewes). Since the TAMU Index partially corrects for the effect of initial size or wool production it should be more useful in comparing rams of different ages or sizes.

The data were analyzed on an annual and overall basis. Relationships between index values, individual traits, and selling prices were determined by correlation analyses. A stepwise regression procedure was used to determine which independent variables were important in predicting sale price. The degree to which breeder reputation was important in influencing selling price was estimated by using analyses of variance after sale prices had been adjusted for index value.

RESULTS AND DISCUSSION

The mean values of performance-tested traits of sale rams are shown in Table 1. There is little evidence of time trends over the short period covered and for this sub-sample of the total rams tested. The average ram offered for sale was an open-faced, smooth bodied ram weighing over 227 lbs. with an ADG of .770 lbs. and produced an estimated 11.9 lbs. of clean wool calculated on an annual basis.

Figure 1 represents the mean plus or minus two standard deviations of the selling price per year. Approximately 95% of all rams sold lie within the range of two standard deviations from the mean selling price. Variation in mean selling price between and within years was large. Over time there appears to be an increased interest in consignors and buyers resulting in a trend to increased prices. However, 1980 was an exception to this trend when a larger number of rams were sold. This, itself, may be a cause for lower prices, although economic conditions and wool prices in 1980 may have influenced sell price. Neville et. al. (2) found that prices for market hogs directly affected selling prices of performance-tested boars.

Mean prices received by individual consignors are reported in Table 2. These prices have been adjusted for differences in index value (ROM) and only the top 10 in a given year are listed. Except for 1978, significantly different prices were paid for rams belonging

to different breeders which were not accounted for by index values. Either some preference for rams from a particular flock was being shown or buyers were influenced by traits not given great importance in the index.

Correlation coefficients of performance traits to selling price are presented in Table 3. Final weight is the major effect on price. This is true even though there is considerable age variation in the rams, and final weight is to some degree a function of age. However, ADG was not highly related to price (r = .17). ROM index value shows the second highest relationship to sale price. Other factors having a significant relationship to price are grease and clean wool weight, staple length, and face cover (negative) and skin fold scores (negative). These values were all lower than expected. One explanation may be that the diverse breeding goals of individual flocks resulted in selection for different traits. Also, since the rams are offered for sale in a freshly shorn condition some selection for body conformation, a trait not measured, may have occurred.

Attempts were made to predict sale price based on a combination of traits having the most important relationship to price. The R^2 values varied from 0.39 to 0.66 for various years.

LITERATURE CITED

1. James, J. W. 1980. The analysis of sire buying policies. Ann. Genet. Sel. Anim. 12:33-47.

2. Neville, W. E. Jr., O. M. Hale, L. W. Grimes and W. C. McCormick. 1976. Factors affecting sale price of three breeds of performance-tested boars. J. Anim. Sci. 43:20-26.

Table 1. Yearly and Overall Mean Values of Performance Tested Traits of Rambouillet Rams

Year	No. Animals	Final Weight (lbs)	ADG (lbs)	Wool (lbs) Grease (12 Mo.)	Wool (lbs) Clean Basis	Yield (%)	Staple Length (in) (12 Mo. Basis)	Fiber Diameter (μ)	Face Cover Score	Skin Fold Score	Belly Wool Score	ROM Index	TAMU Index
1976	25	227.0	.777	21.8	11.7	53.5	4.9	22.0	1.5	1.4	2.2	102	100
1977	38	220.0	.792	22.2	12.3	55.4	4.8	22.3	1.6	1.4	1.8	106	101
1978	42	227.0	.810	22.0	11.0	50.0	4.9	22.0	1.6	1.7	2.1	101	97
1979	56	232.1	.739	22.7	12.1	53.4	5.2	20.3	1.6	1.7	2.2	101	--
1980	61	225.9	.750	21.3	10.8	50.5	5.1	21.0	1.4	1.4	2.0	99	97
1981	36	233.2	.757	24.6	13.2	53.6	5.1	21.6	1.4	1.3	1.8	109	107
Overall	258	227.5	.770	22.4	11.9	52.7	5.0	21.5	1.5	1.5	2.0	103	100

Figure 1. Mean Plus or Minus Two Standard Deviations of Selling Price (U.S. Dollars) of Rambouillet Rams, 1976-1981.

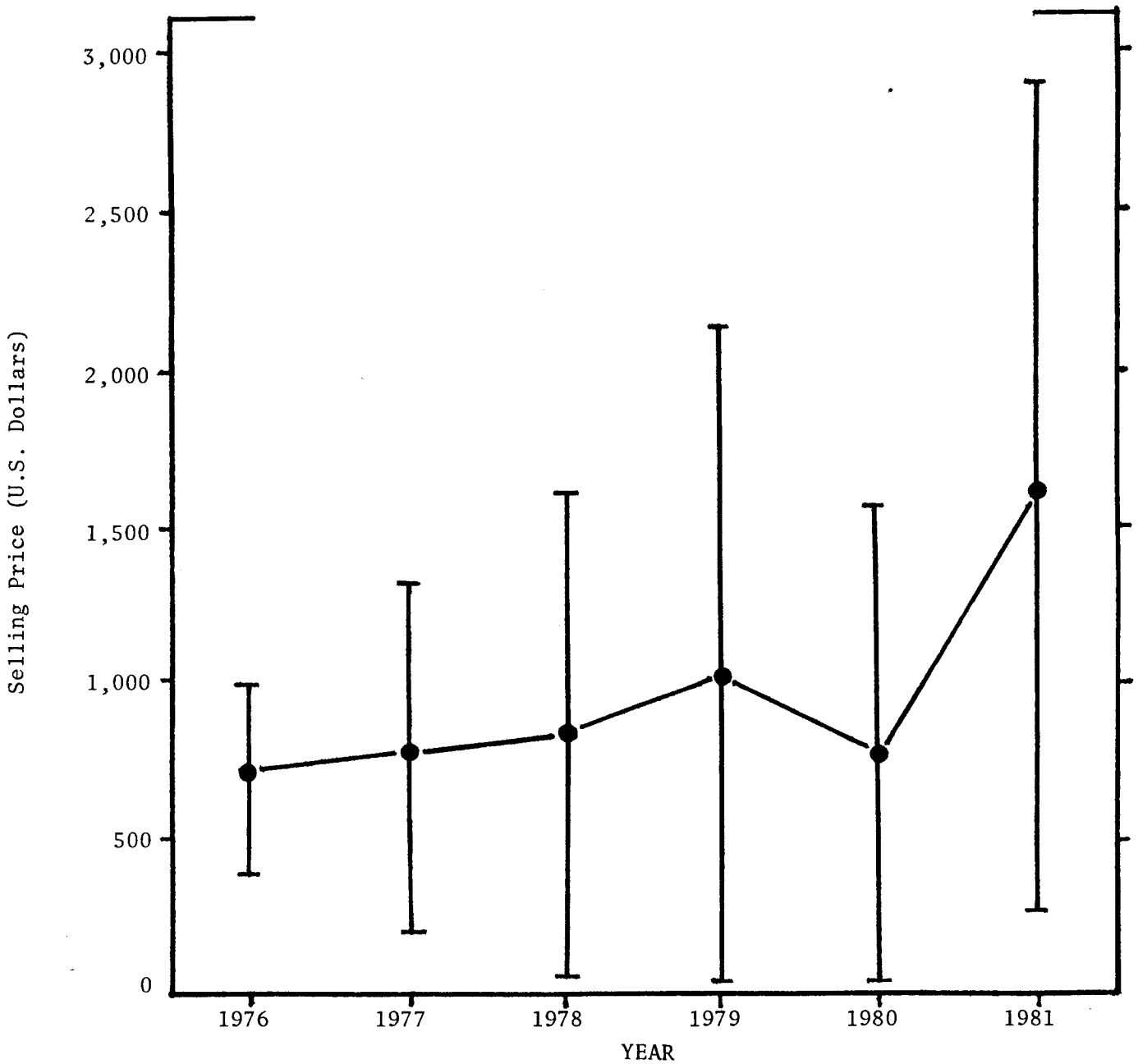

Table 2. Least Square Mean Price by Breeder for Performance-Tested Rambouillet Rams

ITEM	YEAR					
	1976	1977	1978	1979	1980	1981
Total number of breeders	14	28	32	41	49	40
Number of sale consignors	6	12	17	18	18	15
Number of rams sold	25	38	42	56	61	36
Average sale price, U.S. dollars	664	823	881	1,050	837	1,544
Consignments[c] and average price received						
First, number of rams	3	2	2	10	2	3
mean sale price	1,146[a]	1,738[a]	1,847[a]	2,407[a]	2,619[a]	3,839[a]
Second, number of rams	4	1	3	2	8	2
mean sale price	747[b]	1,316[a]	1,613[a]	2,216[a,b]	1,032[b]	3,671[a]
Third, number of rams	11	8	2	2	3	1
mean sale price	653[b]	1,033[b]	1,303[a]	1,677[a,b]	1,015[b]	2,092[a,b]
Fourth, number of rams	4	4	3	1	1	1
mean sale price	528[b]	1,007[b]	1,079[a]	1,381[a,b]	987[b]	1,909[a,b]
Fifth, number of rams	1	4	4	1	2	7
mean sale price	402[b]	769[b]	1,052[a]	1,080[a,b]	974[b]	1,623[b]
Sixth, number of rams	2	4	2	2	1	2
mean sale price	245[b]	768[b]	829[a]	1,063[a,b]	894[b]	1,502[b]
Seventh, number of rams		5	4	1	2	1
mean sale price		712[b]	793[a]	867[a,b]	875[b]	1,198[b]
Eighth, number of rams		3	1	1	14	3
mean sale price		583[b]	787[a]	859[a,b]	826[b]	1,162[b]
Ninth, number of rams		2	1	12	10	1
mean sale price		493[b]	786[a]	831[b]	806[b]	1,135[b]
Tenth, number of rams		2	7	1	1	1
mean sale price		442[b]	779[a]	756[b]	757[b]	1,134[b]

[c]Only the top ten selling consignors are listed, though statistical analysis considered all consignors. Mean sale prices with different subscripts [a,b] are significantly different ($P<.05$).

