

Species Preference of Hereford and Santa Gertrudis Cattle on A Southern New Mexico Range¹

CARLTON H. HERBEL AND ARNOLD B. NELSON

Research Range Scientist, Jornada Experimental Range, Crops Research Division, Agricultural Research Service, U. S. D. A., Las Cruces, New Mexico; and Animal Nutritionist, Animal Science Department, New Mexico State University, University Park.

Highlight

The species preferences of Hereford and Santa Gertrudis cows were observed during a 3-year period. The cattle grazed a variety of species, undoubtedly an important factor affecting nutritional status. They ate, to some extent, all available species. There was no apparent difference between breeds in the quantity of coarse plants consumed.

The species grazed by livestock and the species preferred during various seasons are important in formulating grazing management plans and for nutritional studies. Season of growth, succulence, abundance, and nutritive qualities are plant properties influencing species preference. Tribe (1952) reported that in animals, age, stage of pregnancy, general physical condition, and hunger also affect grazing preference.

The purpose of this portion of the overall study was to determine the plants grazed by cattle during the various seasons.

Methods and Materials

This study was conducted on the Jornada Experimental Range, 25 mi north of Las Cruces, New Mexico. See Herbel and Nelson (1966) for a general description of the study area, for details on management of

the test herd, and for the methods used in observing the cows. At the same time the activities of the Hereford and Santa Gertrudis cows were being observed, their species preferences were noted. There were 58

observations of each breed over the 1961-64 study period. During daylight hours, while the cattle were grazing, we noted the species being grazed at 4-min intervals. Species grazed at nighttime were not noted. Samples similar to the grazed portions were also collected for chemical analyses which will be reported in another paper.

Since the species grazed depends on available vegetation, we sampled the experimental area annually during the summer by means of 100-ft line-intercept transects (Canfield, 1941). The data were stratified according to soil type. Fig. 1 shows the soil types on the experimental area (pastures 10 and 11). Names used in describing these soils are tentative, pending final correlation.

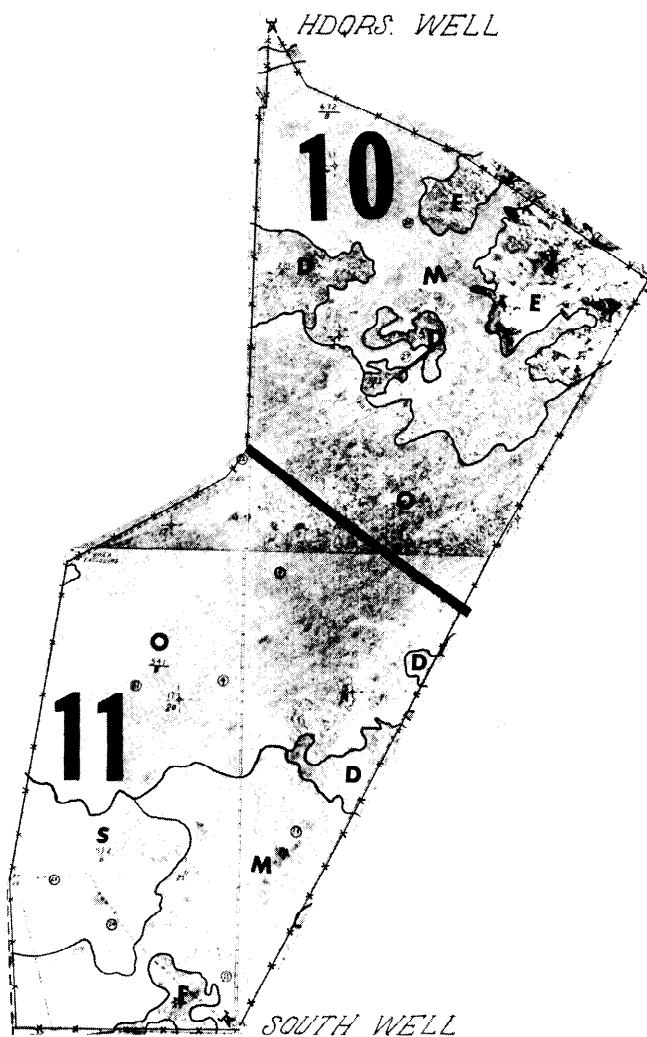


FIG. 1. Soil types on the experimental area (pastures 10 and 11 of the Jornada Experimental Range).

