Forage Selectivity by Goats on Lightly and Heavily Grazed Ranges[1]

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Highlight

Average annual diets were similar on lightly and heavily grazed ranges, but variability over time did not always follow similar patterns on the two grazing treatments, and periodic differences in dietary botanical composition resulted. Goats in this study should be classified in the popular sense as "grazers" rather than "browsers."

Selectividad de Forraje por Cabras Pastoreando en Pastizales sub y sobre Pastoreados

Resumen[3]

El estudio se llevó a cabo en la Estación Experimental de la Universidad de Texas A & M ubicado cerca de Sonora, Texas, E.U.A. Se cmplcaron cabras con "Fístula esofógica y cánula tipo D" para determinar la composición botánica de sus dietas a través del año cuando pastorean áreas con sub y sobre pastoreo.

Según el promedio del año no hubo diferencias significativas entre sus dietas en respecto a las proporciones de ramoneo, hierbas y gramíneas pero hubo diferencias entre las estaciones. Las dietas en primavera en el área con sub pastoreo tuvieron principalmente gramíneas y hierbas mientras en el área con sobre pastoreo gramíneas y especies ramoneables. En ambas áreas las gramíneas fueron muy consumidas en la época de Junio a Octubre.

El pastoreo de las hierbas fué restringido a su disponibilidad pero las gramíneas y las especies ramoneables fueron consumidas a través del año dependiendo de su gustocidad.

De las especies ramoneables el Encino fué el más preferido. Las cabras en el área con sobrepastoreo comieron algunas especies leñosas consideradas como especies indeseables. Principalmente los tallos y hojas jóvenes fueron consumidas.

Se concluyó que para las condiciones bajo las que se hicieron las observaciones, las cabras deben considerarse como consumidoras de gramíneas en vez de ramoneadoras.

Knowledge of the grazing animal's food habits and forage preference is fundamental to designing effective grazing systems, evaluating the effects of grazing use on plant communities, and formulating economical supplementation programs on nutritionally deficient ranges. Such information assumes particular importance on rangelands having complex use patterns, such as those in the Edwards Plateau region of central and western Texas. There sheep, cattle, Angora goats, and white-tailed deer (*Odocoileus virginianus*) frequently share the same range year-long. The problem of allocating forage among animal species in accord with immediate economic priorities, and yet maintaining or improving the condition of these ranges requires a thorough knowledge of animal's food habits. Unfortunately, little such information is available for goats.

The earliest attempt to scientifically characterize grazing habits of Angora goats in the Edwards Plateau (Cory, 1927) generally supported the popular opinion that goats are browsers, but it also illustrated that other classes of forage are used extensively. This research indicated that goats spent 53% of their total feeding time utilizing woody forage species, 38% of their time grazing grass and forbs, and the remainder of the time was spent in supplcmentary feeding and miscellaneous grazing activities. Later studies in the same area (Fraps and Cory, 1940) were designed to study changes in forage use over time, and feeding animals were observed monthly. Browse was found to comprise more than 50% of the diet during all seasons except spring, when 53% of the grazing time was spent utilizing forbs. Grass consumption was highest in fall (43% of the diet), but never exceeded 32% at other seasons. Fraps and Cory (1940) also observed that goats consistently used a much larger number of plant species over the year than either cattle or sheep did.

Recent investigations of the competitive relationships between white-tailed deer and domestic livestock in the Edwards Plateau (McMahan, 1964) suggested that goats select at least 50% of their diet from browse species at all seasons on ungrazed range, as well as on ranges stocked at rates of 8, 16, and 24 acres per animal unit. McMahan's (1964) data also indicated that forb usage was appreciably higher on previously ungrazed range than on any of the three comparable grazed ranges.

A major deficiency of many food habits studies has been the failure to include data relative to forage availability. Unless such information is available, it is difficult to decide if animals used a particular species or class of forage because it was preferred, or because there was nothing else available. Neither of the two early studies (Cory, 1927; Fraps and Cory, 1940) presented information on forage availability. McMahan (1964) measured the "abundance" of available forage and listed seasonally preferred species, but did not report quantita-

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FIG. 1. Esophageally cannulated goats collecting samples of grazed forage on lightly grazed range.

tive data on forage availability. The present study measured the botanical composition of goats' diets and the forage available for consumption. Nutritional properties of these diets will be handled in a later paper.