Table 3. Correlations of Performance-Tested Traits and Selling Price of Rambouillet Rams (1976-1981)

	PRICE						
	Year						
Trait	1976	1977	1978	1979	1980	1981	Overall
Final Weight	.45[a]	.34[a]	.30	.58[a]	.53[a]	.61[a]	.49[a]
ADG	.06	.09	-.02	.36[a]	.36[a]	.29	.17[a]
Grease wool weight	.33	.30	.03	.15	.25	.20	.25[a]
Clean wool weight	.55[a]	.38[a]	.08	-.03	.18	.07	.19[a]
Clean wool yield	.37	.18	.04	-.23		.09	-.07
Staple length	-.17	.35[a]	.10	.14	.31[a]	-.22	.14[a]
Fiber diameter	-.46[a]	-.19	-.02	-.03	-.19	.05	-.09
Face cover score	.30	-.24	-.42[a]	-.26	-.26[a]	-.31	-.25[a]
Skin fold score	-.02	-.08	-.33[a]	-.20	-.20	-.31	-.21[a]
Belly wool score	.30	.00	.09	.15	-.03	.11	.04
Birth type	-.19	-.01	-.14	.30	.24	.02	.11
ROM Index	.32	.52[a]	.24	.36[a]	.57[a]	.32	.39[a]
TAMU Index	-.22	.28	-.07		.51[a]	.18	.24[a]

[a] Correlation coefficients are significant ($P \leq .05$)

PRELIMINARY OBSERVATIONS ON RESULTS OF CROSSING ANGORA AND MEAT-TYPE (SPANISH) GOATS

Phil Thompson and Maurice Shelton

SUMMARY

Preliminary data are reported on mohair and kid production from pure Angora and first cross (F1) and backcrosses to Angora. A very low level of low value fiber was obtained from the crossbred types. Kid production favored the crossbred groups, but based on the mohair prices during this period of the study the income greatly favored pure Angoras. This study also suggests that a long period of time would be required to grade up suitable Angora from a non-Angora type, and that this practice should be discouraged.

INTRODUCTION

During the decade of the 60's, low mohair prices and the resultant low demand for replacement stock tempted many producers to cross their Angora does to Spanish meat-type males to improve the meat qualities of their offspring. The recovery of mohair prices in the decade of the 70's, no doubt, resulted in some of these being graded back to Angoras to capitalize on the demand for increased numbers of Angora types. Although there was considerable producer experience with this practice dating back to the early days of the industry in the U.S., no research data were available on the level of production from these crossbred or to what degree the grading up process would contribute to a kemp problem. A study was initiated in 1978 with a small number of goats at the leased Winters Ranch near Brady, Texas to provide some data on this question. This preliminary report provides some data on the mohair and kid production of these crosses compared with pure Angora. A more complete report will be prepared at a later date which will also include fiber diameter measures.

EXPERIMENTAL PROCEDURE

Animals initially used in this experiment were from the 1977 kid crop on the Winters-Wall Ranch at Brady, Texas. Angora females were from a flock of grade Angora does. All Angora x Spanish females (F1) used were offspring from Spanish does resulting from the use of Angora males as cleanup males. Some 1/2 Spanish yearlings were added for age group comparisons in 1981. All breeding age does were weighed and

exposed to Angora billies for a minimum of 60 days on approximately October 15. Does were kidded out in barns to record individual birth dates and isolate any rearing problems. All kids were weaned in August with weaning weights recorded in the hair. Female kids were replaced into the flock to produce 3/4 (backcross) and 7/8 Angora types.

The animals were managed as one group, and thus feed and labor costs were essentially the same except that first-cross females were sheared only once per year. In commercial practice, the two types would no doubt receive differential levels of management. Fleece data was recorded on all animals during February. No data was taken from Angora and Spanish does (1/2 Spanish) at the August shearing since they were shorn only once per year in the spring. Data measurements recorded were average staple length, grease fleece weight, and shorn body weights. Prior to shearing, a mohair patch sample was taken from the shoulder area from each individual for analysis by the Wool and Mohair Laboratory at Texas A&M University. These data are not available at this time.

RESULTS AND DISCUSSION

Reported in Table 1 and 2 are mohair and kid production from Angora and crossbred types. All data are reported on the doe flocks. Angora does produced significantly more mohair fiber than did the 1/2 Spanish goats or any of their progeny. The data shows that 6-month fleeces from grade Angora were twice as heavy as 12-month Spanish fleeces at their common shearing dates in the spring. Half Spanish fleeces on a 12-month basis produced long staple fiber, high yielding fine fleeces, but lacked density, weight, and the does lacked overall body cover. The mohair collected from this experiment was sold by breed groups at a local commission warehouse. The actual income from the mohair and estimated value of the kids (in the hair) is reported in Table 3.

The 3/4 Angora offspring from the 1/2 Spanish does were shorn on a 6-month schedule. Average staple length is more similar to the Angora does and greater than their dams. These does also doubled the total fiber production of their dams, but this was significantly less than the Angoras. Fleeces from 3/4 Angora does lacked in density and body coverage. Monetary returns for this fiber was higher than 1/2 Spanish fleece due to the definite weight advantage. As the 3/4 Angora does have matured, their shorn body weights more closely compare with those of the Angora does. No doubt 1/2 and 3/4 groups had large amounts of kemp, but data on this is not available at present.

The prices received for the crossbred hair was very low, compared to that from pure Angoras. The prices received might have been better

if a larger supply were available. It is known that at times special uses exist for crossbred hair if it was available in sufficient volume to access this market.

As expected, kid production tended to favor the crossbred types. Kid production from each group, especially the Angoras, is generally favorable compared to estimates of that occurring in the industry. Large size differences favored the crossbred does and this is no doubt a major contributing factor to the increased reproductive rate (1,2,3). Since the kids were not all sold, estimated values in the hair was placed on the kids produced and is reported in Table 3. These data suggest that based on prices received during the period of this study, the Angora produced much more income than the crosses.

It should also be pointed out that although initial matings in this effort was initiated in 1977, only 3/4 females were available in 1982 with 7/8 kids on the ground. This indicates the time span required in the grading up process. If crossbred females were kept for a normal productive life, over 20 years would be required to develop a flock of high grades and likely an even longer time to eliminate kemp as a problem in the flock.

LITERATURE CITED

1. Menzies, J. W. 1968. Effect of Angora doe size on kid and mohair production. PR 2524.

2. Shelton, Maurice. 1965. The relation of size to breeding performance of Angora goats. PR 2339.

3. Shelton, Maurice and J. R. Stewart. 1973. Partitioning losses in reproductive efficiency in Angora goats. PR 3187.

Table 1. Fleece Weights and Body Weights of Angora, F1, and Backcross Does

Year and Season	Angora				1/2 Angora				3/4 Angora			
	No.	Age	Fleece Wt.	Body Wt.	No.	Age	Fleece Wt.	Body Wt.	No.	Age	Fleece Wt.	Body Wt.
2/79	26	2	4.2	52.1	25	2	1.4	72.0				
8/79	25	2	3.9	50.5								
Year total or mean			8.1	51.3								
2/80	24	3	3.4	57.8	24	3	1.7	82.2	14	1	1.4	41.4
8/80	22	3	3.7	51.1					11	1	1.5	50.7
Year total or mean			7.1	54.5							1.45	46.1
2/81	28	4	4.7	70.5	22	4	1.6	81.4	19	2	2.2	40.6
8/81	30	4	4.5	59.5					24	2	2.2	61.7
Year total or mean			9.2	65.0							2.2	51.1
2/82	31	Mixed	3.9	61.2	32	Mixed	1.4	69.4	31	2&3	2.8	60.2

Table 2. Reproductive Performance of Angora, F1, and Backcross Does

Year	Age	No.	Breed Wt.	% Kidding	% Kids Born	% Kids Weaned	Weaned Wt. of Kids
	ANGORA						
79	2	27	49.5	74.1	88.9	66.7	37.2
80	3	24	56.4	79.2	91.7	79.2	29.2
81	4	30	54.4	92.9	110.7	100.0	41.0
82	Mixed	31	76.7	80.6	100.0	87.1(marked)	
	1/2 ANGORA						
79	2	25	67.3	72.0	112.0	104.0	44.8
80	3	25	75.8	96.0	164.0	148.0	38.4
81	4	22	75.3	100.0	140.9	131.8	50.9
82	Mixed	24	92.6	79.4	120.6	111.8(marked)	
	3/4 ANGORA						
81	2	11	57.6	100.0	150.0	100.0	47.2
82	2&3	30	81.3	93.5	119.4	87.1(marked)	

Table 3. Estimated Income from Three Types of Does for the Years 1979-81

Year	Angora		1/2 Angora		3/4 Angora	
	Gross Income From Mohair[1]	Est. Gross Income From Kids	Gross Income From Mohair[1]	Est. Gross Income From Kids	Gross Income From Mohair[1]	Est. Gross Income From Kids
1979	38.04	26.66	1.04	26.00	--	--
1980	18.00	23.76	1.91	37.00	2.82	--
1981	26.35	40.00	0.97	32.95	5.48	25.00

[1] Less shearing costs

ANGORA GOAT PERFORMANCE TEST

J. L. Groff, M. Shelton and J. W. Bassett

An Angora goat performance test was initiated in 1980 to assist the industry in identifying and developing more productive animals. Research animals from T.A.E.S. flocks and billies from both stud and commercial breeders were entered for a 112 day feeding period. A total of 111 males from 20 flocks or owners completed the initial test. After an initial three weeks adjustment period, all animals were shorn, weighed and placed on feed. Animals were weighed at 28-day intervals and were sheared again at the completion of the feeding period. Data recorded and variations shown are as follows:

Trait	Range
Final body weight, lbs.	160 - 78 pounds
Average daily gain, lbs.	0.60 - 0.15 pounds
Grease fleece weight, lbs.	24.5 - 7.0 pounds
Clean fleece weight, lbs.	16.0 - 5.7 pounds
Clean yield, %	82.5 - 47.4 percent
Lock length, inches	7.3 - 4.3 inches
Fiber diameter, microns	55.3 - 32.3 microns
Face cover, 0-5	5.0 - 0.0 score
Neck cover, 0-5	4.9 - 0.5 score
Belly cover, 0-5	4.8 - 1.4 score
Kemp, 0-5	4.3 - 0.3 score
Character, 0-5	5.0 - 0.7 score
Luster, 0-5	4.9 - 0.5 score

A selection index was empirically derived for initial utilization and consideration until more accurate data are available for constructing a valid selection index. The index is as shown:

I = 4 x adjusted clean fleece weight + 40 x average daily gain + 0.12 x final body weight + 2 x average lock length - 0.8 x fiber diameter - 3 x face cover score + character score + belly cover score + neck cover score.

