Effects of Supplementation on Intake, Growth Rate, and Fleece Production by Female Angora Kid Goats Grazing Rangeland[1]

J. E. Huston, C. A. Taylor, C. J. Lupton, and T. D. Brooks

Texas Agricultural Experiment Station, Texas A&M University System, San Angelo 76901 and Sonora 76950

ABSTRACT: Ninety-eight and 88 female Angora kid goats (6 mo of age) were grazed/browsed on Edwards Plateau rangeland in 92- and 88-d trials in 1989 and 1990, respectively. The goats were either not supplemented (negative control, NC) or fed isoenergetic amounts of corn (C), a corn/cottonseed meal/ molasses mixture (C/CSM), or a corn/cottonseed meal/ fish meal/molasses mixture (C/CSM/FM). The C/CSM and C/CSM/FM supplements provided equal CP but different amounts of ruminally undegraded protein (UDP). The goats were allowed to graze/browse in a common pasture and were separated into treatment groups three times each week for feeding. Intakes of supplement and forage were measured using a dual-marker technique. Forage intake was not increased with supplemental feeding ($P = .21$), but tended ($P = .08$) to be greater with high-protein supplements than with C. Total digestible DMI was greater ($P < .01$) for supplemented goats and was not affected by supplement type. Supplemental feeding increased BW gain ($P < .01$) and clean fleece weight (CFW; $P < .01$). High-protein supplements increased BW gain ($P < .01$), CFW ($P = .07$), fiber diameter (FD; $P < .01$), and staple length ($P < .01$) compared with C. Greater amounts of UDP (C/CSM/FM) did not increase BW gain ($P = .99$) but tended to increase CFW ($P = .12$) and FD ($P = .15$). Supplemental feeding increased total digestible DMI by partial substitution (corn) for forage or addition (high-protein supplements) to forage, and both energy and protein increased BW gain and CFW and influenced mohair traits.

Key Words: Goats, Supplementary Feeding, Intake, Mohair, Protein

J. Anim. Sci. 1993. 71:3124–3130

Introduction

Angora goats breed seasonally during the fall (September to November in the northern hemisphere) and give birth in late winter, just before favorable spring conditions. In the Edwards Plateau region of Texas, rapid forage growth during the March to May period usually provides for high-quality diets to support lactation by the dam and growth by the young kid. By weaning at approximately 5 mo of age, the kids depend more on forage than on dam's milk for required nutrients. The period between weaning and first breeding (approximately 14 mo) is critical for the productive life of Angora females (Shelton, 1965). Comparing nutrient requirements (NRC, 1981) with nutrient concentrations in forages of the region (Huston et al., 1981), suggested that both energy and protein in the diets were insufficient for optimal growth when these young goats graze/browse rangeland after weaning. Hoaglund et al. (1992) suggested that the amount of ruminally undegraded protein in a range supplement affected both BW gain and wool fiber characteristics in sheep. Our study was conducted to determine the effects of supplemental feeding and of level and source of protein in the supplement on growth rate and fleece characteristics of Angora female kid goats on Edwards Plateau rangeland.

Materials and Methods

Female Angora kid goats (approximately 6 mo of age and 16.6 ± 3.4 kg) were assigned randomly during two successive fall seasons to receive one of four treatments while grazing/browsing rangeland. The study was conducted on the 1,377-ha Sonora Research Station on the southern edge of the Edwards Plateau resource region at an elevation of 640 m. The average frost-free period is from late March through October. Long-term average annual precipitation (1918 to 1988) is 60.9 cm, with rainfall peaks in May, June,

[1]This report is approved as TA 30915 by the Director of the Texas Agric. Exp. Sta., Texas A&M Univ. System, College Station.

Received February 1, 1993.
Accepted June 29, 1993.