Methods

Field research was conducted in two adjacent 80-acre pastures on the Texas A&M University Agricultural Research Station at Sonora, Texas. The lightly grazed pasture had been grazed continuously by goats at the rate of 40 acres per animal unit for the preceding 11 years and was classified in "good" range condition according to Soil Conservation Service procedures for determining range condition. The heavily grazed pasture had been grazed at the rate of 13.3 acres per animal unit throughout the same period and was classified in "fair" range condition. For the purposes of this study, no attempt was made to separate the effects of range condition and grazing intensity on diet, and the combination of these factors in each pasture was considered as a "treatment." The two "treatments" are referred to as heavily grazed and lightly grazed in this paper.

Mature wether goats (Fig. 1) fitted with esophageal fistulae and "Type D" cannulae (Van Dyne and Torell, 1964) were used to collect 657 representative samples of grazed forage during an 11-month period in 1967. Initially, six animals were randomly assigned to each of the two pastures, but replacements for unusable animals were not always available and numbers varied from four to six in the lightly grazed pasture and from five to six in the heavily grazed pasture. Including replacements, a total of 18 fistulated goats were used during the study.

Samples were collected once daily for five consecutive days beginning the second week in January. This sequence was repeated at 3-week intervals through November, giving a total of 16 collection periods. During fly-free seasons, the fistulated animals remained in their respective pastures when not in use for sample collection. When flys were a nuisance, the animals were moved to a screened barn for the interim between sample collection periods. An adjustment period of at least five days was allowed when animals were replaced on pasture in preparation for a sampling period.

A typical sample collection sequence began by penning the animals at dusk, with access to water. At dawn the following morning, cannulae were opened, screen-bottom collection bags were attached, and the goats were allowed to graze freely for a period of 30 minutes to 1 hour. After removing the collected samples, the cannulae were closed and the animals were released to graze at-will for the remainder of the day. This operation was conducted simultaneously in the two pastures.

Immediately following collection, each sample of fistula material was thoroughly hand-mixed, subsampled for in vitro digestibility analysis, bagged individually in a polyethylene bag, and frozen at –20 C to wait chemical and botanical analysis.

The botanical analysis was performed on composited samples of fistula material representing forage selected by a particular goat during a 5-day collection period. Samples were prepared for analysis by first handchopping the frozen individual samples until free of clumps, then selecting 10-gram (dry weight) aliquots of the chopped material from each individual sample, and finally combining these aliquots by thorough agitation in a water suspension. Water was then removed by filtration, and approximately 200 grams of the saturated composite sample was spread over the floor at a 7.5- × 12- inch laboratory tray. This sample was then analyzed microscopically (0.7 × -3.5X) by the point frequency procedure of Chamrad and Box (1964). One-hundred points were observed on each sample and each contact was recorded as browse, forb, or grass, and leaf, stem, or fruit. In addition, browse items were identified to species. Unidentifiable particles were so recorded.

The forage available for consumption was measured in each pasture once during each of four seasons. For purposes of this study, the seasons were designated as follows: winter—December through February; spring—March through May; summer—June through August; and fall—September through November. Forage production of all species was estimated by locating 250 2-ft^2 plots in each pasture, utilizing a stratified-random sampling design (N.A.S.-N.R.C., 1962). The pastures were stratified on the basis of soil types (Oakes and Crozier, 1948) and plots were allocated proportionally to these strata. All herbaceous vegetation that occurred in these plots was measured by the method outlined by Goebel et al. (1958). Plot measurements were projected vertically to include all browse and woody vegetation occurring in a 4.7-ft zone or horizon of available forage. This zone was predetermined by measuring the height of the browse-line in the heavily grazed pasture.

Data from botanical determinations on composite samples were analyzed statistically by analysis of variance, using least-squares procedures. Pastures and collection periods were considered as fixed effects and animals were considered as random effects. In this model, the mean squares for animals/pastures was the error term for testing significance of the main effect, pastures. The mean squares of the residual were used as the error term for testing significance of period effects and the pasture × period interaction. Data on available forage were not analyzed statistically.

