Animal Performance and Fleece Characteristics of Angora Goats Maintained on Western and Southern Texas Rangeland[1,2]

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ABSTRACT: Two hundred castrated male Angora goats (18 mo of age) were divided equally between rangeland sites in the oak savannah of the Edwards Plateau (EP) and the mixed-brush shrublands of the South Texas Plains (STP) for 5 yr to study influence of environment and age on body weight (BW), mohair production, and mohair fiber characteristics. Goats were grazed on rangeland typical of the respective regions and were given typical management that included shearing in February and July or August of each year. Shorn goats were weighed and individual fleeces were measured for grease weight (GFW), clean yield (CMFP), average fiber diameter (AFD), and proportion of medullated fibers, med (MFP) and kemp (KFP). Rainfall and maximum and minimum temperatures were recorded daily at each site. The AFD ($P = .01$) and its associated SD ($P < .001$) and kemp levels ($P = .03$) were all higher at the STP than at the EP site (39.4 vs 37.9 μm, 10.4 vs 11.1 μm, and .80 vs .68%, respectively). Angora goats at EP weighed less (38.1 vs 41.7 kg, $P = .03$), and sheared less (1.90 vs 2.22 kg, $P = .01$), finer (36.4 vs 39.3 μm, $P < .001$), and less kempy (.52 vs .84%, $P < .001$) mohair at the February shearing than at the August shearing. No seasonal differences in body weight or in mohair production or quality were apparent at STP. The proportions of total variation in grease mohair production (30.6%), CMFP (22.2%), and AFD (15.7%) due to year effects were two to three times greater at STP than at EP. In contrast, year effects were responsible for only a small proportion (2.2 to 4.6%) of the variation in medullated fibers. The effects of rainfall accumulation within specific 6-mo growing periods were positive for BW, GFW, CFW, AFD, SD of AFD and MFP and negative for CMFP and KFP. Only the rainfall effects on SD of AFD and medullated fibers were significant ($P < .05$). The effects of age were positive for BW ($P < .001$), CMFP ($P = .046$), AFD ($P < .001$), MFP ($P = .014$), and KFP ($P = .084$) and negative for GFW ($P = .046$) and CFW ($P = .107$). This study documents influence of environment and age of goats on body weight, mohair production, and fiber characteristics.

Key Words: Age, Angora, Goats, Body Weight, Environment, Mohair

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Introduction

Angora goats were introduced into the United States more than 100 yr ago because of their capacity to produce large quantities of white fiber (mohair). Unique dietary preferences for foliage from trees and shrubs make the goat less competitive for dietary components with sheep or cattle than sheep with cattle or among individuals of a single species. Goats in the Edwards Plateau (**EP**) region depend heavily on "oak-type" browse, especially during winter and periods of low-moisture dormancy (Rector, 1983). In the South Texas Plains (**STP**) region, goats rely on "leguminous" browse (mostly species of *Acacia*) and other "thorny" species (Warren et al., 1984), which are generally higher in protein than shrubs from the Edwards Plateau Region (Huston et al., 1981; Varner and Blankenship, 1979). Mohair quality characteristics are affected by nutrient content of diet (Shelton and Huston, 1966; Calhoun et al., 1988), age of goat, and season of the year (Bassett, 1966). This study was initiated during the fall of 1986 to determine the effects of year, location (therefore, diet and other environmental factors), season, and animal age on body weight, mohair production, and mohair fiber characteristics in castrated male Angora goats.

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Table 1. Survival of Angora goats and rainfall at two study locations[a]

Month	Year	Time, mo	Age, mo	No. of goats		Rainfall, cm[b]	
				EP	STP	EP	STP
Aug	1986	0	18	100	100	—	—
Feb	1987	6	24	97	98	49.0	53.8
Aug	1987	12	30	95	97	48.7	59.8
Feb	1988	18	36	92	92	23.8	13.8
Aug	1988	24	42	89	79	36.7	10.5
Feb	1989	30	48	85	72	18.5	19.7
Aug	1989	36	54	83	51	45.7	17.3
Feb	1990	42	60	82	50	15.8	29.1
Aug	1990	48	66	80	47	49.3	61.3
Feb	1991	54	72	79	46	28.5	26.5
Aug	1991	60	78	79	45	29.5	23.2

[a]EP = Edwards Plateau, STP = South Texas Plains.
[b]Rainfall for the preceding February–July or August–January period.