Table 1. Supplemental feeds and composition of forage and supplements in a study to determine the effects of feeding on female Angora kid goats on rangeland

	Feeding treatment[a]			
Item	NC	C	C/CSM	C/CSM/FM
Ingredient, %				
Corn	—	100	37	45
Cottonseed meal	—	—	60	35
Fish meal	—	—	—	17
Molasses	—	—	3	3
Target feeding rate, g/d				
DM	—	204	232	225
Digestible DM	—	180	180	180
CP	—	20	75	75
CP, %				
Supplement				
Ruminally degraded (RDP)	—	7.4	26.8	21.1
Undegraded (UDP)	—	2.4	5.7	15.3
Total	—	9.8	32.5	36.4
IVDMD, %				
Forage	49.9	49.9	49.9	49.9
Supplements	—	81.0	74.0	75.2

[a]Ingredients are expressed on an as-fed basis. All other values are on a DM basis. Treatment abbreviations refer to negative control (NC; no supplemental feed), corn (C), a corn/cottonseed meal/molasses mixture (C/CSM), and a corn/cottonseed meal/fish meal/molasses mixture (C/CSM/FM).

and September. Precipitation amounts during July through December in 1989 and 1990 were 14.5 and 53.1 cm, respectively. Predominant soils at the station are Tarrant silty clay and Tarrant stony clay with some Kavett silty clay soils in the low-lying areas. These soils overlay a fractured limestone substrate. Vegetation on the site includes grasses, forbs, and woody species. Dominant midgrasses are sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), cane bluestem (*Bothriochloa barbinodis* [Lag.] Herter), Texas cupgrass (*Eriochloa sericea* [Scheele] Munro), and Wright threeawn (*Aristida purpurea* Nutt. var. *wrightii* [Nash] Allred). A prominent cool-season grass is Texas wintergrass (*Stipa leucotricha* Trin. & Rupr.). Shortgrasses include common curlymesquite (*Hilaria belangeri* [Steud.] Nash), red grama (*Bouteloua trifida* Thurb.), hairy tridens (*Erioneuron pilosum* [Buckl.] Nash), and hairy grama (*Bouteloua hirsuta* Lag). Dominant woody species are live oak (*Quercus virginiana* Mill.), juniper (*Juniperus* spp.), Mexican persimmon (*Diospyros texana* Scheele), and honey mesquite (*Prosopis glandulosa* Torr. var *glandulosa*).

Ninety-eight and 88 animals were included in the study for 92 and 88 d in 1989 (Trial 1) and 1990 (Trial 2), respectively. The goats were sheared and weighed before the beginning (September) and at the end (December) of the trials. In each trial, the kids grazed/browsed in the same pasture in a common herd. Three times per week the kids were gathered, separated into treatment groups, and group-fed as presented in Table 1. The study was designed to determine the effects of supplemental feed, CP level in supplements, and degradability of the supplemental CP on forage intake, BW change, and fleece characteristics. Feed treatments included a negative control (no supplemental feed; **NC**); corn (**C**); a corn, cottonseed meal, and molasses mixture (**C/CSM**); and a corn, cottonseed meal, fish meal, and molasses mixture (**C/CSM/FM**). The C/CSM and C/CSM/FM supplements were formulated to provide high ruminally degraded protein (**RDP**) and high ruminally undegraded protein (**UDP**), respectively. At the target feeding rate, all groups would be fed equal amounts of energy that approximated half their maintenance requirements (NRC, 1981). The C group would be fed approximately 25% of the requirements for protein, and the C/CSM and C/CSM/FM groups would receive 100% of requirements for total protein, with the protein from sources that differed in ruminal degradability. Supplements were analyzed for protein fractions according to procedures described by Wilkerson and Klopfenstein (1991) using a ruminally fistulated steer fed good-quality sorghum hay.