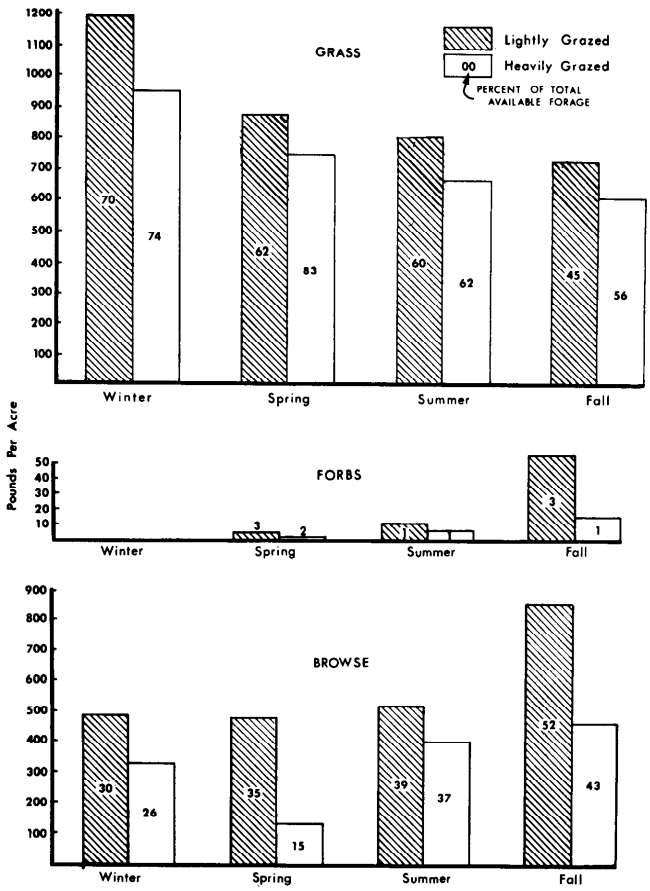

FIG. 2. Seasonal availability of browse, forbs, and grass on lightly and heavily grazed ranges.

Results

Forage Availability

There was consistently more grass available in the lightly grazed pasture than in the heavily grazed pasture, but grass constituted a greater proportion of the total available forage in the heavily grazed pasture than it did in the lightly grazed pasture (Fig. 2). Practically all of the grass available during the winter and a large portion of that available in spring was the dry, cured material remaining from a favorable growing season the previous year. Significant production of new growth was not observed in either pasture before early April due to abnormally dry weather. Curlymesquite grass[4] (*Hilaria belangeri*) was the dominant grass species at all seasons in the heavily grazed pasture and during the winter and summer in the lightly grazed pasture. Sideoats grama (*Bouteloua curtipendula*) was the dominant grass species on the range during spring and fall in the lightly grazed pasture.

More browse was available in the lightly grazed pasture than in the heavily grazed pasture (Fig. 2).

[4] Seasonal availabilities of individual forage species on the two grazing treatments are tabulated in appendices of Malechek (1970).

Table 1. Means and standard errors for the percentages of three forage classes in goats' diets on lightly and heavily grazed ranges.

	Lightly grazed		Heavily grazed	
Forage class	Mean	Std. error	Mean	Std. error
Grass	49.7	2.6	55.1	2.4
Forbs	10.9	1.3	7.2	0.9
Browse	38.9	2.8	37.6	2.7

In terms of biomass of individual species, pricklypear (*Opuntia lindheimeri*) was the dominant source of available browse in both pastures at all seasons. It usually constituted from 50% to 80% (by weight) of the total browse crop in both pastures. An exception was the spring season in the lightly grazed pasture when pricklypear made up 32% of the available browse. The marked increase in browse availability during fall in the lightly grazed pasture was due primarily to increased pricklypear production.

Forb production in this locality was heavily dependent upon autumn and winter precipitation. Consequently, the availability of forbs in both pastures was low at all seasons (Fig. 2). There was, however, a noticeable increase in forb production during the fall, particularly in the lightly grazed pasture, in response to late summer and early autumn rains. During the three seasons when forbs were sufficiently abundant to measure on the range, there always were more pounds of forbs available in the lightly grazed pasture than in the heavily grazed pasture.

Forage Classes in Diets

Average diets for goats grazing heavily and lightly stocked ranges are presented in Table 1. There were no significant ($P < .05$) differences between mean animal diets from the two pastures for any of the three respective forage classes in diets (Table 2). However, comparisons and evaluations of herbivores' diets on the basis of annual means

Table 2. Analysis of variance for the percentages of three forage classes in goats' diets on lightly and heavily grazed ranges.