¹Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. D. A., and the Animal Science Department, New Mexico Agricultural Experiment Station. Partially supported by Western Regional Research Project W-34. Published as Journal Series No. 238, Agricultural Experiment Station, New Mexico State University.

The soils were described as follows (Soil Conservation Service, 1963):

D. Hoban silt loam, 0 to 1% slopes.—This is a moderately deep to deep, light-colored, calcareous soil that has a silty surface and moderately fine-textured, slowly permeable subsoil. Moderate to strong lime (calcium carbonate) zones usually occur at depths of 20 in and below. It occurs in the lower parts of the Jornada basin and receives some flood water during severe thunderstorms.

E. Dona Ana complex, 0 to 3% slopes.—The principal soils of this mapping unit are deep and calcareous with medium-textured surfaces over weakly developed, moderately fine-textured, slowly permeable subsoils. Prominent horizons of calcium carbonate accumulations occur below 25 in. The landscape is traversed by a series of erosional escarpments which range in height from 6 in to 7 ft. In many places at the foot of the escarpments accumulations of sand have formed a narrow, sandy ridge, varying from a few inches to several feet thick over fine underlying material.

F. Continental loam, 0 to 3% slopes.—This is a deep to moderately deep soil with a medium-textured surface over well-developed, clayey, slowly permeable subsoil. Strong lime zones occur below 26 in.

M. Turney sandy loam, 1 to 3% slopes.—This is a deep to moderately deep, light-colored, calcareous soil with sandy surface over weakly developed, moderately permeable, sandy clay loam subsoil. A prominent lime zone usually occurs below 20 in. Surface soils were wind-shifted in many places.

O. Banbar loamy fine sand, 1 to 3% slopes.—This soil is deep with moderately sandy surfaces over reddish, moderately permeable, sandy clay loam subsoils. Accumulations of lime are frequent at depths below 16 to 20 in. The surface is very susceptible to wind erosion.

S. Cacique loamy fine sand, 1 to 3% slopes.—These are mostly moderately deep soils with moderately sandy textured surfaces, with permeable subsoils. The soils are underlain with discontinuous layers of indurated caliche. In many places, due to rodent activity, caliche fragments have been mixed throughout the soil profile.

Table 1. Average basal cover (1961-64) by soil types for pastures 10 and 11 in units of 0.01%.