Diet samples were collected three times per week from a minimum of four esophageally fistulated adult Angora goats during the last 60 d of each trial. The fistulated goats were on hand at the beginning of this study and previously were prepared surgically according to a procedure reviewed and approved by the University Animal Care and Use Committee. The fistulated goats grazed/browsed on the study area with the kid goats and were penned on sampling days, fitted with screen-bottomed collection bags, and released to graze/browse for 20 to 30 min. The resulting diet samples were subsampled, combined across goats for each collection day, frozen, freeze-dried, and ground to pass a 1-mm screen. These diets were described according to plant species by micro-histological examination (Sparks and Malechek, 1968) and 48-h IVDMD by the two-step method of Van Soest et al. (1966). Inoculum for the incubation step was obtained from an adult, ruminally fistulated steer fed a diet of good-quality sorghum hay. Diets were not analyzed for protein or fiber components because they included high amounts of oak and other browse plants. These plants normally contain high and variable amounts of secondary plant chemicals (e.g., tannins) that interfere with nutrient use. This phenomenon is extremely important in range settings, but consideration of its effect on nutritional value of dietary constituents was beyond the scope of our study.

Supplement and forage intakes were determined using a dual-marker procedure in 10 kids from each treatment group during the last 30 d of each trial. Total fecal output was estimated using continuous-release, chromic oxide boluses (Captec [NZ] LD, Auckland, NZ) according to procedures of Ellis et al. (1981). The boluses were administered 7 d before the initial collection of feces from individual kids. During the 7-d adjustment period, the kids were fed supplements that had been marked with ytterbium nitrate (Yb) by spraying a solution on the dry feed and mixing it. Fecal grab samples, taken on three consecutive days directly from the rectum of each of the 10 kids in each treatment, were stored at –5°C until they were analyzed. The samples were prepared for analyses by drying at 60°C for 48 h, grinding to pass a 1-mm screen, ashing at 450°C for 6 h, oxidizing the ash in a distilled water-sulfuric acid-perchloric acid (150:150:200 mL) solution, and bringing to standard volume with distilled water (Fenton and Fenton, 1979). Ytterbium and Cr concentrations were determined in the diluted digest by atomic absorption at 398.8 and 357.9 nm, respectively, in a nitrous oxide-plus-acetylene flame. Daily fecal output (**FO**) was estimated by dividing the concentration of Cr in the feces into the amount of Cr released daily (provided by the manufacturer) from the bolus. For the purpose of these calculations, it was assumed that the average consumption levels of the supplemental feeds by the 10 selected kids in each treatment were equal to average levels for their respective treatment group. Consumption of supplements by individual kids was then estimated from the relative fecal excretion of ytterbium (FO × Yb concentration in feces). Fecal contributions from supplements were calculated from calculated supplement intake and supplement digestibility determined in vitro (Van Soest et al., 1966). The difference between total feces and feces of supplement origin was considered the undigested fraction of the consumed forage (forage fecal output, **FFO**). Forage DMI was calculated by dividing FFO by the fractional expression of the indigestibility (1 – IVDMD) of the forage diet. Digestible DM (**DDM**) intake was calculated using DMI and IVDMD values.

The fleeces removed at the end of each trial were weighed and characterized for yield, staple length, and proportions of med, kemp, and colored fibers by standard methods (ASTM, 1991). Fiber diameters were measured on 1,000 fibers of core samples of each fleece using the Peyer Texlab FDA 200 System (Siegfried Peyer AG, Wollerau, Switzerland; Lynch and Michie, 1976).

The unbalanced data were analyzed as a two-way design. The statistical model included main effects of year and treatment and the year × treatment interaction. The GLM procedure of SAS (1991) was used. Contrasts of treatment effects were as follows: 1) NC vs C, C/CSM, and C/CSM/FM, 2) C vs C/CSM and C/CSM/FM, and 3) C/CSM vs C/CSM/FM. The data are presented as least squares means.

Results and Discussion

Botanical composition of diet differed between 1989 and 1990 (Table 2). In 1989, rainfall was low (37.8 cm vs an average of 60.9 cm), and forbs were almost nonexistent. The diet was mostly live oak, which is typically low in digestibility during the fall (Huston et al., 1981), and juniper. Above average rainfall (76.7 cm) in 1990 resulted in the availability of highly digestible fall forbs (Huston et al., 1981). This large difference in diet digestibility reflects the tendency of goats to maximize diet quality by changing diets quickly when availability of plants changes (Taylor, 1983). The overall pattern of diet selection and quality indicates that the goats were heavy browsers during the fall, which is consistent with previous observations on Edwards Plateau rangeland (Malechek and Leinweber, 1972; Bryant et al., 1979; Rector, 1983).