Index values ranged from 81.0 to 26.7 reflecting the tremendous variation in the animals on this first test.

A second test was started in February 1982 with 195 billies from 31 producers starting the feeding program. As a result of this performance test it will be possible to make reliable estimates of genetic and phenotypic parameters which will greatly assist in more efficient selection for genetic improvement within the Angora goat industry.

ALTERNATIVES TO INCREASE ECONOMIC EFFICIENCY OF RANCH FIRMS IN THE EDWARD'S PLATEAU

Robert E. Whitson
Gwynne K. Lundgren

SUMMARY

A fifteen year linear programming model was specified for a representative owner/operator ranch firm in the Central Edwards Plateau region of Texas. The principal activities in the model included alternative grazing systems; cattle, sheep, Angora goats singularly or in combinations; brush control alternatives and integration of stocker steers in the ranch firm. The most profitable grazing system when averaged across all livestock combinations was the short duration system; the most profitable livestock combination was cattle and Angora goats (50:50). Mesquite was most often found to be controlled profitably with the herbicide 2,4,5,-T. For all grazing/livestock combinations steers could be profitably maintained on the ranch only 40% to 50% of the time.

INTRODUCTION

Linear programming is an optimization tool used to maximize a given parameter, such as profit, subject to limited resources. The profit function was to be maximized and was composed of costs and sales over the fifteen year period. All sales and costs were expressed in 1980 dollars and a ten percent annual real discount rate was selected to represent a return to capital and risk.

PROCEDURE

The Edward's Plateau representative ranch was 4065 Ha. of which 340 Ha. were cropland. Brush problems considered were honey mesquite/pricklypear on the deep sites and blueberry juniper on the shallow sites. 2-4-5-T, 2-4-5-T plus picloram (1:1), rootplowing, overestablishment of Kleingrass. Juniper was controlled with chaining (2 way) or tree dozing (grubbing). Grazing systems analyzed included 1) a yearlong grazed, properly stocked system, 2) a four-pasture, three-herd, deferred rotation system, 3) a ten-pasture, one-herd, short duration system, and 4) an overgrazed (20% over "properly stocked") continuously grazed system. Livestock considerations included 1) cattle:sheep (50:50), 2) cattle:sheep:Angora goats (45:27.5:27.5), 3) cattle:goats (50:50), or 4) sheep:goats (50:50). Stocker steer calves were allowed to be maintained on small grains or on rangeland in the model.

RESULTS AND DISCUSSION

Results of this study indicate that ranch managers who are willing to properly adopt planned grazing systems and utilize combination live-

stock in the eastern half of the Edward's Plateau can expect net returns per Ha. to increase significantly over time.

For the representative ranch, when shifted from an overgrazed yearlong cow/calf operation to a planned grazing system resulted in net returns to land, management, and owner capital increasing by 20% to 40%. By further utilizing combination livestock of cattle: goats (1:1), net returns were estimated to increase an additional 35% to 38%. Maintaining steers was determined to be profitable from 40% to 50% of the time. If maintained only when profitable, steer calves on small grains increased annual net returns from seven percent to fifteen percent; steers on rangeland increased net returns four percent to ten percent. Mesquite control on deep sites was profitable when 2,4,5-T was available but marginally so when 2,4,5-T plus picloram was utilized. Juniper control on shallow sites was not profitable for any grazing system/livestock combination. However, brush control and improved grass establishment was estimated to be less profitable per dollar invested than the establishment of a planned grazing system.

AN INVESTIGATION OF LIVE ANIMAL MEASUREMENTS AND CARCASS TRAITS OF MEAT-TYPE (SPANISH) GOATS

Gary Snowder, Maurice Shelton and G.C. Smith

SUMMARY

Live animal and carcass measurements on 95 intact male meat-type (Spanish) goats were studied to characterize the goat population and to determine if carcass traits could be improved through selection based on live animal measurements. Live animal measures (i.e., body weight, chest depth, chest width, loin width, loin length, hip height and body length) were not highly correlated to carcass traits when adjusted for body size. The major part of the carcass weight was found in the leg (31.7%) and shoulder (34.9%). Overall, the carcasses were lean, having a very thin layer of subcutaneous fat and an average kidney and pelvic fat depot of only 0.28 pounds. Variation between sire groups tended to be small, resulting in low and erratic values for heritability estimates.

INTRODUCTION

Most of the world's population of approximately 400 million goats are exploited primarily for meat (including by-products) and skins. Fiber types (Angora and Cashmere) and established dairy types constitute a rather small part of the total world population. Overall, goats contribute significantly to the world human food needs. This contribution is often increased by the practice of milking non-dairy goats for human consumption.

Although the majority of the goat population in Texas is Angora, Spanish goat numbers have increased over the years. Normally the income realized from Angora goats substantially exceeds that of meat goats, both on an industry and on an individual animal basis. However, Angora production is a much more labor-intensive industry. Those producers who elect to run meat goats usually do so because they have browse to be utilized and do not wish to invest the greater amount of labor required to do a good job with Angora goats.

Little research has been accomplished on goats kept for meat production. The present study was performed to characterize the population and to explore the possibilities of improving meat production traits through selection.

MATERIALS AND METHODS

A flock of Spanish-type goats is being maintained by the Texas Agricultural Experiment Station at the Winters Ranch near Brady, Texas. A portion of the male kids from the 1980 kid crop was used for the present study. Male kids with known sires were weaned in mid-summer. They were

moved to San Angelo and maintained on pasture for a few weeks; during that time most of them lost weight. Following this, they were put in dry-lot on a performance test primary emphasizing growth rate. After this test-period a few were selected for use as breeders and the remainder (95 head) were scheduled for slaughter through the Meats Laboratory at the Department of Animal Science in College Station. However, some time delay was involved in scheduling slaughter. During this time the goats were turned back to poor quality pasture; again, most of them lost weight. At the time of slaughter the animals were approaching one year of age and thus, might be referred to as kids or yearlings. It should be pointed out that this is an atypical slaughter animal (one-year-old intact male kids). However, this is the age and sex on which selection would most likely be practiced.

Various live animal measures were made shortly before slaughter. These include chest width, chest depth, loin width, loin length, hip height and total body length. The animals were subsequently delivered to College Station where they were slaughtered, graded (according to USDA standards for lamb carcasses) and fabricated into wholesale cuts (using cutting methods identical to those used for lamb carcasses).

RESULTS

The means, standard deviations and ranges for live animal and carcass traits are shown in Table 1. Although the ranges of the traits are considerable, the animals were fairly uniform in size as indicated by the relatively small standard deviations for each trait. The mean dressing percentage of 49.6% may be somewhat elevated due to the animals having been hauled, and in some cases held for a time, before slaughter. In general, the carcasses were very lean. Although not reported here, the subcutaneous fat layer was almost non-existent and the average kidney and pelvic fat depot weighed only 0.28 pounds. Since these animals were intact males this no doubt reduced their tendency to deposit fat, but it is well established that goat carcasses are lean compared to other species of farm or ranch livestock (Smith et al., 1982 and Gall, 1982). The major part of the carcass weight was found in the leg (31.7%) and shoulder (34.9%). Compared with ram lambs (Kemp et al., 1970), these goats had higher percentages of their carcass weight in the leg and shoulder and lower percentages of their carcass weight in loin and in kidney and pelvic fat.

The correlations among live animal measurements are shown in Table 2. The correlation coefficients are all statistically significant except for the relationship of hip height to loin length. However, this statistic is based on only 28 values and may not be a good estimate of this relationship. Although most of the values are statistically significant they tend to be lower than might have been expected. The explanation for this is not clear, but may represent poor repeatability in making body measurements. Only one measurement of a trait for each goat was obtained so it is not posssible to estimate repeatability. Table 2 also contains correlation coefficients which have been adjusted for body weight to reduce the influence of size on the measurement value; all these values are of low magnitude and not significant.

The correlations among carcass traits in both pounds and percentages are shown in Table 3. The correlations based on weights are all significant and of a high magnitude; this would be expected with the range in weight among these carcasses. The correlations based on percentages are of much lower magnitude, but still a number are significant. Perhaps the most significant is the negative relationship between the percentage of leg and carcass weight as well as certain other carcass components, especially the breast, shoulder and rack. The negative relationship between leg and carcass weight confirms similar data obtained from other species that as the intact male matures the forequarters increase in size compared to the rear quarters. Also, with a fixed quantity (carcass weight), as the forequarters increase, the leg must decrease as a percentage of the total.

The correlations of various live measures to carcass traits are shown in Table 4. Correlation coefficients are reported for actual live measures with both weights and percentages of carcass components. When expressed in actual weight the coefficients are essentially all significant and some are of high magnitude. This would be expected since the larger animals would show an advantage in both respects. When the carcass traits are expressed in percentages, the magnitude of the correlations is greatly reduced and most are not significant. Similarly, if both sets of values are adjusted for size the relationships become very small. These data suggest a very low predictive value for live animal measures as they relate to carcass traits. However, since some of the values are significant one should not completely rule out the use of body measures. For instance, several measures of forequarter size (i.e., chest width or depth) are negatively related to leg weight. Thus, with further study it might be possible to develop more refined measures of forequarter volume which would have some value in selecting for increased leg weight. However, since growth and sexual maturity of males result in increased forequarter weight, caution should be exercised to insure that such selection does not result in reduced sexuality or fertility in the male or in their female relatives.