Source of variation	Degrees of freedom	Mean squares		
		Grass	Forbs	Browse
Pastures	1	786.5	529.2	35.3
Animals/pastures	16	361.5	207.5**	507.0**
Periods	15	2626.0**	349.0**	2543.2**
Pastures × periods	15	528.1**	178.4**	664.2**
Residual	115	212.2	38.2	259.4

** $P < .01$

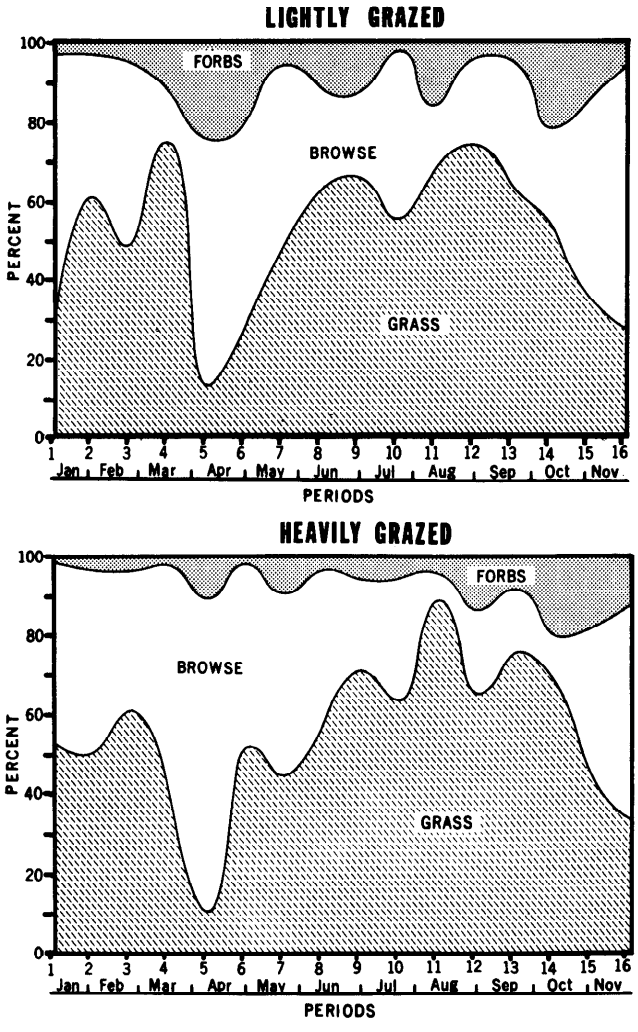

FIG. 3. Percentages of grass, forbs, and browse in goats' diets on lightly and heavily grazed ranges.

are of questionable value, where extensive season-to-season variation in diet composition is present (Fig. 3). Differences among periods were highly significant ($P < .01$) for all three dietary forage classes. The overall pattern of variability in the two pastures was similar. Statistical comparisons for individual periods (Kramer, 1956) revealed only six periods of the 16 when differences existed between pastures for a dietary forage class. For example, in January (Period 1), there was more grass selected on the heavily grazed range, but by mid-March (Period 4), the pattern of diet selectivity had reversed in the two pastures, and goats on lightly grazed range were selecting more grass and less browse than those on heavily grazed range (Fig. 3).

An abrupt alteration of dietary composition was observed on both pastures in early April (Fig. 3), when grass content of diets dropped to the lowest point in the study. Browse, primarily the newly emerged leaves of the deciduous shin oak (*Quercus pungens* var. *vaseyana*), constituted the bulk of diets on both ranges at that time but forb consumption was appreciably greater in the lightly grazed pasture.

Grass was the major class of forage consumed on both grazing treatments throughout the period from June to mid-October (Fig. 3). Diets in either pasture rarely contained more than 30% browse or 15% forbs during this time. There was no difference between pastures with respect to either browse or forb contents of diets throughout the June-October period.

Samples of ingested material from late October and November collections showed the proportion of browse to be rapidly increasing in late autumn

Table 3. Percentages of individual species of browse in goats' diets on lightly and heavily grazed ranges.