Species	Soil type									
	D		E	F	M		O		S	
	10 ¹	11 ¹	10	11	10	11	10	11	11	
Perennial Grasses										
<i>Aristida longiseta</i>	0.1	1.5	4.3	4.7	2.4	1.9	0.1	0.1	1.6	
<i>Bouteloua eriopoda</i>	1.7	1.9	0.9	0.7	1.8	9.3	3.9	2.9	25.6	
<i>Hilaria mutica</i>	24.4	7.7	13.9	6.4	1.4	4.2	—	0.4	0.3	
<i>Scleropogon brevifolius</i>	137.7	68.6	63.4	66.0	22.0	10.0	0.2	1.3	0.2	
<i>Sporobolus airoides</i>	1.6	0.7	1.6	—	5.1	0.2	0.3	0.2	0.6	
<i>S. flexuosus</i>	0.7	1.2	5.4	0.1	4.7	6.3	8.6	16.9	12.8	
Others	2.7	3.4	3.9	4.8	3.7	6.1	0.2	1.0	3.8	
Annual Grasses										
<i>Bouteloua barbata</i>	0.1	—	0.3	—	1.0	T	0.5	1.7	0.5	
Perennial Forbs										
<i>Croton corymbulosus</i>	0.2	1.3	1.0	1.0	2.1	0.8	2.6	0.9	1.6	
<i>Lesquerella fendleri</i>	T	0.1	0.1	—	—	—	—	0.2	—	
<i>Perezia nana</i>	1.0	1.1	0.7	0.3	0.1	0.1	—	0.1	0.1	
<i>Psilostrophe tagetinae</i>	0.1	—	—	0.1	0.1	0.2	0.6	0.4	0.4	
<i>Sphaeralcea subhastata</i>	0.3	0.2	0.2	0.1	0.3	0.4	0.3	—	—	
Others	0.5	1.9	0.8	1.9	1.9	2.1	2.1	2.0	1.4	
Annual Forbs										
<i>Corispermum nitidum</i>	—	—	—	—	0.6	—	1.5	0.6	—	
<i>Dithyrea wislizeni</i>	—	—	—	—	—	T	T	0.4	T	
<i>Iva dealbata</i>	—	0.1	0.6	—	0.1	0.2	—	—	—	
<i>Salsola kali</i>	0.6	0.5	1.7	5.0	1.3	3.5	2.3	2.3	5.5	
Others	0.4	1.5	0.5	0.8	1.0	0.8	1.6	3.0	2.3	
Shrubs										
<i>Ephedra trifurca</i>	—	1.2	1.8	—	0.6	0.1	0.1	0.4	0.1	
<i>Gutierrezia sarothrae</i>	0.8	0.5	0.8	0.2	2.7	4.5	4.3	4.5	4.5	
<i>Yucca elata</i>	—	—	—	—	2.8	0.4	1.5	3.3	0.6	
Others	—	0.2	6.1	—	1.5	1.3	1.1	3.6	4.4	

¹10 = Pasture 10; 11 = Pasture 11.

Table 2. Average seasonal preference (%) for grasses by Hereford and Santa Gertrudis cows for the 1961-64 study period.

Species	Fall		Winter		Spring		Summer	
	H ¹	SG ¹	H	SG	H	SG	H	SG
<i>Aristida longiseta</i>	5.1	2.9	0.4	1.2	7.3	4.7	4.6	4.7
<i>Bouteloua eriopoda</i>	6.5	5.2	19.3	26.8	2.2	4.2	4.5	6.4
<i>B. curtipendula</i>	—	—	—	0.1	—	—	—	—
<i>Hilaria mutica</i>	0.6	4.2	—	1.7	1.0	0.7	8.8	14.5
<i>Muhlenbergia arenacea</i>	0.8	2.0	—	2.6	—	—	2.9	0.5
<i>M. porteri</i>	—	0.6	—	—	—	—	—	—
<i>Panicum hallii</i>	6.1	0.6	0.4	0.3	—	—	—	—
<i>P. obtusum</i>	0.8	0.5	—	0.4	—	—	3.1	1.3
<i>Scleropogon brevifolius</i>	6.9	11.5	3.7	14.1	0.1	7.5	11.4	15.5
<i>Sporobolus airoides</i>	4.9	3.9	2.6	4.0	12.7	25.8	8.0	11.4
<i>S. flexuosus</i>	15.7	11.0	14.2	11.4	11.7	13.6	28.1	12.8
<i>Tridens pulchellus</i>	1.1	3.1	1.9	0.5	—	1.9	—	4.9
Total perennial grasses	48.5	45.5	42.5	63.1	35.0	58.4	71.4	72.0
<i>Bouteloua aristidoides</i>	—	—	—	—	—	—	—	0.1
<i>B. barbata</i>	1.7	3.3	7.1	1.9	—	—	—	9.4
<i>Munroa squarrosa</i>	—	0.5	—	—	—	—	—	—
Total annual grasses	1.7	3.8	7.1	1.9	—	—	—	9.5

¹H = Herefords; SG = Santa Gertrudis.