Materials and Methods

Two hundred male Angora goats (18 mo of age) were selected from a flock of 1,200 previously maintained together on a ranch in Crockett County, TX. Goats were castrated with a burdizzo (to produce “wethers”) and identified individually with ear tags. They were stratified by weight and allotted randomly to two locations. After shearing, one group was transported to an Edwards Plateau location in McCulloch County (EP, latitude 31°7′, longitude 99°20′W, elevation 524 m) and the other group to a South Texas Plains location in Zavala County (STP, latitude 29°13′, longitude 99°45′W, elevation 279 m). The climate of the EP property is subtropical with dry winters and hot, sometimes humid summers. Average annual precipitation is 63 cm with a bimodal pattern of rainfall being common, May and September being the peak rainfall months. The average frost-free period is 226 d. Periodic droughts and very dry summers are frequent. Typical of the Edwards Plateau, the study area has a large number of grasses (34 species including *Stipa leucotricha*, *Aristida* spp., and *Bouteloua* spp.), forbs (107 species including *Gaillardia pulchella*, *Ratibida columnaris*, and *Erodium texanus*), vines (including *Sarcostemma crispum*, *Convolvulus equitans*, and *Cocculus carolinus*, and woody species (32 species including *Quercus virginiana*, *Quercus durandii* var. *breviloba*, *Zanthoxylum clava-herculis*, and *Mimosa biuncifera*), and is predominately a plateau oak-shin oak savannah. Lower areas of deeper soils support large populations of honey mesquite (*Prosopsis glandulosa* var. *glandulosa*). Rangeland grazed by goats in STP was typical of that area having an overstory of *Acacia* spp. and *Prosopsis glandulosa* with an understory of native grasses including *Bouteloua curtipendula*, *Bouteloua trifida*, *Buchloe dactyloides*, *Hilaria belangeri*, Aristida wrightii, and *Setaria leucopila*, and native forbs including *Ambrosia cumanensis* and *Croton texensis*. Average annual rainfall for the area is 50 cm and the average frost-free period is 300 d.

Goats were grazed on rangeland typical of the respective regions and given typical management for a 5-yr period. Stocking rate at EP was one animal unit per 6 ha, whereas that at STP ranged from one animal unit per 10 to 13 ha. Rainfall and temperature data were recorded daily at or close to each site. Goats were sheared and body weights (**BW**) were determined at 6-mo intervals (in February and July or August). In the fall of 1990, the BW data for STP were inadvertently misplaced. The following characteristics were measured for each fleece: grease fleece weight (**GFW**), clean yield (clean mohair fibers present [**CMFP**], ASTM, 1993a), fiber diameter (**AFD**, Lynch and Michie, 1976), and med (**MFP**) and kemp (**KFP**) fiber content (ASTM, 1993b). Clean fleece weight (**CFW**) was calculated using GFW and CMFP.

The data were analyzed using a mixed linear model that included location-season as a fixed effect, rainfall and age of goat (in months) as covariates, and year within location-season as a random effect. The analysis was conducted using the MIXED procedure of SAS (1992). This model provided estimates of location × season effects after the effects of rainfall and age were accounted for by linear covariates. Fitting year as a random effect allowed estimation of the proportion of total variance that was due to year effects after rainfall and age are accounted for by linear regression.

Other models were considered in which rainfall was nested within location and also within location and season. Though such models may be justifiable from a biological viewpoint, their use resulted in no tangible differences compared with the simpler model. All goats remaining in the flock at each shearing were used in the analysis. The only basis for removal of a goat from the experiment was death.

Results and Discussion

Data were collected over the 5-yr period for the numbers of goats listed in Table 1 (initial population was 100 goats at each location). During this time, 21

Table 2. Least squares means and standard errors by location and season adjusted to average rainfall and average age