Differences in intake and performance by the goats between years (Table 3) reflect differences in IVDMD of the forage portion of the diets (Table 2). The greater IVDMD of the forage during 1990 resulted in increased (P = .004) DDM intake from forage and tended (P = .13) to increase total DDM intake, even

Table 2. Botanical composition and digestible dry matter (DDM) of diets of female Angora kid goats grazing/browsing Edwards Plateau rangeland during two fall seasons

Item	Class of forage in diet, %: Grasses	Forbs	Browse	DDM, %
1989	4.7	.5	94.8	42.7
1990	5.5	49.0	45.5	57.1
Mean	5.1	24.8	70.1	49.9

Table 3. Intake, body weight gain, and mohair production and characteristics in female Angora kid goats during two consecutive years on rangeland

Item	Year		SE	Probability[a]	
	1989	1990		Yr	Yr × Trt
No. of goats	35	37	—	—	—
Initial BW, kg	17.7	18.7	.5	—	—
Intake					
DM, g/d					
Supplement	147	124	13.0	.224	.57
Forage	775	654	19.8	.0001	.30
Total	922	778	24.0	.0001	.79
DDM, g/d[b]					
Supplement	109	98	9.8	.43	.74
Forage	331	373	9.8	.004	.29
Total	440	471	14.2	.13	.84
Goat performance					
No. of goats	97	86	—	—	—
Initial BW, kg	16.3	17.2	.6	—	—
Weight gain, g/d	21.8	27.4	4.6	.18	.40
Clean fleece, g/kg of BW	51.2	51.4	1.7	.87	.50
Fiber diameter, μm	26.4	26.7	.4	.38	.44
Staple length, cm	8.0	7.7	.11	.001	.87
Med fibers, %	.30	.45	.06	.008	.77
Kemp fibers, %	.58	.68	.08	.15	.94
Colored fibers, %	.0018	.0023	.002	.83	.49

[a]Trt = supplement treatment.
[b]DDM = digestible DM.

at lower forage ($P < .0001$) and total ($P < .0001$) DM intakes. No differences were found between years for either BW gain ($P = .18$) or clean fleece growth ($P = .87$). Huston (1978) suggested that goats consuming low-quality diets engage a strategy to increase digestible energy intake by increasing DMI. The ability of the goats in the 1989 trial (forage DDM = 42.3%) to have similar BW gains and clean fleece growth to those in the 1990 trial (forage DDM = 57.1%) supports that concept. Explanations for differences between years in staple length ($P < .001$) and med fibers ($P = .008$), and a trend ($P = .15$) for differences in kemp fibers, are not readily evident, but may be characteristic of the individual goats used in the different studies. No year × treatment interactions (Table 3) were noted, and pooled data were reported for both year and treatment differences.

The actual nutrient concentrations and intake levels for the supplements were different from target values (Tables 1 and 4), in that lower and more variable amounts of DM, DDM, and CP were consumed. However, intakes of supplemental DDM were not different ($P = .29$) among supplemented groups, and intakes of CP followed the general pattern of the experimental design. Moreover, differences in the relative intakes of supplemental RDP and UDP were successfully imposed.

Pooled data for the 2-yr study (Table 4) indicate that supplements did not affect the intake of forage DM ($P = .21$) or DDM ($P = .30$). Supplements were generally additive with forage and increased the intake of total DM ($P < .001$) and DDM ($P < .001$). The corn supplement (C) tended to decrease intakes of forage DM ($P = .08$) and DDM ($P = .06$) compared with the higher protein supplements. Intake of both forage DM and DDM did not differ ($P = .21$) between the two high-protein supplements.