Table 1 shows the average basal cover for 1961-64 for the 2 pastures. The cover for the perennial grasses listed under "others" consisted primarily of ear muhly (*Muhlenbergia arenacea* (Buckl.) Hitchc.) and fluffgrass (*Tridens pulchellus* (H.B.K.) Hitchc.) but with smaller amounts of several others. The "others" perennial forbs were primarily desert bailey (*Baileya multiradiata* Harv. & Gray), trailing four-o'clock (*Allionia incarnata* L.), *Chamaesaracha coniodes* (Moric.) Britt., and rocky mountain zinnia (*Zinnia grandiflora* Nutt.) but with lesser amounts of several others. The major species included in other annual forbs were whitestem stickleaf (*Mentzelia albicaulis* Dougl.), purple roll leaf (*Nama hispidum* Gray), and white eriogonum (*Eriogonum rotundiflora* Benth.).

Because of droughty conditions in 1963 and 1964, the estimates of cover declined during the study period. Sixweeks grama (*Bouteloua barbata* Lag.) occurred primarily in 1962, with very small amounts in 1961 and 1964, although a substantial amount emerged after the sampling was completed in July of 1963 and 1964. Russianthistle (*Salsola kali* L.) was found only in 1961 and 1962.

Results

Each day a cow was observed, there generally were 70 to 90 observations of the species being grazed. Tables 2 and 3 show the average species preference as a percentage of the total number of observations for each season for the 1961-1964 study period. The data are presented for both the Hereford and Santa Gertrudis cows for each season.

Perennial Grasses.—On a year-long basis, Herefords were observed grazing perennial grasses 49.4% of the time while for the Santa Gertrudis it was 59.7%. The major period of growth for the perennial grasses shown in Table 2 is during the summer. However, the following are green during the spring and late fall of the years having available soil moisture: alkali sacaton (*Sporobolus airoides* (Torr.) Torr.), red threeawn (*Aristida longiseta* Steud.), tobosa (*Hilaria mutica*

Table 3. Average seasonal preference (%) for forbs and shrubs by Hereford and Santa Gertrudis cows for the 1961-64 study period.

Species	Fall		Winter		Spring		Summer	
	H ¹	SG ¹	H	SG	H	SG	H	SG
<i>Allionia incarnata</i>	—	0.6	—	—	—	—	2.2	—
<i>Bahia absinthifolia</i>	1.2	—	—	0.1	0.9	—	—	—
<i>Baileya multiradiata</i>	1.0	1.6	—	—	—	—	0.4	2.4
<i>Chamaesaracha coniodes</i>	—	—	—	—	1.8	—	—	—
<i>Cirsium ochrocentrum</i>	1.4	0.3	—	—	—	—	—	—
<i>Croton corymbulosus</i>	5.9	12.3	2.8	2.9	7.3	12.0	11.4	10.5
<i>Erysimum capitatum</i>	—	1.0	—	—	—	—	—	—
<i>Lesquerella fendleri</i>	0.4	—	3.7	0.3	0.8	1.0	—	—
<i>Melampodium leucanthum</i>	1.6	—	—	—	0.7	0.8	0.3	—
<i>Perezia nana</i>	2.9	2.7	—	0.2	—	—	—	—
<i>Psilostrophe tagetinae</i>	4.5	7.3	2.5	5.2	16.4	10.7	0.6	1.4
<i>Solanum elaeagnifolium</i>	1.8	0.2	—	—	—	—	—	—
<i>Sphaeralcea subhastata</i>	6.8	1.0	0.2	—	0.5	0.3	—	0.1
<i>Zinnia grandiflora</i>	2.4	1.4	0.5	—	—	—	0.5	1.2
Total perennial forbs	29.9	28.4	9.7	8.7	28.4	24.8	15.4	15.6
<i>Aphanostephus ramosissimus</i>	—	—	—	—	—	0.4	—	—
<i>Corispermum nitidum</i>	0.1	—	8.8	6.0	—	—	—	—
<i>Cryptantha crassisepta</i>	—	—	—	—	6.1	—	—	—
<i>Descurainia menziesi</i>	—	—	—	0.8	—	—	—	—
<i>Dithyrea wislizeni</i>	—	3.0	5.9	2.2	0.3	—	—	—
<i>Gutierrezia sphaerocephala</i>	1.2	—	—	—	—	—	—	—
<i>Hoffmannseggia densiflora</i>	0.4	—	—	—	—	—	—	—
<i>Iva dealbata</i>	3.2	7.2	—	1.3	—	0.5	—	—
<i>Kallstroemia hirsutissima</i>	—	—	—	—	—	—	—	0.1
<i>Mentzelia albicaulis</i>	—	—	1.9	—	1.4	—	—	—
<i>Nama hispidum</i>	—	—	—	—	0.3	0.6	—	—
<i>Phacelia intermedia</i>	—	—	—	—	—	0.2	—	—
<i>Salsola kali</i>	6.1	4.2	1.0	0.7	3.7	3.1	7.1	1.1
<i>Tribulus terrestris</i>	0.4	—	—	—	—	—	—	—
Total annual forbs	11.4	14.4	17.6	11.0	11.8	4.8	7.1	1.2
<i>Atriplex canescens</i>	0.5	0.1	—	—	0.1	—	—	0.2
<i>Ephedra trifurca</i>	4.5	4.8	2.0	0.6	2.3	—	0.8	0.2
<i>Flourensia cernua</i>	—	2.0	0.9	—	—	—	0.6	—
<i>Gutierrezia sarothrae</i>	1.0	—	0.6	0.2	3.1	0.1	—	—
<i>Prosopis juliflora</i>	—	—	0.2	—	—	—	0.8	1.2
<i>Yucca elata</i>	2.4	0.9	19.3	14.4	19.3	11.7	3.7	0.3
Total shrubs	8.4	7.8	23.0	15.2	24.8	11.8	5.9	1.9