Sire means for a number of the traits studied are shown in Table 5. A total of six sires had a meaningful number of offspring in the group slaughtered. Variations between the sires in the various traits is small, and in many cases the observed differences tend to be explained by differences in body weight. This suggests that it may be difficult to obtain substantial selection differential for carcass traits or, in other words, to find sires which are recognizably superior. The authors do not interpret this to mean that such efforts should not be made, but only that it will be difficult. Perhaps because of the small differences among sires and the overall low variability in size, attempts to obtain heritability estimates yielded values of low magnitude.

LITERATURE CITED

Kemp, James D., J.D. Crouse, W. Deweese and W.G. Moody. 1970. Effect of slaughter weight and castration on carcass characteristics of lambs. Journal of Animal Science 30:348.

Smith, G.C., R.R. Riley, J.W. Savell and M. Shelton. 1982. Yields of carcass and dress-off items and carcass quality-quantity measures for Angora and Spanish goats. Proceedings Third International Goat Conference pp. 469-471.

Gall, C.F. 1982. Carcass composition. Proceedings Third International Goat Conference pp. 472-487.

Table 1. Overall means of live and carcass measures in intact male Spanish goats

Item	No.	Mean	Deviation	Range
Liveweight, lb.	95	57.72	7.74	42.0 - 82.0
Chest width, cm.	95	15.54	1.40	12.3 - 20.5
Chest depth, cm.	95	26.13	1.70	20.9 - 30.0
Loin width, cm.	95	8.47	.72	7.2 - 11.0
Loin length, cm.	95	17.90	1.96	14.6 - 24.0
Body length, cm.	95	55.59	3.00	49.5 - 66.0
Hip height, cm.	28	61.60	3.44	55.2 - 67.1
Hot carcass weight, lb.	95	28.64	4.73	20.2 - 49.2
Percent (of live wt.)	--	49.62		
Total leg, lb.	95	9.08	1.38	6.8 - 14.8
Percent (of carcass wt.)	--	31.74		
Loin, lb.	92	2.36	.52	1.5 - 4.5
Percent (of carcass wt.)	--	8.24		
Rack, lb.	92	2.42	.48	1.5 - 4.0
Percent (of carcass wt.)	--	8.45		
Total shoulder, lb.	95	9.98	1.77	7.2 - 18.4
Percent (of carcass wt.)	--	34.85		
Total shank, lb.	95	1.91	.32	1.4 - 2.9
Percent (of carcass wt.)	--	6.67		
Breast, lb.	95	2.64	.55	1.2 - 4.3
Percent (of carcass wt.)	--	9.22		
Kidney and pelvic fat, lb.	94	.28	.07	.2 - .5
Percent (of carcass wt.)	--	.98		

Table 2. Correlation coefficients[a] among live animal measurements for intact male Spanish goats

Trait	Live Weight	Chest Width	Chest Depth	Loin Width	Loin Length	Body Length
Chest width	.6841					
Chest depth	.5847	.3665				
Adjusted[b]		-.057				
Loin width	.5393	.3903	.2948			
Adjusted[b]		.035	-.030			
Loin length	.5837	.3159	.3531	.2622		
Adjusted[b]		-.141	.018	-.077		
Body length	.5788	.4398	.4486	.4352	.3789	
Adjusted[b]		.074	.167	.179	.062	
Hip height	.5084	.5816	.2035	.3923	.0562	.4888
Adjusted[b]		.352	-.079	.270	-.069	.296

[a]Correlation coefficients greater than or equal to .195 are significant ($P<.05$)

[b]Adjusted for body weight

Table 3. Correlation coefficients[a] among carcass traits in intact male Spanish goats

Trait	Trait						
	Leg	Loin	Rack	Shoulder	Shank	Breast	Kidney and pelvic fat
Loin, lb.	.865						
Percent	-.287						
Rack, lb.	.835	.804					
Percent	-.225	.0756					
Shoulder, lb.	.920	.851	.810				
Percent	-.207	-.1947	-.2343				
Shank, lb.	.880	.827	.794	.838			
Percent	.0821	-.0653	-.106	-.224			
Breast, lb.	.798	.739	.733	.749	.822		
Percent	-.274	-.0931	-.0903	-.437	.2102		
Kidney and pelvic fat, lb.	.603	.636	.543	.559	.617	.621	
Percent	-.154	.1478	-.0724	-.1645	.0364	.1124	
Hot carcass wt. lb.	.974	.907	.879	.961	.905	.846	.643
Percent	-.206	.3439	.116	.0310	-.2290	-.0174	-.0446

[a]Correlation coefficients greater than or equal to .195 are significant ($P<.05$)

Table 4. Correlation coefficients[a] among live and carcass measures in intact male Spanish goats

Carcass Measures	Live Measures						
	Live Weight	Chest Width	Chest Depth	Loin Width	Loin Length	Body Length	Hip Height
Hot carcass	.7629	.6897	.4350	.5075	.3350	.4396	.4673
Total leg, lb.	.7417	.6681	.4043	.5168	.3435	.4128	.4819
Percent	-.342	-.321	-.269	-.113	-.100	-.233	
Loin, lb.	.6309	.6086	.2813	.3875	.2181	.3540	.3696
Percent	.131	.201	-.080	.029	-.005	.047	
Rack, lb.	.6561	.5823	.3332	.4172	.1036	.3450	.2687
Percent	.048	.046	-.022	.013	-.311	-.006	
Total shoulder, lb.	.7216	.6673	.4480	.4977	.3370	.4510	.5434
Percent	.012	.057	.141	.035	.076	.139	
Shank, lb.	.7383	.5788	.4376	.4305	.3418	.4924	.3425
Percent	-.046	-.252	-.013	-.084	-.011	.164	
Breast, lb.	.6873	.5968	.4523	.3944	.3604	.3470	.1498
Percent	.183	.111	.205	.049	.180	.015	
Kidney and pelvic fat, lb.	.5405	.5687	.1728	.2953	.2417	.3303	.1836
Percent	-.005	.095	-.175	-.078	.022	.001	

[a]Correlation coefficients greater than or equal to .195 are significant ($P<.05$)

Table 5. Progeny means of live and carcass measures in intact male Spanish goats

Trait / Sires:	W 14		W 47		Y122		2243		2245		719	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Leg, %	10	31.27	7	31.72	21	31.96	13	32.48	8	32.01	10	31.01
Loin, %	10	8.61	7	8.24	19	8.22	13	7.82	8	8.33	10	8.29
Rack, %	10	8.58	7	8.70	19	8.39	13	8.34	8	8.59	10	8.39
Shoulder, %	10	34.72	7	34.88	21	34.76	13	35.29	8	34.86	10	35.45
Shank, %	10	6.43	7	6.79	21	6.51	13	5.82	8	6.78	10	6.49
Breast, %	10	9.19	7	8.71	21	9.23	13	8.99	8	8.77	10	8.94
Kidney and pelvic fat, %	10	.96	7	.98	21	.97	13	.93	7	.94	10	1.00
Carcass, weight, lb.	10	28.08	7	27.63	21	29.85	13	26.69	8	26.61	9	30.09
Live weight, lb.	10	55.70	7	60.57	21	58.29	13	55.31	8	55.25	10	59.60
Chest width, cm.	10	15.93	7	15.54	21	15.87	13	15.03	8	14.99	10	15.57
Chest depth, cm.	10	25.67	7	25.93	21	26.20	13	25.88	8	25.29	10	26.27
Loin width, cm.	10	8.47	7	8.93	21	8.53	13	8.21	8	8.40	10	8.41
Loin length, cm.	10	17.12	7	17.94	21	18.17	13	16.93	8	17.61	10	18.90
Body length, cm.	10	54.99	7	56.24	21	55.43	13	54.59	8	56.19	10	55.67

PALATABILITY OF LAMB, MUTTON AND GOAT MEAT

C.L. Griffin, M.W. Orcutt, G.C. Smith, J.W. Savell and M. Shelton

SUMMARY

Leg steaks and loin chops from carcass of thirty young intact males and thirty aged females of Rambouillet, Karakul or Barbado sheep and of Angora or Spanish goats were evaluated by members of two untrained sensory panels each comprised of ten persons. Flavor, juiciness, tenderness and overall palatability were scored by the panelists utilizing eight-point hedonic scales. Scores of panelists from foreign countries generally were higher than those of their domestic counterparts. Samples from Rambouillet, Karakul and Barbado sheep received higher palatability ratings than did samples from Angora or Spanish goats.

INTRODUCTION

To aid lesser-developed countries in increasing meat consumption in conjunction with providing a commodity for internal trade, several researchers have investigated the feasibility of utilizing native sheep and goats of those countries (1, 3, 4, 5, 6, 7, 8). In those studies, meat production was emphasized while palatability characteristics were considered of little significance.

In the United States, consumption of meat from sheep and goats is less than that of most other countries. In addition, there seems to be a general dislike among U.S. consumers for lamb, mutton and goat meat. Such cultural differences may make it difficult to extrapolate sensory data collected in the United States and results of such studies to circumstances extant in lesser developed countries.

The purpose of the present study was to determine if differences in sensory perceptions existed between people from the U.S. and people from foreign countries when they evaluated cooked samples of meat from different breeds and ages of sheep and goats.

EXPERIMENTAL PROCEDURE

Six young intact males and six aged females of each breed-species group (Rambouillet, Barbado or Karakul sheep and Angora or Spanish goats) were randomly selected for slaughter. At 48 hr postmortem, loin chops and leg steaks (1.5 cm) were cut, double-wrapped in freezer paper and stored (-10°F) until used. Chops and steaks were thawed (16-18 hr; 34°F) and cooked on broiler racks in 350°F ovens to an internal temperature of 160°F. Chops and steaks were trimmed of exterior fat and connective tissue and were served while still warm to each of the panelists.

Panel members were students (10 female; 10 male) from Texas A&M

University. Their ages ranged from 19-30 yr and all had eaten and had no dislike for lamb, mutton or goat meat. Panelists on the foreign panel (n=10) represented the countries or areas of Taiwan, India, Mexico, Palestine, Saudi Arabia, Venezuela and Vietnam.

Panelists were instructed in filling out the score sheet but were not trained to evaluate sensory characteristics of the cooked meat. Eight-point hedonic scales were used to evaluate juiciness (8 = extremely juicy; 1 = extremely dry), tenderness (8 = extremely tender; 1 = extremely tough), flavor and overall palatability (8 = extremely desirable; 1 = extremely undesirable).