Performance data for all goats fed in the 2-yr study are shown in Table 5. Supplemental feeding increased BW gain ($P < .01$) and clean fleece weight ($P < .01$) and tended ($P = .14$) to increase staple length. The fiber diameter of all supplemented groups did not differ from that of NC ($P = .21$). Compared with the groups fed the C supplement, groups given the high-protein supplements (C/CSM and C/CSM/FM) had greater BW gains ($P < .01$), heavier clean fleece weights ($P = .07$), and longer staple lengths ($P < .01$). The high-protein supplements also increased fiber diameter ($P < .01$), which is a negative effect on mohair quality. The high UDP supplement (C/CSM/FM) had no effect on gain ($P = .99$), tended to increase clean fleece weight ($P = .12$) and fiber diameter ($P = .15$), and decreased ($P = .05$) staple length. Supplemental feeding, under the conditions of this study, had little or no effect on the occurrence of med, kemp, or colored fibers.

The effects of supplemental feeding and feed type on total DDM intake, rate of gain, and clean fleece production by Angora kid goats in this study are consistent with results reported by others. Freeman et al. (1992) observed similar effects of supplemental energy and protein on forage intake and BW change

Table 4. Effects of supplemental feed on dry matter (DM), crude protein (CP), and digestible dry matter (DDM) intake by female Angora kid goats on rangeland

	Feeding treatment[a]					Probability[b]		
Item	NC	C	C/CSM	C/CSM/FM	SE	A	B	C
No. of goats	20	16	19	17	—	—	—	—
Final BW, kg	18.6	20.7	21.9	22.4	.7	—	—	—
Intake, g/d								
DM								
Supplement	—	192	190	162	18.2	—	.50	.29
Forage	744	663	700	751	27.8	.21	.08	.21
Total	744	855	890	913	33.6	.01	.28	.64
CP								
Supplement								
Ruminally degraded (RDP)	—	14.2	50.8	34.1	3.9	—	.01	.01
Undegraded (UDP)	—	4.6	10.8	24.7	1.6	—	.01	.01
Total	—	18.8	61.6	58.8	5.3	—	.01	.72
DDM								
Supplement	—	155	140	120	14.0	—	.17	.33
Forage	364	325	347	372	13.9	.30	.06	.21
Total	364	480	486	492	20.1	.01	.72	.84

[a]See Table 1 for description of treatments.
[b]Orthogonal contrasts: A = NC vs C, C/CSM, C/CSM/FM; B = C vs C/CSM, C/CSM/FM; and C = C/CSM vs C/CSM/FM.

by steers. The steers consumed supplements in addition to forage, thereby increasing total intake, and had greater BW gains (or lower BW losses) than those that received only prairie hay. An additional increase in gain resulted when a supplement with a higher rather than a lower percentage of CP was fed. Rittenhouse et al. (1970) and Kartchner (1980) indicated that feeding high-grain supplements tended to decrease forage intake, whereas high-protein supplements tended either to increase or to be additive with forage intake by cattle grazing dormant range forage. In reproducing cattle on native range, grain feeding at .5 to .75% of BW can have negative effects on forage use and cow productivity (Bellows and Thomas, 1976; Huston and Thompson, 1990).

Ruminally undegraded protein (NRC, 1985) can increase BW gain and fleece production by grazing animals (Kempton et al., 1977). Hoaglund et al. (1992) reported increased BW gain and wool-fiber length and a trend toward increased wool-fiber diameter when blood meal was added to soybean meal in supplements for ewes. Whether these increases resulted from increased ruminally undegraded protein or increased total CP intake was not determined. Results of the present Angora goat study indicate that ruminally undegraded protein did not affect growth rate, but tended to affect most fleece characteristics when total CP intakes were similar. Although growth rate responses to increased protein intake are reportedly associated with increased DMI (Owens et al., 1991), changes in wool growth and characteristics are associated with quality and relative mixture of absorbed amino acids (Ferguson et al., 1967; Reis and Colebrook, 1972), even at the same DMI level. One

Table 5. Effects of supplemental feeding on weight gain, mohair production, and fleece characteristics of female Angora kid goats on rangeland