¹H = Herefords; SG = Santa Gertrudis

(Buckl.) Benth.), and mesa dropseed (*Sporobolus flexuosus* (Thurb.) Rydb.).

Red threeawn was grazed when it was green during the spring, summer and fall. It was used by both breeds during the spring of 1962 (the only spring having appreciable moisture during the study period) and the summer and late fall of all 3 yr.

Tobosa was preferred during the summer and early fall. The Santa Gertrudis cows also grazed it each February during the

study period. They were observed grazing it about twice as much as the Herefords each year.

Alkali sacaton was grazed in spring and summer all 3 yr with less use in the winter of 1962 and fall of 1964 by both breeds. It was more prevalent in pasture 10 than in pasture 11 (Table 1) and the breeds were observed using it about the same in each pasture. The Santa Gertrudis cows were in pasture 10 two years during the study period.

Mesa dropseed was more abun-

dant in pasture 11 than in pasture 10. It was grazed throughout the year.

Black grama (*Bouteloua eriopoda* (Torr.) Torr.) was preferred in winter, probably because it has green culms throughout the year. Other species are apparently more palatable at other times. Reduced use of black grama in 1964 corresponded to a decline in cover.

Burrograss (*Scleropogon brevifolius* Phil.), possibly an underrated forage plant, was grazed throughout the year, although a little less in the spring than in the other seasons. It was more abundant in pasture 10 than in pasture 11. Use of it increased during droughty 1963 and 1964.

The other perennial grass species shown in Table 2 were only minor components of the available species. The Herefords were observed grazing Hall's panicum (*Panicum hallii* Vasey) 24.4% of the time during the fall of 1963. It is a short-lived perennial that was not available to the cows except in the fall and early winter of that year. The Santa Gertrudis cows grazed more of the coarse grasses, tobosa and burrograss, than the Hereford cows.

Annual Grasses.—Sixweeks grama, a summer annual, was used in small amounts in the fall of 1961 by the Santa Gertrudis, by both breeds in the winter of 1962, and by the Herefords in the early fall of 1963. The cattle were observed grazing a considerable amount of it when it was dormant in the winter of 1964. This latter use was probably due to a shortage of other, more palatable, species at that time. The Santa Gertrudis cows also made considerable use of sixweeks grama in the late summer of 1964. The other annual grasses shown in Table 2 were very minor components of the species growing in pastures 10 and 11.