RESULTS AND DISCUSSION

Mean sensory panel ratings for the complete population of chops and steaks are presented in table 1. For loin chops, ratings for flavor, juiciness, tenderness and overall palatability were statistically equivalent ($P>.05$) for the foreign and domestic panels. For leg steaks, ratings for flavor, tenderness and overall palatability were higher ($P<.05$) for the foreign panel than for the domestic panel. Loin chops from Rambouillet, Barbado or Karakul sheep were rated higher ($P<.05$) in tenderness than were those from Angora or Spanish goats (table 2). For flavor, loin chops from Rambouillet sheep were superior to those from Karakul sheep. For juiciness, loin chops from all three breeds of sheep were superior to those from Spanish goats. These data suggest that loin chops from Rambouillet sheep differ little in palatablity from those of Barbado sheep ($P>.05$ in 3 of 4 traits) or of Karakul sheep ($P>.05$ in 3 of 4 traits) but are more palatable than those from Angora ($P<.05$) in 2 of 4 traits) and Spanish ($P<.05$ in 2 of 4 traits) goats.

Data for leg steaks (Table 2) reveal that those from Rambouillet sheep did not differ from those from Karakul sheep but were more palatable than those from Barbado sheep ($P<.05$ in 4 of 4 traits), from Angora goats ($P<.05$ in 3 of 4 traits) and from Spanish goats ($P<.05$ in 3 of 4 traits). For these sensory panel members, goat meat is not the equal of lamb-sheep meat in either juiciness or tenderness; flavor of goat meat, however, was not inferior to that of meat from lambs or sheep.

These data concur with data of others (9) who have found that cooked meat from Angora goats is less desirable than that from lamb. However, data of the present study show meat from Spanish goats to be less desirable in juiciness, tenderness and overall palatability than that from the three sheep breeds which disagrees with a previous report (9).

Some researchers have reported that a stronger influence on palatability is exerted by an animal's sex than by its breed (2). In the present study (table 3), no differences in juiciness, tenderness and overall palatability ratings were observed between cooked meat samples from young intact males and those from aged females. However, flavor of loin chops was rated higher (more desirable) for samples from aged females than for samples from young intact males.

Data of this study suggest little difference between panelists from the United States and those from foreign countries in terms of their perception of palatability differences between cooked samples of goat, lamb or sheep meat; foreign panelists appear to be less critical of ovine and caprine samples in terms of their palatability in a like-dislike or in an acceptability-unacceptability context. Results further suggest that attempts to characterize such meats in regard to their acceptability to consumers in a foreign country by use of sensory panel data collected in the U.S.A. using U.S. citizens might not be appropriate.

Results of this study also indicate that Rambouillet and Karakul sheep produce meat that is more tender than that from Angora and Spanish goats. Goats and sheep differed little in flavor of cooked meat.

LITERATURE CITED

Congiu, F. (1978). Rivista di zootecnia e Veterinaria. 4, 249.
Crenwelge, D.D., Smith, G.C., Shelton, M. and Carpenter, Z.L. (1978). J. Anim. Sci. 46, 282.
Dakadghao, A.H., Upadhayay, V.S. and Rekib, A. (1976). In. Vet. J. 35, 535.
Fehr, P.M., Stauvant, D., Delage, J., Dumont, B.L. and Roy, G. (1976). Lvstk. Prod. Sci. 3, 183.
Gaili, E.S.E., Ghanam, Y.S. and Mukhtar, A.M.S. (1972). Anim. Prod. 14, 351.
Owen, J.E. (1975). Trop. Sci. 17, 123.
Richetti, F. (1975). Acta Medica Veterinaria 21, 25.
Riley, R.R., Shelton, M., Savell, J.W. and Smith, G.C. (1982). J. Anim. Sci. (submitted).
Smith, G.C., Pike, M.I. and Carpenter, Z.L. (1974). J. Fd. Sci. 39, 1145.

Table 1. Mean sensory panel ratings for loin chops and leg steaks from the complete population (breeds, species, age groups combined) as evaluated by domestic and foreign panelists

Cut	Trait	Domestic panel (n=60)	Foreign panel (n=60)
Loin chops	Flavor	5.2[a]	5.3
Loin chops	Juiciness	5.0	5.1
Loin chops	Tenderness	4.9	5.2
Loin chops	Overall palatability	4.9	5.2
Leg steaks	Flavor	5.1	5.3
Leg steaks	Juiciness	4.3	4.6
Leg steaks	Tenderness	4.2	4.8
Leg steaks	Overall palatability	4.6	5.0

[a]Means underscored by a common line are not different (P>.05).

Table 2. Mean sensory panel ratings for loin chops and leg steaks among breeds (panels and age groups combined)

CUT	TRAIT	RAMBOUILLET SHEEP (n=24)	BARBADO SHEEP (n=24)	KARAKUL SHEEP (n=24)	ANGORA GOAT (n=24)	SPANISH GOAT (n=24)
Loin chops	Flavor	5.4[a]	5.2[a,b]	4.9[b]	5.3[a,b]	5.4[a]
Loin chops	Juiciness	5.2[a,b]	5.5[a]	5.3[a]	4.7[b,c]	4.6[c]
Loin chops	Tenderness	5.7[a]	5.6[a]	5.2[a]	4.3[b]	4.2[b]
Loin chops	Overall palatability	5.4[a]	5.2[a]	5.1[a,b]	4.7[b]	4.9[a,b]
Leg steaks	Flavor	5.4[a]	5.0[b]	5.2[a,b]	5.2[a,b]	5.2[a,b]
Leg steaks	Juiciness	4.9[a]	4.2[b]	4.8[a]	4.2[b]	4.0[b]
Leg steaks	Tenderness	5.4[a]	4.5[b]	5.1[a]	4.0[b,c]	3.8[c]
Leg steaks	Overall palatability	5.2[a]	4.6[b]	5.1[a]	4.4[b]	4.4[b]

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

[d]Eight-point hedonic scales were used with 8 = extremely desirable, juicy and tender and 1 = extremely undesirable, dry and tough for flavor and overall palatability, juiciness and tenderness, respectively.

Table 3. Mean sensory panel ratings for loin chops and leg steaks among aged female and young intact males (panels and breeds combined)

Cut	Trait[b]	Young intact males (n=60)	Aged females (n=60)
Loin chops	Flavor	5.1	5.4
Loin chops	Juiciness	5.0	5.1
Loin chops	Tenderness	5.1	5.0
Loin chops	Overall palatability	5.1	5.1
Leg steaks	Flavor	5.2	5.3
Leg steaks	Juiciness	4.3	4.6
Leg steaks	Tenderness	4.7	4.4
Leg steaks	Overall palatability	4.8	4.8

[ya]Means underscored by a common line are not different (P>.05).

[b]Eight-point hedonic scales with 8 = extremely desirable, juicy and tender and 1 = extremely undesirable, dry and tough for flavor and overall palatability, juiciness and tenderness, respectively.

UPDATING COOKING TIME/TEMPERATURE RELATIONSHIPS FOR ROASTING OF LAMB CUTS

C.L. Griffin, G.C. Smith, J.W. Savell and H.K. Johnson

SUMMARY

Cooking time/temperature relationships for lamb roasts were updated for inclusion in lamb cookery publications. Eight different cuts: whole, bone-in legs; shank-half legs; sirloin-half legs; boneless legs; boneless shoulders; pre-sliced shoulders; seven-rib rack and crown roasts were used. Cooking times were recorded for ten roasts from each cut as they were cooked (350°F oven--not preheated) to rare (140°F), medium (160°F) or well-done (170°F). Cooking losses tended to increase with higher degrees of doneness; as cut weight increased, cooking times (min/lb) decreased. Recommendations for revisions in cooking times were determined from means and standard deviations of cooking times for each roast.

INTRODUCTION

The American Lamb Council and the National Live Stock and Meat Board recently determined that the recommendations for time/temperature used for cooking of lamb that are reported in their publications (e.g. "FACTS ABOUT LAMB") were based on only a limited number of cuts and that those cuts had not been cooked under controlled conditions. Since the original study was conducted, advanced technology has resulted in more sensitive temperature-monitoring equipment and different oven styles. This study was conducted, utilizing modern equipment, to update cooking time/temperature recommendations for eight cuts of lamb: whole, bone-in legs; shank-half legs; sirloin-half legs; boneless legs; boneless shoulders; pre-sliced shoulders; seven-rib rack roasts and crown roasts. Updated cooking time/temperature relationships and the rationale for their selection are reported.

EXPERIMENTAL PROCEDURE

Lamb carcasses (55-65 lb) were fabricated to produce 240 roasts: whole bone-in legs, shank-half legs; sirloin-half legs, boneless legs, boneless shoulders, pre-sliced shoulders, seven-rib rack roasts and/or crown roasts. All cuts were trimmed to 1/4" external fat thickness. Cooking times were recorded for ten roasts from each cut as they were cooked (350°F oven--not preheated) to rare (140°F), medium (160°F) or well-done (170°F). Internal temperatures of roasts were monitored using two thermocouples placed in the approximate geometric center of each roast. Copper-constantan thermocouples (40 gauge; .02 in diam.) attached to a recording thermometer were used to avoid influencing cooking time via heat conduction into the meat (Hostetler and Dutson,

1977).

Analyses of variance were conducted to determine effects of degree of doneness on cooking times and cooking losses. Duncan's new multiple range test was utilized to determine which times and losses were different (Barr et al., 1979; Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Korschgen et al. (1980) reported cooking times of 45-52 min/lb for 3-5 lb beef rib roasts cooked to 140°F. Data in Table 1 indicate that similar-weight lamb cuts required 19-37 min/lb to reach an internal temperature of 140°F. Variations in time may be attributable to differing sizes and shapes of cuts as well as to whether or not cuts were boneless (Price and Schweigert, 1971). An average increase of seven minutes per pound was required to raise the internal temperature from 140 to 160°F, while an average increase of five minutes per pound was needed to raise the internal temperature from 160 to 170°F. Larger cuts required less time per pound than smaller cuts to reach the same internal temperature.