	Feeding treatment[a]					Probability[b]		
Item	NC	C	C/CSM	C/CSM/FM	SE	A	B	C
No. of goats	35	50	48	50	—	—	—	—
Initial BW, kg	17.5	16.5	16.2	16.5	.5	—	—	—
Weight gain, g/d	1.9	16.9	39.8	39.8	4.1	.01	.01	.99
Clean fleece, g/kg, BW	44.4	51.4	53.0	56.3	1.5	.01	.07	.12
Fiber diameter, μm	26.1	25.8	26.7	27.4	.4	.21	.01	.15
Staple length, cm	7.74	7.65	8.20	7.94	.10	.14	.01	.05
Med fibers, %	.28	.35	.48	.39	.05	.08	.21	.22
Kemp fibers, %	.60	.55	.65	.72	.07	.69	.10	.46
Colored fibers, %	.00	.0018	.00	.0063	.002	.34	.59	.04

[a]Table 1 for description of treatments.
[b]Orthogonal contrasts: A = NC vs C, C/CSM, C/CSM/FM; B = C vs C/CSM, C/CSM/FM; and C = C/CSM vs C/CSM/FM.

Table 6. Comparison of intake estimates derived experimentally and from equations published by NRC (1981) for female Angora kid goats on rangeland

	Year			Feeding treatment[a]				
Item	1989	1990	SE	NC	C	C/CSM	C/CSM/FM	SE
No. of goats	35	37	—	20	16	19	17	—
Final BW, kg	20.4	21.4	.5	18.6	20.7	21.9	22.4	.7
Daily intake, g/kg								
Measured DM								
Supplement	6.9	5.8	—	—	9.2	8.6	7.5	.9
Forage	39.1	30.7	1.0	41.3	32.7	31.9	33.8	1.4
Total	46.0	36.5	1.2	41.3	41.9	40.5	41.3	1.6
Predicted DM (NRC)								
Forage	38.3	29.2	1.0	39.1	28.1	32.5	35.2	1.5
Total	45.2	34.9	.8	39.1	37.3	41.1	42.7	1.1

[a]See Table 1 for description of treatments.

difference in our data on the effects of UDP in goats compared with those of Hoaglund et al. (1992) in sheep was that, whereas both sets of data report increased clean fleece and indications of equal or increased fiber diameter, the staple length was decreased in our goats and increased in their sheep. Results of a previous study with Angora males fed a high level of hydrolyzed feather meal indicated that fleece weight was greater, but staple length was less, than that of goats fed a similar level of a cottonseed meal supplement (Huston and Shelton, 1968). Additional research is required to determine whether this observation is indicative of a species difference in the use of UDP for fiber growth.

The estimates of intake in this study contain several sources of possible error, including inconsistent release of the chromic oxide from the slow release bolus, inaccuracy in estimating individual animal supplement intakes, and the error associated with use of in vitro estimates of digestibilities of the forage and supplement components of the diets. However, these experimentally measured components of intake compare remarkably well with intake predicted using BW, BW gain, and mohair growth (Table 6) from equations published by the NRC (1981). The measured and predicted values are consistently similar, both between years and among supplemental feeding groups. The closeness of the measured and predicted means and the variation (SE) associated with these estimates suggest that such efforts to describe grazing behavior under extensive range conditions are indeed reasonable. Although inaccuracies are intrinsic to grazing studies, errors that result are likely no more costly to interpretation, perhaps less so, than are studies conducted outside the circumstances of application.

Implications

Without supplementation, weaned Angora kid goats will have suboptimal body weight gains and mohair growth while grazing/browsing dormant native rangelands. Although corn is often fed to goats on range, feeding supplements that have a greater percentage of crude protein will promote greater weight gain and fleece production, but slightly increase mohair fiber diameter. Animal byproduct protein concentrates such as fish meal are effective protein sources for goats and may be of greater value than oilseed byproduct meals in stimulating mohair growth because of their comparatively low ruminal protein degradation.

Literature Cited

ASTM. 1991. Annual Book of ASTM Standards. Sect. 7. Vol. 07.01. ASTM. Philadelphia, PA.

Bellows, R. A., and O. O. Thomas. 1976. Some effects of supplemental grain feeding on performance of cows and calves on range forage. J. Range Manage. 29:192.