Perennial Forbs.—On a year-

long basis, both breeds were observed grazing perennial forbs about 20% of the time. All of the perennial forbs shown in Table 3 grow during the summer rainy season and most of them will make some growth in the spring seasons having sufficient moisture. Two, bladderpod (*Lesquerella fendleri* (Gray) Wats.) and western wallflower (*Erysimum capitatum* (Dougl.) Greene), make most of their growth in the years having winter-spring moisture.

Bladderpod was more abundant in pasture 11 than in pasture 10. The Herefords were observed grazing it November 1961 through February 1962, June 1962, and November 1963. The Santa Gertrudis grazed it in January and April 1963. It was not present in the droughty winter-spring of 1964. The Santa Gertrudis cows used a small amount of western wallflower in November and December, 1961.

Trailing four-o'clock was grazed only in September of 1964 even though it was available in other years.

In one observation in September, 1962 the Santa Gertrudis grazed desert bailey 43.7% of the time. Normally, it made up only a small portion of the diet in late summer and early fall.

Chamaesaracha coniodes was observed being grazed only on April 3, 1963 by the Herefords, even though it was present in the other years. During the fall of 1961, mature thistle (*Cirsium ochrocentrum* Gray) was grazed in the early morning hours when dew softened the stickers.

Leatherweed croton (*Croton corymbulosus* Engelm.) was grazed throughout the year, but less during the winter than in other seasons. On several occasions it made up 50% of the grazed plants.

Desert-holly (*Perezia nana* Gray) was a minor part of the diet in late fall and early winter after it matured. Woolly paper-

flower (*Psilostrophe taetinae* (Nutt.) Greene) was eaten primarily during the fall, winter, and spring of 1962-63. During several observations it made up over 50% of the grazed plants.

Globemallow (*Sphaeralcea subhastata* Coult.) was grazed primarily by the Herefords in the falls of 1961 and 1963 while they were in pasture 11. It occurred about equally in both pastures. Rocky mountain zinnia was used primarily in the late fall and early winter each year except that both breeds made some use of it during the summer of 1962. The remaining perennial forbs shown in Table 3 were only minor components of the available species.

Annual Forbs.—The following annual forbs, shown in Table 3, grow during the summer rainy season: faint crown (*Aphanostephus ramosissimus* DC.), tickseed (*Corispermum nitidum* Kit.), annual snakeweed (*Gutierrezia sphaerocephala* Gray), sumpweed (*Iva dealbata* Gray), hairy caltrop (*Kallstroemia hirsutissima* Vail.), and puncturevine (*Tribulus terrestris* L.). Russianthistle emerges primarily in late winter in years having precipitation at that time. The other annual forbs shown in Table 3 make most of their growth in the spring in the years having spring precipitation.

Tickseed, relished during the winter of 1961-62 apparently because the plants had much seed, did not grow in any other year of this study. Deer's tongue (*Cryptantha crassisejala* (Torr. & Gray) Greene) made up 55% of the Herefords diet on April 19, 1964, the only time it was observed being grazed.

Wislizenus spectaclepod (*Dithyrea wislizeni* Engelm.) was grazed in the winters of 1962 and 1963 by the Herefords and the late fall and winter of 1962-63 by the Santa Gertrudis. Sumpweed was used primarily in the fall and early winter of 1961-62.

It did not occur in the other years. Whitestem stickleaf occurred only in pasture 11 in 1961 and 1962. It was grazed by the Herefords in the winter and early spring of that year.

Russianthistle was grazed primarily during the spring, summer, and fall of 1962. The Herefords ate about twice as much of this species as the Santa Gertrudis even though there was an abundance of it in both pastures in 1962.

Shrubs and Shrub-like Plants.—The Herefords grazed these plants, particularly soaptree yucca (*Yucca elata* Engelm.), more than the Santa Gertrudis. Soaptree yucca was eaten primarily in the winter and spring, when the faces of the cattle that eat the leaves often become green. Increased use of it was made in the dry winter-spring of 1964 when it sometimes made up 70% of the grazed plants. In late spring and summer, if the plants bloom, the cattle particularly relish the flowers and flower stalks. They will fight for them and, if necessary, stand on their hind legs to reach them.