		Edwards Plateau location		South Texas Plains location	
Trait	n	Fall	Spring	Fall	Spring
Body wt, kg	1,439	41.7 ± 1.2	38.1 ± 1.1	42.8 ± .9	40.7 ± .8
Grease fleece wt, kg	1,538	2.89 ± .12	2.47 ± .11	2.66 ± .18	2.74 ± .18
Clean yield, %	1,538	77.5 ± .9	77.3 ± .9	79.6 ± 1.2	78.1 ± 1.2
Clean fleece wt, kg	1,538	2.22 ± .09	1.90 ± .08	2.09 ± .12	2.12 ± .12
Average fiber diameter, μm	1,537	39.3 ± .5	36.4 ± .4	39.4 ± .8	39.3 ± .8
SD of fiber diam., μm	1,537	10.9 ± .3	9.9 ± .2	11.4 ± .3	10.8 ± .3
Med fibers, %	1,538	.93 ± .17	1.56 ± .16	1.29 ± .13	1.39 ± .13
Kemp fibers, %	1,538	.84 ± .06	.52 ± .06	.86 ± .05	.74 ± .05

goats died in the EP flock, with deaths occurring at a fairly uniform rate throughout the study. No predation was actually observed in either flock, but premature death caused by coyotes, dogs, or wild hogs is likely to have occurred. In contrast, only 45 goats survived at the STP location. Most of the deaths occurred during a 2-yr period beginning in the spring of 1988 and were attributed to guajillo (*Acacia berlandieri*) poisoning (41 deaths from February, 1988, to August, 1989; Table 1. Except for this period, annual rates of goat losses at STP and EP were similar). This *Acacia* shrub does not occur in the area in which the goats were born and raised (i.e., in Crockett County, TX). Thus, these goats were naive to the detrimental effects of guajillo and succumbed after browsing it. Angora goats in STP eat a combination of grass, forbs, and browse when presented with the normal diversity. During droughts (such as the one of 1988, Table 1), herbaceous plants become dormant and are consumed by termites, leaving only browse for the goats. Guajillo is, at these times, the greenest, leafiest, most palatable plant available and is consumed in large quantities (Forbes et al., 1994). The shrub also produces a toxin (*N*-methyl phenylethylamine) that, when consumed in large quantities and not diluted by other dietary components, causes a fatal and nonreversible paralysis of the hind limbs. This disease is known as guajillo wobbles.

Comparisons Between Locations. Least squares means and standard errors of each trait measured in this experiment are presented in Table 2. By using the described statistical model, these location and season means incorporate adjustments to average rainfall and average age. The associated differences and P values are summarized in Table 3. There was a general trend for the means of all measured traits to be larger at the STP location that at the EP location. This trend is consistent with the observation that phenotypic correlations among body weight, fleece weights, and fiber diameter are all positive (Lewis and Shelton, 1985). However, average fiber diameter, SD of average fiber diameter, and kemp content were the only traits that were significantly different ($P < .05$) between locations. Thus, to a very close approximation, Angora wethers maintained at EP produced the same amount of clean mohair as their counterparts at STP but had a slightly higher quality (i.e., lower fiber diameter [1.5 μm, $P = .01$]). The mechanism for producing similar quantities of mohair differing in fineness was not established, because staple length and follicle density were not measured in this study. Clearly, the location difference in fiber diameter exists because goats at EP sheared less (.33 kg, $P = .01$) and finer (2.8 μm, $P < .001$) mohair in spring than in fall. In contrast, STP wethers produced comparable quantities of mohair with similar average fiber diameters on the two shearing dates. No rationale is currently available for the slightly lower (.12%, $P = .03$) kemp levels in the EP goats. The smaller fiber diameter and kemp values observed at EP than at STP have negligible commercial significance. All mohair > 34 μm is classified as "Adult" grade and sold as such, with no premium being paid for (for example) 34 vs 40 μm.

Season Comparisons, Edwards Plateau Location. At the fall shearing, all traits (except med fibers) were larger than at the spring shearing. All of these differences were significant ($P = .05$) except for clean yield (CMFP, $P = .91$). Thus, it is clear that EP goats are heavier (3.6 kg, $P = .03$) in August, shear more (.33 clean kg, $P = .01$) and coarser (2.8 μm, $P < .001$) mohair containing more kemp (.32%, $P < .001$), but less med fibers (.64%, $P = .01$) than the same goats in February. This conclusion is consistent with experience in this area where typically November frost eliminates most of the green nutrition composed of grasses, forbs, and shrubs, though plateau oak leaves, which are rather low in digestibility, persist. Relatively low-quality feed is available throughout the winter months up to shearing in February. Subsequently, spring rains and warmer temperatures usually generate an abundance of plant growth of relatively high nutritive value that permits goats to gain weight and produce more mohair than in the previous season. A major production variable in this period is the point at which summer heat and lack of moisture cause the range to dry out and nutritive values of plants to decline. Generally, goats in the EP