		Periods																
		Winter			Spring				Summer				Fall				Winter	
Species		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean
Plateau Oak	L.[1]	62	12	12	0	3	0	0	0	0	0	0	0	0	0	0	0	5
	H.	32	28	12	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Shin Oak	L.	0	0	0	4	34	53	42	24	21	40	16	22	30	21	44	58	26a[2]
	H.	0	0	0	5	56	36	34	31	15	22	5	19	16	10	32	6	18a
Junipers	L.	4	2	18	4	0	0	0	0	0	0	0	0	0	1	6	6	3b
	H.	6	10	8	20	2	3	2	1	2	0	0	0	0	3	5	31	6b
Pricklypear	L.	3	21	9	0	3	0	0	0	0	2	1	0	1	0	0	3	3
	H.	6	9	6	26	1	1	4	2	1	8	1	1	0	0	0	0	4
Tasajillo	L.	0	1	9	2	0	0	3	0	0	0	0	0	0	0	0	0	1
	H.	2	5	5	4	0	1	3	0	1	0	0	1	0	0	1	26	3
Other Browse[3]	L.	0	1	0	0	10	1	1	0	0	0	0	0	0	0	0	0	1
	H.	0	0	0	1	16	4	3	3	1	0	0	1	0	0	0	0	2

[1] L. signifies lightly grazed; H. signifies heavily grazed.

[2] Means with same letter are significantly ($P < .05$) different.

[3] Includes Sacahuista, Elbowbush (*Forestiera pubescens*), Hackberry (*Celtis reticulata*), pricklyash (*Zanthoxylum clava-herculis*), Catclaw (*Acacia greggii*), and Agarito (*Berberis trifoliolata*).

diets in both pastures, while the proportions of grass and forbs were decreasing correspondingly.

In addition to the conventional woody shrub or tree species, the browse category in this study included such species as pricklypear, tasajillo (*Opuntia leptocaulis*), and sacahuista (*Nolina texana*). Browse in diets was, therefore, identified to species to explain as nearly as possible the variability between pastures and among periods. Percentages of individual browse species found in diets are tabulated in Table 3.

Plateau oak (*Quercus virginiana* var. *fusiformis*) was the major browse species in diets on both treatments in January and early February. Although an evergreen, this tree characteristically sheds much of its foliage in February and March, and replacement by new leaves was delayed by droughtly conditions the year of the study. Hence, little oak forage was available during February and March and heavy use of pricklypear and junipers (*Juniperus asheri* and *J. pinchoti*) was observed. Shin oak essentially replaced other browse species in diets from the time of leaf emergence in early April until frost-kill in early November. Heavy use of junipers and tasajillo was noticed in late November on heavily grazed range.

Although no significant differences were observed between pastures with respect to yearly averages of *forage classes* in diets (Table 2), the means of two *species* in the browse category did differ between pastures (Table 3). Specifically, goats on lightly grazed range selected more shin oak and less juniper than did goats on heavily grazed range.

Plant Parts in Diets

Leaves were the major plant part constituent in diets on both grazing treatments throughout the year (Fig. 4), and there were significantly ($P < .10$) more leaves and fewer stems consumed on lightly grazed range (Table 4). Samples from goats on lightly grazed average 88% leaves and 10% stems for the year, compared to 83% leaves and 15% stems for samples from goats on heavily grazed range. Fruits were a minor part of the diet averaging approximately 3% and 2% for the lightly and heavily grazed pastures, respectively.

Variability over time was highly significant for all three dietary plant parts (Table 4), but not nearly as extensive as that observed for dietary forage classes (Table 2). The pattern of variability over time was similar in the two pastures for the fruit category, but dissimilar for stems and leaves (Fig. 4). Pricklypear pads and the cylindrical joints of tasajillo were included in the stems category, and the relatively high percentages of stems observed in late winter and early spring (Fig. 4) were largely reflections of high percentages of these two species in diets (Table 3).