Bryant, F. C., M. M. Kothmann, and L. B. Merrill. 1979. Diets of sheep, Angora goats, Spanish goats and white-tailed deer under excellent range conditions. J. Range Manage. 32:412.

Ellis, K. J., R. H. Laby, and R. G. Burns. 1981. Continuous controlled release administration of chromic oxide to sheep. Proc. Nutr. Soc. Aust. 6:145.

Fenton, T. Q., and M. Fenton. 1979. An improved procedure for the determination of chromic oxide in feed and feces. Can. J. Anim. Sci. 59:631.

Ferguson, K. A., J. A. Hemsley, and P. J. Reis. 1967. Nutrition and wool growth. The effect of protecting dietary protein from microbial degradation in the rumen. Aust. J. Sci. 30:215.

Freeman, A. S., M. L. Galyean, and J. S. Caton. 1992. Effects of supplemental protein percentage and feeding level on intake, ruminal fermentation, and digesta passage in beef steers fed prairie hay. J. Anim. Sci. 70:1562.

Hoaglund, C. M., V. M. Thomas, M. K. Petersen, and R. W. Kott. 1992. Effects of supplemental protein source and metabolizable energy intake on nutritional status in pregnant ewes. J. Anim. Sci. 70:273.

Huston, J. E. 1978. Forage utilization and nutrient requirements of the goat. J. Dairy Sci. 61:988.

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.

Huston, J.E., and M. Shelton. 1968. Protein supplementation of Angora goats. Texas Agric. Exp. Sta. Prog. Rep. PR-2523.

Huston, J. E., and P. V. Thompson. 1990. Effects of stocking rate and supplemental feeding on adult beef cows on rangeland in the Edwards Plateau region of Texas. Texas Agric. Exp. Sta. Prog. Rep. PR-4850.

Kartchner, R. J. 1980. Effects of protein and energy supplementation of cows grazing native winter range forage on intake and digestibility. J. Anim. Sci. 51:432.

Kempton, T. J., J. V. Nolan, and R. A. Leng. 1977. Principles for the use of non-protein nitrogen and by-pass proteins in diets of ruminants. World Anim. Rev. 22:2.

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

Malechek, J. C., and C. L. Leinweber. 1972. Forage selectivity by goats on lightly and heavily grazed ranges. J. Range Manage. 25:105.

NRC. 1981. Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries. National Academy Press, Washington, DC.

NRC. 1985. Ruminant Nitrogen Usage. National Academy Press, Washington, DC.

Owens, F. N., J. Garza, and P. Dubeski. 1991. Advances in amino acid and N nutrition in grazing ruminants. Proc. 2nd Grazing Livest. Nutr. Conf. p. 109. Oklahoma Agric. Exp. Sta. Misc. Pub. MP-133.

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

Reis, P. J., and W. F. Colebrook. 1972. The utilization of abomasal supplements of protein and amino acids by sheep with special reference to wool growth. Aust. J. Biol. Sci. 25:1057.

Rittenhouse, L. R., D. C. Clanton, and C. L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Shelton, M. 1965. The relation of size to breeding performance of Angora does. Texas Agric. Exp. Sta. Prog. Rep. PR-2339.

Sparks, D. R., and J. C. Malechek. 1968. Estimating percentage dry weight in diets using a microscope technique. J. Range Manage. 21:264.

SAS. 1991. SAS System for Linear Models (3rd Ed.). SAS Inst. Inc., Cary, NC.

Taylor, C. A., Jr. 1983. Foraging strategies of goats as influenced by season, vegetation, and management. Ph.D. Dissertation. Texas A&M Univ., College Station.

Van Soest, P. J., R. H. Wine, and L. A. Moore. 1966. Estimation of true digestibility of forages by the in vitro digestion of cell wall. Proc. 10th Int. Grassl. Congr. p 438.

Wilkerson, V. A., and T. J. Klopfenstein. 1991. Collaborative study of in situ forage protein degradation. Proc. Forage Grassl. Conf., April 1-4, 1991. p 99. Columbia, MO.