In Table 2, mean cooking losses are listed for various lamb cuts cooked to each of three degrees of doneness. Cooking losses varied considerably between cuts; however, for all cuts, cooking losses increased as the internal temperature increased from 140 to 160°F and from 160 to 170°F. An average additional loss of 6.5% occurred when the internal temperature was increased from 140 to 160°F while the difference between 160 and 170°F was 6.2%. Based on these data, cooking loss increased 1% for every increase of one minute in cooking time; the latter finding concurs with data for beef loin steaks (Hostetler et al., 1982).

On the basis of this study, lamb cuts require less time per pound to roast than does beef at each of three internal temperatures; while the relationship of cooking time to cooking loss is similar to that for beef steaks. As lamb cuts increased in weight, cooking times per pound decreased.

From this study the cooking time recommendations in Table 3 were recommended by the Texas Agricultural Experiment Station and subsequently adopted by the American Lamb Council and the National Live Stock and Meat Board. T.A.E.S. recommendations were developed from considerations of the standard deviations for each of the cuts included in this study. The differences in cooking times for cuts are undoubtedly due to differences between these cuts in fat content and/or muscle structure and, hence, in heat conductivity.

LITERATURE CITED

Barr, A.J., Goodnight, J.H., Sall, J.P. and Helwig, J.T. 1979. "A User's Guide to SAS". Sparks Press, Raleigh, N.C.

Hostetler, R.L. and Dutson, T.R. 1977. Effect of thermocouple wire size on the cooking of meat samples. J. Food Sci. 42:845.

Hostetler, R.L., Dutson, T.R. and Smith, G.C. 1982. Effect of

electrical stimulation and steak temperature at the beginning of cooking on meat tenderness and cooking loss. J. Food. Sci. 42:845.

Korschgen, B.M., Berneking, J.M. and Baldwin, R.E. 1980. Energy requirements for cooking beef rib roasts. J. Food Sci. 45:1054.

Price, J.F. and Schweigert, B.S. 1971. "The Science of Meat and Meat Products". W.H. Freeman and Co. San Francisco, CA.

Steel, R.G.D. and Torrie, J.H. 1980. "Principles and Procedures of Statistics." 2nd Ed. McGraw-Hill Book Co. New York, NY.

National Live Stock and Meat Board. "Facts About Lamb". Publication number 06-151. Published by National Live Stock and Meat Board, 444 N. Michigan Ave., Chicago, IL.

Table 1. Mean cooking times[a] for lamb cuts cooked to different degrees of doneness

CUT[b]	DEGREE OF DONENESS		
	RARE (140°F)	MEDIUM (160°F)	WELL (170°F)
Boneless shoulder	32.4[c]	39.7[d]	43.3[e]
Pre-sliced shoulder	37.3[c]	40.5[c]	49.0[d]
Boneless leg	30.1[c]	38.0[d]	39.1[d]
Whole, bone-in leg	18.6[c]	22.4[d]	25.3[e]
Shank-half leg	33.3[c]	42.8[d]	49.8[e]
Sirloin-half leg	29.8[c]	37.4[d]	49.6[e]
Crown Roast	22.1[c]	30.4[d]	33.6[d]
Seven-rib rack roast	31.0[c]	40.1[d]	43.1[e]

[a]Mean cooking times expressed as minutes per pound.

[b]Ten cuts of each type for each degree of doneness were cooked.

[c,d,e]Means in the same row bearing a common superscript are not different (P>.05).

Table 2. Mean cooking losses[a] for lamb cuts cooked to different degrees of doneness

CUT[b]	DEGREE OF DONENESS		
	RARE (140°F)	MEDIUM (160°F)	WELL (170°F)
Boneless shoulder	23.04[c]	27.28[d]	35.01[e]
Pre-sliced shoulder	23.79[c]	28.78[d]	37.72[e]
Boneless leg	21.37[c]	32.58[d]	33.95[e]
Whole, bone-in leg	16.52[c]	22.79[d]	29.52[e]
Shank-half leg	15.21[c]	20.81[d]	24.25[e]
Sirloin-half leg	15.28[c]	23.74[d]	32.29[e]
Crown roast	16.00[c]	21.85[d]	28.07[e]
Seven-rib rack roast	14.42[c]	19.08[d]	25.97[e]

[a]Mean cooking losses expressed as percentage.

[b]Ten cuts of each type for each degree of doneness were cooked.

[c,d,e]Means in the same row bearing a common superscript are not different (P>.05).

Table 3. Updated cooking times for lamb cuts (325° oven - not preheated)

PRODUCT	DEGREE OF DONENESS[a]	MEAN COOKING TIME[b] MIN. (SD)	MEAN COOKING TIME[b] MIN/LB (SD)	RECOMMENDED COOKING TIME TOTAL HOURS	RECOMMENDED COOKING TIME MIN/LB
Leg, Whole Bone-In (7-9 lb)	Rare	140.6 (16.8)	18.6 (2.2)	2.5	15-20
	Medium	179.3 (14.2)	22.3 (1.6)	3.0	20-25
	Well	204.0 (19.9)	25.3 (2.6)	3.5	25-30
Leg, Boneless (5-7 lb)	Rare	191.2 (12.4)	30.1 (5.2)	3.0	25-30
	Medium	224.2 (32.5)	38.0 (9.2)	3.5	30-35
	Well	232.1 (17.5)	39.0 (8.6)	4.0	35-40
Leg, Shank-Half (2-4 lb)	Rare	115.3 (10.7)	33.3 (2.4)	2.0	30-35
	Medium	141.4 (15.5)	42.8 (5.1)	2.5	35-40
	Well	151.5 (21.1)	49.8 (9.5)	3.0	45-50
Leg, Sirloin-Half (2.5-5 lb)	Rare	113.2 (12.8)	29.8 (4.7)	2.0	25-30
	Medium	148.9 (23.4)	37.4 (4.7)	2.5	35-40
	Well	213.4 (14.9)	49.6 (3.5)	3.0	45-50
Shoulder Boneless (4-6 lb)	Rare	162.3 (12.0)	32.4 (1.8)	2.5	30-35
	Medium	182.9 (16.7)	39.7 (2.3)	3.0	35-40
	Well	214.0 (11.4)	43.3 (2.8)	3.5	40-45
Shoulder Pre-Sliced (2-5 lb)	Rare	117.0 (20.5)	37.4 (8.1)	2.0	35-40
	Medium	150.1 (20.2)	40.5 (7.3)	2.5	40-45
	Well	191.3 (37.2)	49.0 (7.8)	3.0	45-50
Rack[c] (1.5-2.5 lb)	Rare	64.5 (8.1)	31.0 (5.4)	1.00	30-35
	Medium	75.2 (12.5)	40.1 (5.0)	1.25	35-40
	Well	69.9 (16.7)	43.1 (6.6)	1.50	40-45
Crown Roast Not Stuffed[c] (2-3 lb)	Rare	57.2 (7.7)	22.1 (4.1)	1.00	15-20
	Medium	76.3 (9.3)	30.4 (5.0)	1.25	25-30
	Well	87.2 (10.4)	33.6 (4.4)	1.50	30-35

a
Rare = 140°F
Medium = 160°F
Well = 170°F

b
Mean cooking time based upon 10 for each cut for each degree of doneness.

c
Rack and Crown Roast; oven was set at 375°F and not preheated.

EFFECTS OF AGE, SEX, BREED AND SPECIES ON FATTY ACID COMPOSITION OF SUBCUTANEOUS FAT FROM SHEEP AND GOATS

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SUMMARY

Subcutaneous fat was obtained from 120 young intact male or aged female sheep or goats and used for fatty acid analysis. Both sex (age) and breed had significant effects on fatty acid composition. The breed effect was more evident in the young intact male group than in the aged female group, while the sex effect was more evident in sheep than in goats. The fat from young intact males was higher in C18:2 than was that from aged females in all five breed/specie groups. Both young intact male and aged female goats had less C18:1 in their fat than did sheep. Fat from young intact male Karakul had the lowest C18:0 but the highest proportion of fatty acids with odd-numbered carbons (C15:0, C17:0 and C17:1).

INTRODUCTION

Sheep and goat meat are not considered as palatable as other red meats by most consumers primarily due to their characteristic flavor (Sink and Caporaso, 1977). Intensity of flavor is affected by several factors with the flavor of meat from younger sheep generally being considered more desirable than that from older sheep (Paul, 1964). Generally, the flavor intensity of meat from wethers is less than that from ewes while meat from ewes is less intense in flavor than that from rams (Hammond, 1932). There is research that suggests no difference in flavor due to differences in sex (Batcher et al., 1962; Wilson et al., 1970). There are also differences in flavor between breeds of sheep; Cramer et al. (1970) observed that mutton flavor is more predominant in the fine-wool breeds, and that mutton flavor dominance is directly related to the fineness of wool.

Fatty acid composition of sheep is largely unaffected by sex and slaughter weight (Wise, 1977; Kemp et al., 1981) while both breed and age have an effect (Wise, 1977; Congiu and Argiolas, 1977). Kemp et al. (1981) found no definite relationship between fatty acid content of lamb and its organoleptic properties. However, some relationship between fatty acid composition and palatability has been reported in beef (Melton et al., 1982; Dryden and Marchello, 1970). This study was conducted to analyze the fatty acid composition of subcutaneous fat from different sexes, ages and breeds of sheep and goats.

MATERIALS AND METHODS

One hundred-twenty young intact males and aged females of three sheep breeds and two goat breeds (Table 1) were obtained from the

Texas Agricultural Experiment Station (TAES), San Angelo, and were slaughtered at the TAES Meat Laboratory. Details of production, management, age at slaughter, dressing percentage and carcass traits for these animals have been reported by Riley et al. (1982). Subcutaneous fat tissue was obtained (near the dock) and stored at -18°C for subsequent fatty acid analysis.