The major use of longleaf mormontea (*Ephedra trifurca* Torr.) was in the late fall and early winter. The Herefords also made some use of it in the spring and early summer of 1964 when other forage was in short supply.

The fruits of broom snakeweed (*Gutierrezia sarothrae* (Pursh) Britt. and Rusby) were used by both breeds. On one occasion, March 31, 1962, the Herefords were observed eating it 55% of the time.

Small amounts of honey mesquite beans (*Prosopis juliflora* (Swartz) D.C. var. *glandulosa* (Torr.) Cockerell) were eaten on 3 occasions.

Discussion and Conclusions

Because of favorable moisture conditions the more ephemeral

species, annuals and short-lived perennials, occurred primarily in 1961 and 1962. The cattle grazed such plants as russianthistle, tick-seed, thistle, and sixweeks grama even after they were matured, particularly when they were softened by dew in the early morning hours.

Burrograss was readily grazed, particularly when some of the other species had been reduced by drought. Heretofore, it had been considered a grass of little value.

The cattle grazed black grama primarily during winter and tobosa during summer. This coincides with the recommended seasons of use for black grama and tobosa ranges (Paulsen and Ares, 1962).

There was no apparent difference in the total percentage of coarse plants grazed by the 2 breeds. The Santa Gertrudis ate more of the coarse grasses but the Herefords consumed more russianthistle and soaptree yucca.

The cattle grazed leatherweed croton, woolly paperflower, Wislizenus spectaclepod, russianthistle, longleaf mormontea, and soaptree yucca during the winter and spring when these plants contain a considerable amount of green material. This is probably why there is usually an adequate amount of carotene and protein in the diet of cows during the winter-spring period in this area (Watkins et al. 1950). Even in the dry winter-spring periods when the forbs are not growing, soaptree yucca, longleaf mormontea, and fourwing saltbush supply considerable amounts of carotene and protein. Thus, it appears that yearlong ranges having some forbs and desirable shrubs furnish the livestock with a better diet than do pure grass ranges.

The cattle ate, to some extent, all available species. Plants such as broom snakeweed, honey mes-

quite, and tarbush (*Flourensia cernua* DC.) were not grazed as much as the others.

Summary

The grazing preferences of Hereford and Santa Gertrudis cows were observed during a 3-year period. Average basal cover of the vegetation by soil type is presented to show plant species available for grazing.

The cattle grazed a variety of species, undoubtedly an important factor in their diets. During the winter and spring, the cattle grazed a number of forbs and shrubs not previously known to have been grazed in significant amounts. Some mature and dry species were grazed, particularly while softened by dew.

The cattle ate all available species to some extent. There was no apparent breed difference in the percentage of coarse plants grazed. Although the Santa Gertrudis consumed more of the coarse grasses, the Herefords ate more russianthistle and soaptree yucca.

LITERATURE CITED

- CANFIELD, R. H. 1941. Application of the line interception method in sampling range vegetation. *J. Forest.* 39: 388-394.
- HERBEL, C. H. AND A. B. NELSON. 1966. Activities of Hereford and Santa Gertrudis cattle on a southern New Mexico range. *J. Range Manage.* 19:173-176.
- PAULSEN, H. A., JR., AND F. N. ARES. 1962. Grazing values and management of black grama and tobosa grasslands and associated shrub ranges of the Southwest. U. S. Dep. Agr. Tech. Bull. 1270. 56 p.
- SOIL CONSERVATION SERVICE, U.S.D.A. 1963. Standard soil survey of Jornada Experimental Range, N. Mex. Unpubl. n.p.
- TRIBE, D. E. 1952. The relation of palatability to nutritive value and its importance in the utilization of herbage by grazing animals. Sixth Intl. Grassl. Congr. Proc. II: 1265-1270.
- WATKINS, W. E., J. H. KNOX, AND J. W. BENNER. 1950. Carotene and vitamin A in the blood plasma of range cows. *N. Mex. Agr. Exp. Sta. Bull.* 355. 9 p.