Table 3. Trait differences between locations and between seasons at a location after adjustment to average rainfall and average age

Trait	EP[a] vs STP[b]	Fall vs Spring at EP	Fall vs Spring at STP
Body wt, kg (*P* value)	−1.8 (.08)	3.6 (.03)	2.1 (.10)
Grease fleece wt, kg (*P* value)	−.02 (.91)	.42 (.02)	−.07 (.78)
Clean yield, % (*P* value)	−1.4 (.17)	.16 (.91)	1.5 (.38)
Clean fleece wt, kg (*P* value)	−.04 (.69)	.33 (.01)	−.03 (.85)
Average fiber diameter, μm (*P* value)	−1.5 (.01)	2.80 (.00)	.15 (.89)
SD of fiber diam., μm (*P* value)	−.7 (.00)	.9 (.01)	.6 (.11)
Med fibers, % (*P* value)	−.09 (.51)	−.64 (.01)	−.09 (.63)
Kemp fibers, % (*P* value)	−.12 (.03)	.32 (.00)	.12 (.11)

[a]EP = Edwards Plateau location.
[b]STP = South Texas Plains location.

region have access to more and better-quality feed in the period between March and August than between September and February. This is reflected in goat and fleece weights and AFD measurements.

The higher kemp levels observed in the fall fleeces are consistent with data reported by Bassett (1986) and Dreyer and Marincowitz (1967). However, controlled feeding studies with Angora wethers in outdoor pens failed to identify this effect (Lupton et al., 1991). Production of hollow kemp fibers during the months leading up to winter may be the result of an almost defunct mechanism by which goats produce seasonal thermal protection for themselves. Although selective breeding against kemp has been practiced in Texas for many years resulting in generally low levels (< 1%), individual Angora goats having high (> 5%) kemp contents are occasionally identified. Hollow med and kemp fibers are discriminated against by the textile industry because the latter (having medulla greater than 60% of the fiber diameter) appear white after dyeing, whereas med fibers take dye normally. From a genetic viewpoint, hollow fiber production (med and kemp) is considered to be controlled by a single mechanism (Lupton et al., 1991). Nevertheless, the data generated for EP goats in this experiment suggest that med and kemp production are unrelated, because med fibers are more prevalent (.64%, $P = .01$) in spring than in fall fleeces.

In summary, body weights and mohair production and quality of Angora goats maintained in EP are all affected significantly by season. These differences seem to be direct responses to the amount and quality of available forage.

Season Comparisons, South Texas Plains Location. Body weights at the fall shearing tended to be higher (2.1 kg, $P = .10$) than at the spring shearing, a similar trend to that observed for EP. However, neither mohair production nor fiber diameter was different ($P > .7$) between shearings. Similarly, med ($P > .6$) and kemp ($P > .1$) levels were not different between August and February fleeces. Arithmetically, the measured differences were in the same directions as those observed for med and kemp seasonal differences at EP. In contrast to the EP site, the cooler days of fall and the long growing season at the STP location provide good growing conditions for the *Acacia* species that predominate in this area. Foliage on these plants is unaffected by mild frosts and sometimes persists throughout the winter, providing Angora goats with adequate nutrition. The dry, hot conditions predominating from late spring through the summer severely restrict new growth on these shrubs and consequently availability of nutrients from this source. The anomalous body weight and fleece weight relationship in STP indicates that winter forage may be more efficiently partitioned to fiber production (compared with body maintenance) than is summer forage at this location.

Variation in Traits Due to Year. Fitting year as a random effect in the statistical model permitted estimation of the proportion of total variance that was due to year effects. These estimates are summarized by research site in Table 4 after rainfall and age were accounted for by linear regression. Year effects are considered to include, inter alia, the effects of varying temperatures and rainfall patterns that in turn produce varying quantities and ratios of plant species at varying times of the year. Thus, although the variation due to year for body weight was smaller at STP than at EP, it ranged from two to three times greater at STP than at EP for mohair production, yield, and fiber diameter. The greater proportions of

Table 4. Proportion (%) of total variance (S^2_T) and total variance in traits due to year effects

Trait	EP[a]	S^2_T	STP[b]	S^2_T
Body wt	12.7	44.0	6.8	41.3
Grease fleece wt	12.4	.4	30.6	.5
Clean yield	11.6	27.8	22.2	31.6
Clean fleece wt	13.6	.2	27.5	.2
Average fiber diameter	4.6	14.3	15.7	16.2
SD of fiber diameter	13.7	1.8	16.8	1.9
Med fiber content	4.2	2.3	2.2	2.3
Kemp fiber content	4.6	.3	3.8	.3

[a]EP = Edwards Plateau location.
[b]STP = South Texas Plains location.