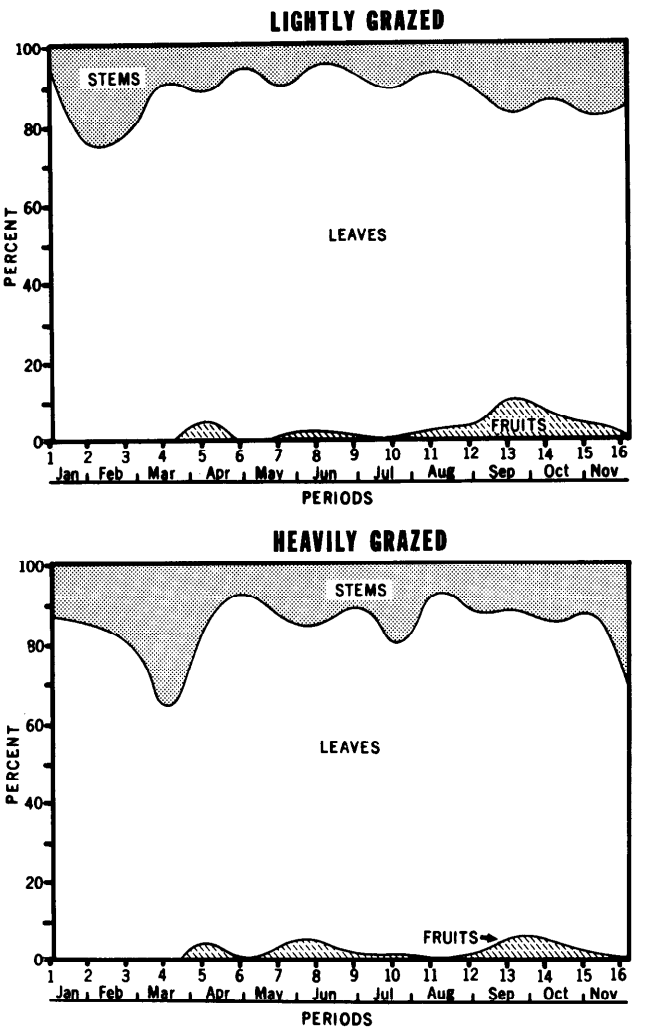

FIG. 4. Percentages of leaves, stems, and fruits in goats' diets on lightly and heavily grazed ranges.

Both pastures were highest in dietary fruits in September and early October. Seedheads of sideoats grama and hairy tridens (*Erioneuron pilosum*) were the major fruit items in the lightly grazed pastures, whereas, seedheads of hairy tridens and oak mast were equally important in the heavily grazed pastures.

Table 4. Analysis of variance for the percentages of three plant parts in goats' diets on lightly and heavily grazed ranges.

Source of variation	Degrees of freedom	Mean squares		
		Leaves	Stems	Fruits
Pastures	1	739.7†	569.9†	1.7
Animals/pastures	16	200.4**	229.6**	16.5*
Periods	15	290.8**	494.5**	50.3**
Pastures × periods	15	182.5**	218.0**	7.5
Residual	115	75.3	72.0	7.3

** $P < .01$; * $P < .05$; † $P < .10$.

Discussion

Forb consumption by goats in this study was probably restricted by limited availability, particularly during spring on the heavily grazed range. However, availability of forbs on the range was no reliable index of amounts in diets. For example, forbs were highly preferred in spring, and at one period on lightly grazed range, comprised almost 30% of the diet, even though there were fewer than 10 lbs./acre available on the range at the time. Previous work by Kothmann (1968) suggests that during more favorable years, forb availabilities ranging from 70 to 250 lbs./acre could be expected in the area.

Levels of grass in diets during spring, summer, and fall appeared to parallel the growth of warm-season perennial grasses in the area. This is not unusual as grazing animals are known to select for green, succulent forage (Heady, 1964). However, the extent of grass use by goats in this study was surprising, in view of results of obtained by Fraps and Cory (1940) and McMahan (1964). Both of these previous investigations showed browse to be, by far, the most important class of dietary forage during summer and fall. Their results were based on ocular observations of single animals. In the present study, the basic data group was a mean calculated from the analysis of grazed samples from at least four and usually six animals. Studies of individual animal variability in forage selectivity (Van Dyne and Heady, 1965) indicate that results from single animal studies may be of very limited value for drawing valid conclusions.

Grass received somewhat heavier use in the heavily grazed pasture than in the lightly grazed pasture during most of the summer and fall, but differences in dietary grass in the two pastures at a particular time were never statistically significant. Furthermore, the general trends for percent of grass in the diets were similar in the two pastures at this time. Therefore, it is likely that the heavy grass usage in the summer and fall was a true reflection of animal preference and not the result of forced utilization caused by a shortage of browse. Had browse been the most preferred forage at that time, it would have been used more extensively in the lightly grazed pasture where there were relatively large supplies of palatable browse available.