A 0.1g sample of fat tissue was transferred to a 20 ml screw-capped tube. Four ml of 2% H_2SO_4 in anhydrous methanol and 1.0 ml of benzene were added to the tube which was then sealed (air-tight) with a teflon-lined cap while purging the tube with purified nitrogen gas. The sealed tube was placed in boiling water for 4 hr with occasional stirring and was cooled to room temperature. The sample was neutralized with about 200-300 ul of 30% NH_4OH. Four ml of double-distilled water was added to the sample and the mixture was extracted three times with 4 ml hexane. The three extractions were combined and evaporated to dryness using a stream of N_2. To purify the methyl esters, 0.5 ml chloroform was added to the dry sample and 20 ul was applied on 20 cm-long silica gel F^{254} thin layer chromotographic plates. Methyl esters were separated with hexane: diethylether (9:1) as a solvent system. After separation, the band of methyl esters was identified by the aid of UV light and scraped off with a razor blade. The methyl esters were extracted from the gel by washing with $CHCl_3$ in a glass filter funnel. The filtrate was evaporated to dryness using a stream of N_2 and redissolved in 2 ml of hexane. One ml was stored at -20°C, the other 1 ml was evaporated to dryness with N_2 and redissolved in 2 ml CS_2 for gas chromatographic analysis. The CS_2 was 99+% spectrophotometric grade (Aldrich Chemical Co. gold label). The remainder of the solvents were glass-distilled (Burdick & Jackson Labs, Inc.).

Fatty acids were determined as methyl esters by gas chromotography using a 2 mm ID x 1.6 m long column packed with 10% SP-2330 on 100/120 mesh Chromosorb WAW (Supelco, Inc.). The carrier gas was Helium administered at a flow rate of 30 ml/min. The initial column temperature of 140°C was maintained for 1 min and then raised to 220°C at a rate of 3°C/min.

Analysis of variance was completed using General Linear Models program of SAS (Helwig and Council, 1979). Means were separated using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Mean values for fatty acid composition stratified according to breed/specie are presented in Table 2. For all breed/specie groups combined, means and standard deviations for fatty acid composition of the subcutaneous fat, expressed as percentages, are similar to those reported for lamb fat by Dugan (1957). Oleic (C18:1), stearic (C18:0), and palmitic (C16:0) were the major fatty acids, comprising up to 85% of the total fatty acids in the subcutaneous fat. The percentage of unsaturated fatty acids in ovine/caprine fat in the present study (38-49%) is smaller than that (54.5-63.6%) reported for

ovine fat by Field et al. (1978). The unsaturated fatty acids, since they have lower melting points than the saturated fatty acids, are associated with soft fat, which has been shown (Campion et al., 1976) to have less desirable flavor than does firm fat. Among the five breed/specie groups, fat from Karakul sheep had the highest percentages of pentadecanoic (C15:0), margaric (C17:0), heptadecenoic (C17:1) and total unsaturated fatty acids. Fat from Angora goats had the highest percentages of C16:0 but the lowest percentages of C18:1 and total unsaturated fatty acids.

Analysis of variance showed that both age/sex and breed/specie had significant effects on fatty acid composition. In this study, it was not possible to separate sex and age since all males were young and all females were old (aged). Likewise, it is not possible to segregate breed and specie. Previous investigators (Wise, 1977; Congiu and Argiolas, 1977) have shown that fatty acid content of body fat is affected by age but not by sex. Since the statistical analysis determined that there was an interaction between breed/specie and age/sex, these effects will be discussed separately.

Effect of age/sex, specie and breed/specie.

Data in Table 3 show that subcutaneous fat from young intact males vs. aged females is quite different in fatty acid composition. Analyzing goats and sheep separately reveals that the difference in fatty acid composition between the two age/sex groups is largely caused by differences among sheep. Young intact male sheep had higher ($P<0.01$) percentages of C14:0, C15:0, C17:1, C18:1 and total unsaturated fatty acids in their subcutaneous fat than did aged females, but had lower ($P<0.01$) percentages of C18:0 and total saturated fatty acids. Only C14:0 and C18:0 percentages were significantly different between subcutaneous fat samples from young intact male and aged female goats. By analyzing age/sex effects between fat samples from each of the five breed/specie groups (Table 4), much larger differences were noted between young intact males vs. aged females for the Karakul, Barbado and Rambouillet breeds of sheep than for the two age/sex classes of Angora and Spanish goats. Nevertheless, subcutaneous fat from all of the young intact males (from all five breed/specie groups) had a higher ($P<0.01$) percentage of C18:2 than did that from aged females.

Effect of specie, age/sex and breed/specie.

Data in Table 5 show that there were significant differences in percentages of most of the fatty acids in subcutaneous fat from goats vs. sheep. Percentages of C14:0, C16:0, C16:1 and total saturated fatty acids were higher ($P<0.01$) in subcutaneous fat from goats. Analysis of subcutaneous fat from goats vs. sheep between young intact males and aged females revealed that goats had higher ($P<0.05$) percentages of C14:0, C16:0, C16:1, C18:0 and total saturated fatty acids while sheep had higher ($P<0.05$) percentages of C17:1, C18:1, C18:2 and total unsaturated fatty acids. Analysis of subcutaneous fat from aged females revealed that goats had higher ($P<0.05$) percentages of C14:0,

C16:0 and C16:1 but lower ($P<0.05$) percentages of C18:1 than did sheep. Both young intact male and aged female goats had lower ($P<0.05$) percentages of C18:1 than did young male and aged female sheep.

Mean values for fatty acid composition stratified according to age/sex and breed/specie are presented in Table 6. Data reveal that among young intact males, Angora and Spanish goats had subcutaneous fat with higher ($P<0.05$) percentages of C16:0 and total unsaturated fatty acids and with lower ($P<0.05$) percentages of C18:1 than that from Rambouillet, Barbado or Karakul sheep. Among aged females, there were no pronounced differences in fatty acid composition of subcutaneous fat from goats vs. sheep. Among young intact males, Karakul sheep had subcutaneous fat with the lowest ($P<0.05$) percentage of C18:0 and the highest ($P<0.05$) percentages of C15:0 and C17:0. For subcutaneous fat from young intact males, the greatest dissimilarity in fatty acid percentages was for Angora goats vs. Karakul sheep ($P<0.05$ for 9 of 11 fatty acids), for Spanish goats vs. Karakul sheep ($P<0.05$ for 9 of 11 fatty acids) and for Rambouillet sheep vs. Karakul sheep ($P<0.05$ for 7 of 11 fatty acids). For subcutaneous fat from aged females, the greatest dissimilarity in fatty acid percentages was for Angora goats vs. Rambouillet sheep ($P<0.05$ for 4 of 11 fatty acids), for Angora goats vs. Barbado sheep ($P<0.05$ for 4 of 11 fatty acids) and for Angora goats vs. Karakul sheep ($P<0.05$ for 3 of 11 fatty acids).

In general, the differences in fatty acid composition associated with breed/specie were more evident in subcutaneous fat from young intact males than from aged females while differences associated with age/sex were more evident in fat from sheep. Differences in fatty acid composition between fat from goats and sheep were largest for Angora goats vs. Karakul sheep or for Spanish goats vs. Karakul sheep.

LITERATURE CITED

Batcher, O.M., E.H. Dawson, M.T. Pointer and G.L. Gilpin. 1962. Quality of raw and cooked lamb meats as related to fatness and age of animal. Food Technol. 16:102.

Campion, D.R., R.A. Field, M.L. Riley and G.M. Smith. 1976. Effect of weight on carcass merit of very heavy market ram lambs. J. Anim. Sci. 43:1218.

Congiu, F. and A. Argiolas. 1977. Fatty acid compositions of depot fats of sheep and goats of various ages. Rivista di Zootecnia e Veterinaria 6:662.

Cramer, D.A., J.B. Pruett, V.B. Swanson, W.C. Schwartz, R.M. Kattnig, B.L. Phillips and L.E. Wookey. 1970. Comparing breeds of sheep. II. Carcass characteristics. Proc. West Sec. Am. Soc. Anim. Sci. 21:267.

Dryden, F.D. and J.A. Marchello. 1970. Influence of total lipid and fatty acid composition upon the palatability of three bovine muscles. J. Anim. Sci. 31:36.

Dugan, L.R. Jr. 1957. Fatty acid composition of food fats and oils. Amer. Meat Inst. Found, Circ. No. 36.

Duncan, D.B. 1955. Multiple range and multiple F test. Biometrics 11:1.

Hammond, J. 1932. Growth and development of mutton qualities in the sheep. Oliver and Boyd, London. page 537.

Helwig, J.T. and K.A. Council. 1979. SAS User's Guide. SAS Institute, Inc. Cary, NC.

Kemp, J.D., M. Mahyuddin, D.G. Ely, J.D. Fox and W.G. Moody. 1981. Effect of feeding systems, slaughter weight and sex on organoleptic properties and fatty acid composition of lamb. J. Anim. Sci. 51:321.

Melton, S.L., J.M. Black, G.W. Davis and W.R. Backus. 1982. Flavor and selected chemical components of ground beef from steers backgrounded on pasture and fed corn up to 140 days. J. Food Sci. 47:699.

Paul, P.C., J. Torten and G.M. Spurlock. 1964. Eating quality of lamb. I. Effect of age. Food Technol. 18:1779.

Sink, J.D. and F. Caporaso. 1977. Lamb and mutton flavour: Contributing factors and chemical aspects. Meat Sci. 1(2):119.

Wilson, L.L., J.H. Ziegler, M.C. Rough, J.L. Watkins, T.L. Merritt, M.J. Simpson and F.L. Kreuzberger. 1970. Comparison of live, slaughter and carcass characteristics of rams, induced cryptorchids and wethers. J. Anim. Sci. 31:455.

Wise, J.W. 1977. The effects of sex, slaughter weight and breed on carcass composition, fatty acid content and tenderness of lamb. Dissertation, Univ. of Nebraska, Lincoln, NE.