Table 5. Influence of rainfall (cm) on body weight and fleece traits of Angora goats maintained on Texas rangeland

Trait	Estimate	SE	P value
Body wt, kg	.007	.038	.842
Grease fleece wt, kg	.010	.006	.063
Clean yield, %	−.064	.040	.111
Clean fleece wt, kg	.006	.004	.103
Average fiber diameter, μm	.036	.022	.107
SD of fiber diameter, μm	.030	.009	.001
Med fibers, %	.013	.005	.005
Kemp fibers, %	−.004	.002	.040

Table 6. Influence of age (mo) on body weight and fleece traits of Angora goats maintained on Texas rangeland

Trait	Estimate	SE	P value
Body wt, kg	.299	.032	.000
Grease fleece wt, kg	−.008	.004	.046
Clean yield, %	.064	.031	.041
Clean fleece wt, kg	−.005	.003	.107
Average fiber diameter, μm	.081	.016	.000
SD of fiber diameter, μm	.011	.008	.145
Med fibers, %	.011	.004	.014
Kemp fibers, %	.003	.002	.084

total variation in fleece traits at STP due to year are consistent with the observation that rainfall is less predictable on this site at which periods of both drought and abnormally high rainfall occurred during the 5-yr study period (Table 1). The variation due to year for medullated fiber content was low at both locations.

Influence of Rainfall. Several different rainfall accumulation periods were considered and tested, but in the end the most logical approach seemed to be to pair up traits measured at a particular shearing with rainfall accumulation in the preceding 6-mo period (Table 1). Considering both locations, the influence of rainfall was positive for body weight, fleece weights, and fiber diameter (Table 5). However, variability in these traits was so great that the estimates were not significant ($P > .05$). Yield tended to decrease with increasing rainfall ($P = .1$). Although more rain might be considered to wash and produce cleaner fleeces, more rain is also associated with more plant growth and mud and therefore more fleece contamination. The SD of fiber diameter and med fiber content both increased with more rain ($P = .001$ and .005, respectively). Conversely, kemp content decreased with increasing rain ($P = .040$). No rationale can be provided for any of these three statistically significant effects.

The statistical model was modified to calculate the effects of rainfall within location and within location-season. The above statistically significant relationships between rainfall and SD of fiber diameter remained for both locations, whereas the effect of rainfall on med fiber content was significant ($P < .001$) only for the fall clip at the STP site. In contrast, the effect of rainfall on kemp was significant ($P = .05$) only in the spring fleeces at STP. Again, rationales for these relationships remain elusive.

Influence of Age. Although age and year are partially confounded in this experiment, linear effects of age are nevertheless summarized in Table 6. For these castrated Angora goats, body weight increased ($P < .001$) with increasing age, whereas mohair production tended to decrease ($P = .046$ for grease fleece weight and $P = .107$ for clean fleece weight). The aging process also resulted in the production of coarser ($P < .001$) mohair. For each year of age, the mohair coarsened by an average of 1 μm (12 × .081 μm). This effect of age on average fiber diameter is in agreement with data reported by Bassett (1966) that illustrated similar coarsening in female Angora goats with increasing age. The animals also produced more medullated fibers as they aged (for med fibers $P = .014$ and for kemp fibers $P = .084$).

Conclusions

Guajillo poisoning in Angora goats was obviously a very serious problem at the STP site and was accentuated by drought when forage from other sources was scarce. Analyses of accrued data on the surviving animals at the EP and STP research sites permitted the following conclusions. Although all measured traits were greater at STP than at EP, average fiber diameter and its SD and kemp content were the only location differences that were actually significant ($P < .05$). A specific pattern of mohair production was observed at EP in which less mohair having lower ($P < .001$) average fiber diameter was shorn in February than in August. A similar trend was not apparent at the STP site, where seasonal differences in fleece traits were not significant ($P > .1$). The proportion of total variance due to year in mohair production, yield, and average fiber diameter was two to three times greater at the STP site than at the EP site. These observations seem to be consistent with weather patterns and forage type and availability at the respective research locations during this 5-yr period. Specific effects of rainfall on body weight and fleece traits were estimated. Increased rainfall was associated with increased body weight, fleece production, and fiber diameters. However, these rainfall effects were not significant ($P > .06$). A much longer experiment would be required to better understand these effects. In contrast, the effects of age were relatively straightforward. As the goats aged, body weights increased ($P < .001$), clean mohair production decreased ($P = .107$), and fiber diameter ($P < .001$) and medullated fibers ($P < .085$) increased.