Comparing results from this study to those of Kothmann (1968) suggests the possibility of direct competition between sheep and goats for grass in summer, where the two species are grazing common range. Working in other pastures on the Sonora Research Station during a different year, he found sheep on heavily grazed range selected from 70% to 90% of their diet from grass during the June-September period. This corresponded to the period of peak grass use by goats in the present study. Sheep on lightly grazed range selected a diet containing about 55% grass during this time.

Oak mast has been an important food item during fall in other investigations (Fraps and Cory, 1940; McMahan, 1964). Because of the winter and spring drought, very few acorns were produced the year of our study.

Summary and Conclusions

Diets selected by esophageally cannulated Angora goats were compared on lightly grazed, good condition range and heavily grazed, fair condition range.

Averaged over all collections, diets selected on the two grazing treatments did not differ greatly in their respective proportions of browse, forbs, or grass. There were, however, periodic differences between pastures for all three forage classes in diets. The most noticeable was during early spring, when grass and forbs constituted the bulk of the diet on lightly grazed range, while grass and browse were the most important dietary components on heavily grazed range.

Grass was an especially important food item on both ranges from June to October, and dietary levels during this period of time appeared to parallel the growth of warm-season perennial grasses in the area.

Forb consumption in winter and spring was limited by availability, but use of grass and browse throughout the year was generally a function of the relative palatabilities of individual species constituting the two classes of forage. With the possible exception of forbs on heavily grazed range, availability of a particular forage class on the range was not a consistent indicator of the dietary use of that forage class.

Goats on both grazing treatments preferred leaves over stems and fruits. There were significantly more leaves and fewer stems in the diet under light grazing than under heavy grazing, but fruit consumption on the two treatments was similar.

The amount of juniper and shin oak in diets differed significantly between pastures, even though the average browse content of the diets did not differ on the two treatments. Shin oak was consistently the most important species of dietary browse during the period of the year when it was available.

Results of this study indicate that goats could be classified as "grazers" during a great part of the year than they could be classified as "browsers."

Literature Cited

CHAMRAD, A. D., AND T. W. BOX. 1964. A point frame for sampling rumen contents. J. Wildlife Manage. 28: 473–477.

CORY, V. L. 1927. Activity of livestock on the range. Tex. Agr. Exp. Sta. Bul. 367. 47 p.

FRAPS, G. S., AND V. L. CORY. 1940. Composition and utilization of range vegetation of Sutton and Edwards Counties. Tex. Agr. Exp. Sta. Bul. 586. 39 p.

GOEBEL, C. J., L. DEBANO, AND R. D. LLOYD. 1958. A new method of determining forage cover and production on desert shrub vegetation. J. Range Manage. 11:244–246.

HEADY, H. F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17:76–83.

KOTHMANN, M. M. 1968. The botanical composition and nutrient content of the diet of sheep grazing on poor condition pasture compared to good condition pasture. Ph.D. Dissertation. Texas A&M Univ., College Sta. 60 p.

KRAMER, C. Y. 1956. Extension of multiple range tests to group means with unequal numbers of replications. Biometrics 12:307–310.

MALECHEK, J. C. 1970. The botanical and nutritive composition of goat diets on lightly and heavily grazed ranges in the Edwards Plateau of Texas. Ph.D. Dissertation. Texas A&M Univ., College Sta. 61 p.

MCMAHAN, C. A. 1964. Comparative food habits of deer and three classes of livestock. J. Wildlife Manage. 28: 798–808.

N.A.S.–N.R.C. 1962 Basic problems and techniques in range research. Nat. Academy of Sci.—Nat. Res. Council Publication 890. Washington, D.C. 341 p.

OAKES, H. A., AND D. C. CROZIER. 1968. Soil survey of the Ranch Experiment Station. Unpublished manuscript. 33 p.

VAN DYNE, G. M., AND D. T. TORELL. 1964. Development and use of the esophageal fistula: A review. J. Range Manage. 17:7–19.

VAN DYNE, G. M., AND H. F. HEADY. 1965. Botanical composition of sheep and cattle diets on a mature annual range. Hilgardia 36:465–492.