Table 1. Breed, age and sex distributions of sheep and goats from which subcutaneous fat was obtained

Specie	Breed	Young intact males	Aged females	Total
Goats				
	Angora	8	10	18
	Spanish	7	17	24
Sheep				
	Rambouillet	12	13	25
	Barbado	11	11	22
	Karakul	21	10	31
	Total	59	61	120

Table 2. Mean values for fatty acid composition stratified according to breed/specie

Fatty acid	All breed/specie groups combined (n=120)		Breed/specie group				
	Mean	Std. Dev.	Angora goat (n=18)	Spanish goat (n=24)	Rambouillet sheep (n=25)	Barbado sheep (n=22)	Karakul sheep (n=31)
C14:0	2.70	0.93	3.21^{a}	3.09^{ab}	2.64^{abc}	2.10^{c}	2.58^{bc}
C15:0	0.59	0.25	0.60^{ab}	0.56^{b}	0.51^{b}	0.51^{b}	0.74^{a}
C16:0	23.25	2.50	26.84^{a}	25.15^{b}	22.94^{c}	20.11^{d}	22.18^{c}
C16:1	3.14	1.04	3.58^{ab}	3.71^{a}	2.83^{c}	2.69^{c}	3.02^{bc}
C17:0	1.93	0.52	1.91^{b}	1.81^{b}	1.85^{b}	1.72^{b}	2.25^{a}
C17:1	0.82	0.62	0.47^{b}	0.69^{b}	0.75^{b}	0.81^{b}	1.17^{a}
C18:0	24.18	8.18	27.52^{a}	25.50^{a}	24.29^{a}	26.45^{a}	19.53^{b}
C18:1	38.17	5.95	31.58^{c}	35.47^{b}	39.05^{a}	40.27^{a}	41.88^{a}
C18:2	3.01	1.20	2.69^{b}	2.48^{b}	3.60^{a}	3.02^{ab}	3.11^{ab}
Unident. peak	0.47	0.87	0.00^{c}	0.11^{c}	0.07^{c}	0.63^{b}	1.22^{a}
Remainder	1.75	1.36	1.60^{ab}	1.39^{b}	1.52^{b}	1.68^{ab}	2.37^{a}
Total sat.	52.66	7.95	60.07^{a}	56.12^{ab}	52.23^{bc}	50.89^{cd}	47.28^{d}
Total unsat.	45.14	7.01	38.33^{c}	42.36^{bc}	46.23^{ab}	46.80^{a}	49.18^{a}

^{abcd}Means in the same row bearing a common superscript letter are not different ($P>0.05$).

Table 3. Mean values for fatty acid composition stratified according to age/sex and specie

Fatty acid	All specie groups combined (n=120)		Specie group			
			Goat		Sheep	
	Young intact male (n=59)	Aged female (n=61)	Young intact male (n=15)	Aged female (n=27)	Young intact male (n=44)	Aged female (n=34)
C14:0	3.42**	2.37	4.13**	2.58	2.70**	2.17
C15:0	0.63	0.54	0.56	0.59	0.69**	0.49
C16:0	24.01	23.91	26.56	25.49	21.47	22.32
C16:1	3.18	3.31	3.51	3.74	2.85	2.89
C17:0	1.87	1.91	1.68	1.94	2.05	1.87
C17:1	0.85	0.63	0.52	0.64	1.19**	0.61
C18:0	21.34**	28.27	24.33	27.50	18.35**	29.04
C18:1	38.99**	34.97	34.30	33.53	43.69**	36.42
C18:2	3.68**	2.20	3.37**	2.13	3.99**	2.27
Unident. peak	0.51	0.17	0.00	0.09	1.03**	0.25
Remainder	1.53	1.74	1.04	1.73	2.03	1.74
Total sat.	51.26**	57.00	57.27	58.11	45.26**	55.88
Total unsat.	46.71**	41.11	41.70	40.04	51.72**	42.19

** Young intact males differ ($P<0.01$) from aged females within that specie group.

* Young intact males differ ($P<0.05$) from aged females within that specie group.

Table 4. Mean values for fatty acid composition stratified according to breed/specie and age/sex

	Angora goat		Spanish goat		Rambouillet sheep		Barbado sheep		Karakul sheep	
Fatty acid	Young intact males (n=8)	Aged females (n=10)	Young intact males (n=7)	Aged females (n=17)	Young intact males (n=12)	Aged females (n=13)	Young intact males (n=11)	Aged females (n=11)	Young intact males (n=21)	Aged females (n=10)
C14:0	3.88**	2.67	4.43**	2.54	3.12**	2.20	2.15	2.05	2.74	2.25
C15:0	0.55	0.64	0.58	0.56	0.53	0.49	0.56	0.46	0.85**	0.52
C16:0	26.40	27.18	26.74*	24.50	22.78	23.08	19.26	20.95	21.87	22.84
C16:1	3.37	3.76	3.67	3.73	2.44	3.19	2.61	2.77	3.21	2.62
C17:0	1.72	2.05	1.64	1.88	1.85	1.86	1.71	1.72	2.35	2.04
C17:1	0.44	0.50	0.61	0.73	0.85	0.66	1.15**	0.47	1.41**	0.69
C18:0	25.98	28.75	22.44	26.76	20.81*	27.50	22.45**	30.46	14.80**	29.47
C18:1	33.03	30.42	35.74	35.36	41.84*	36.47	43.40**	37.14	44.89**	35.55
C18:2	3.44**	2.09	3.29**	2.15	4.25**	2.99	4.06**	1.99	3.80**	1.65
Unident. peak	0.00	0.00	0.00	0.15	0.16	0.00	0.91	0.35	1.58**	0.47
Remainder	1.19	1.93	0.86	1.61	1.32	1.70	1.74	1.63	2.59	1.92
Total sat.	58.53	61.30	55.82	56.24	49.09*	55.13	46.13**	55.64	42.61**	57.11
Total unsat.	40.28	36.78	43.32	41.96	49.39*	43.82	51.22**	42.38	53.31**	40.50

**Young intact males differ ($P<0.01$) from aged females within a breed/specie group.

*Young intact males differ ($P<0.05$) from aged females within a breed/specie group.

Table 5. Mean values for fatty acid composition stratified according to specie

	All age/sex groups combined		Young intact males		Aged females	
Fatty acid	Goats (n=42)	Sheep (n=78)	Goats (n=15)	Sheep (n=44)	Goats (n=27)	Sheep (n=34)
C14:0	3.36**	2.43	4.13**	2.70	2.58*	2.17
C15:0	0.58	0.59	0.56	0.69	0.59	0.49
C16:0	26.03**	21.89	20.56**	21.47	25.49**	22.32
C16:1	3.63**	2.87	3.51*	2.85	3.74**	2.89
C17:0	1.81	1.96	1.68*	2.05	1.94	1.87
C17:1	0.58**	0.90	0.52**	1.19	0.64	0.61
C18:0	25.91	23.69	24.33**	18.35	27.50	29.04
C18:1	33.91**	40.05	34.30**	43.69	33.53*	36.42
C18:2	2.75*	3.13	3.37*	3.99	2.13	2.27
Unident. peak	0.05**	0.64	0.00**	1.03	0.09	0.25
Remainder	1.38	1.89	1.04*	2.03	1.73	1.74
Total sat.	57.69**	50.57	57.27**	45.26	58.11	55.88
Total unsat.	40.87**	46.95	41.70**	51.72	40.04	42.19

**Goats differ ($P<0.01$) from sheep.

*Goats differ ($P<0.05$) from sheep.

Table 6. Mean values for fatty acid composition stratified according to age/sex and breed/specie

	Young intact males (n=59)					Aged females (n=61)				
Fatty acid	Angora goats (n=8)	Spanish goats (n=7)	Rambouillet sheep (n=12)	Barbado sheep (n=11)	Karakul sheep (n=21)	Angora goats (n=10)	Spanish goats (n=17)	Rambouillet sheep (n=13)	Barbado sheep (n=11)	Karakul sheep (n=10)
C14:0	3.88^{ab}	4.43^{a}	3.12^{bc}	2.15^{d}	2.74^{cd}	2.67^{a}	2.54^{ab}	2.20^{bc}	2.05^{c}	2.25^{abc}
C15:0	0.55^{b}	0.58^{b}	0.53^{b}	0.56^{b}	0.85^{a}	0.64^{a}	0.56^{ab}	0.49^{ab}	0.46^{b}	0.52^{ab}
C16:0	26.40^{a}	26.74^{a}	22.78^{b}	19.26^{c}	21.87^{b}	27.18^{a}	24.50^{b}	23.08^{bc}	20.95^{c}	22.84^{bc}
C16:1	3.37^{ab}	3.67^{a}	2.44^{c}	2.61^{bc}	3.21^{ab}	3.76^{a}	3.73^{a}	3.19^{ab}	2.77^{ab}	2.62^{b}
C17:0	1.72^{b}	1.64^{b}	1.85^{b}	1.71^{b}	2.35^{a}	2.05^{a}	1.88^{a}	1.86^{a}	1.72^{a}	2.04^{a}
C17:1	0.44^{c}	0.61^{bc}	0.85^{bc}	1.15^{ab}	1.41^{a}	0.50^{a}	0.73^{a}	0.66^{a}	0.47^{a}	0.69^{a}
C18:0	25.98^{a}	22.44^{a}	20.81^{a}	22.45^{a}	14.80^{b}	28.75^{a}	26.76^{a}	27.50^{a}	30.46^{a}	29.47^{a}
C18:1	33.03^{b}	35.74^{b}	41.84^{a}	43.40^{a}	44.89^{a}	30.42^{b}	35.36^{a}	36.47^{a}	37.14^{a}	35.55^{a}
C18:2	3.44^{a}	3.29^{a}	4.25^{a}	4.06^{a}	3.80^{a}	2.09^{b}	2.15^{b}	2.99^{a}	1.99^{b}	1.65^{b}
Unident. peak	0.00^{b}	0.00^{b}	0.16^{b}	0.91^{ab}	1.58^{a}	0.00^{a}	0.15^{a}	0.00^{a}	0.35^{a}	0.47^{a}
Remainder	1.19^{b}	0.86^{b}	1.32^{b}	1.74^{ab}	2.59^{a}	1.93^{a}	1.61^{a}	1.70^{a}	1.63^{a}	1.92^{a}
Total sat.	58.53^{a}	55.82^{ab}	49.09^{bc}	46.13^{cd}	42.61^{d}	61.30^{a}	56.24^{ab}	55.13^{b}	55.64^{ab}	57.11^{ab}
Total unsat.	40.28^{b}	43.32^{b}	49.39^{a}	51.22^{a}	53.31^{a}	36.78^{b}	41.96^{a}	43.32^{a}	42.38^{a}	40.50^{ab}

[abcd] Means in the same row and for the same age/sex group bearing a common superscript letter are not different ($P>0.05$).