Implications

Results indicate that castrated Angora goats grazing substantially different Texas rangelands are capable of producing comparable amounts of mohair of similar average fiber diameter. However, because the proportions of total variation in mohair production and quality due to year effects were two to three times greater at the South Texas Plains research site than at Edwards Plateau, producers should expect more variable results among years when raising Angora goats in the South Texas Plains than on the Edwards Plateau. Within year, a specific pattern of mohair production and differences in mean fiber diameter emerged at the Edwards Plateau site, such that the value of the mohair shorn in August would be higher than that obtained in February. This was because more mohair was shorn in August, which, though coarser than the spring clip, would have similar value in terms of dollars received per unit weight. If problems with predation and poisonous plants could be controlled, economic returns from mohair production by castrated Angora goats on the South Texas Plains would be similar to those experienced on the Edwards Plateau, despite the substantially different ecosystems.

Literature Cited

ASTM. 1993a. Annual Book of ASTM Standards. Test method D584. Wool content of raw wool—laboratory scale. Sect. 7. Vol. 07.02: 195. ASTM, Philadelphia, PA.

ASTM. 1993b. Annual Book of ASTM Standards. Test method D2968. Med and kemp fibers in wool and other animal fibers by microprojection. Sect. 7. Vol. 07.02:772. ASTM, Philadelphia, PA.

Bassett, J. W. 1966. Changes in mohair fleece characteristics as influenced by age and season. Texas Agric. Exp. Sta. Prog. Rep. 2402.

Bassett, J. W. 1986. Kemp fiber measurements. Texas Agric. Exp. Sta. Prog. Rep. 4402.

Calhoun, M. C., C. J. Lupton, S. W. Kuhlmann, and B. C. Baldwin, Jr. 1988. Dietary energy intake effects on mohair growth. Texas Agric. Exp. Sta. Prog. Rep. 4589.

Dreyer, J. H., and G. Marincowitz. 1967. Some observations on the skin histology and fibre characteristics of the Angora goat. S. Afr. J. Agric. Sci. 10:477.

Forbes, T.D.A., H. Vera-Avila, R. D. Randel, W. Ma, and W. R. Klemm. 1994. Effects of transportation and electro-ejaculation stress superimposed on stress induced by consumption of phenolic monoamines in male Angora goats. Texas Agric. Exp. Sta. Prog. Rep. 5215.

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. Texas Agric. Exp. Sta. Bull. B-1357.

Lewis, R., and M. Shelton. 1985. A review of four years work in Angora performance testing. Texas Agric. Exp. Sta. Res. Cent. Tech. Rep. 85-1.

Lupton, C. J., F. A. Pfeiffer, and N. E. Blakeman. 1991. Medullation in mohair. Small Ruminant Res. 5:357.

Lynch, L. J., and N. A. Michie. 1976. An instrument for the rapid measurement of fiber fineness distribution. Text. Res. J. 46: 653.

Rector, B. S. 1983. Diet selection and voluntary intake by cattle, sheep, and goats grazing in different combinations. Ph.D. Dissertation. Texas A&M Univ., College Station.

SAS. 1992. Technical Report P-229. SAS/STAT Software Changes and Enhancements, Release 6.07. SAS Inst. Inc., Cary, NC.

Shelton, J. M., and J. E. Huston. 1966. Influence of level of protein and other factors on the performance of yearling billies maintained in drylot. Texas Agric. Exp. Sta. Prog. Rep. 2399.

Varner, L. W., and L. H. Blankenship. 1979. Seasonal changes in nutritive value of deer food plants in South Texas. Proc. 31st Ann. Conf. Southeast Assoc. Fish Wildlife. 31:99.

Warren, L. E., D. N. Ueckert, M. Shelton, and A. D. Chamrad. 1984. Spanish goat diets on mixed-brush rangeland in the South Texas Plains. J. Range Manage. 37:340.