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Factors Affecting the Chemical Composition of Range Forage Plants on the Edwards Plateau

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SUMMARY

Studies were carried out on the Edwards Plateau near Kerrville, Texas, in 1957 to determine the effects of grazing intensity and the presence or absence of canopy on chemical composition of three grasses and one browse species at selected calendar dates.

Nitrogen-free extract, crude protein, crude fiber, ash and phosphorus contents varied significantly with date of clipping. Crude protein decreased from an average high of 13.4 percent on April 2 to 6.2 percent on August 1, but rose to 9.0 percent on October 25 following late summer rains. This same trend was found in calcium and phosphorus. Crude fiber and nitrogen-free extract were negatively related to crude protein content in the grasses.

Purple threeawn was generally found to be less nutritious than Texas wintergrass and curlymesquite. Purple threeawn contained significantly less crude protein, calcium and phosphorus but significantly more crude fiber than either Texas wintergrass or curlymesquite.

Clipping dates did not markedly influence the chemical composition of matured live oak browse. This indicates the valuable role live oak plays in helping to maintain satisfactory nutrient levels in animal diets during the non-growing season. The calcium-to-phosphorus ratio varied from 1.5 to 6.7 in the individual grass and forb samples, but averaged 11.1 in the live oak.

FACTORS AFFECTING THE CHEMICAL COMPOSITION OF RANGE FORAGE PLANTS ON THE EDWARDS PLATEAU

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VARIOUS FACTORS SUCH AS SPECIES OF PLANTS, stage of growth, type of soil and rainfall affect the chemical composition of range forage plants. Other factors such as grazing intensity and shade exert some influence on herbage composition but in a rather undefined direction and extent.

Chemical composition of plants is not a direct index to the availability of the various nutrients inasmuch as nutrient digestibility is not considered (Cook and Harris, 1950). Such analyses, however, give a measure of relative composition and show what plant constituents are deficient or present in excess. In preliminary studies of factors affecting quality of range herbage, chemical composition is a valuable tool.

Intensive studies of the chemical composition of native range plants of the southern limestone region of the Edwards Plateau of Texas and the factors affecting these values have not been carried out previously. The purpose of this study was to ascertain the effect of grazing intensity and the presence or absence of oak canopy upon the chemical composition of selected range plants at various dates throughout the year.

REVIEW OF LITERATURE

Fraps and Cory (1940) reported that protein and phosphorus deficiencies are likely to occur during the winter and during extended dry periods on Edwards Plateau ranges. Greaves (1938) reported that phosphorus is a good indicator of the nutritive value of the forage plants since the percent phosphorus varies directly with that of sulfur, protein and crude fat and inversely with total ash and crude fiber.

Other workers also have found a positive correlation between the protein and the phosphorus content in range grasses and a negative correlation between the content of these two nutrients and progressive maturing of the plants (Clarke and Tisdale, 1945; Savage and Heller, 1947). Savage and Heller (1947) demonstrated that nearly all of the warm-season grasses in the plains area of Oklahoma were deficient in phosphorus while dormant from November to March.

Hart, *et al.* (1932) reported that the composition of many California range forages varied from that of a poor roughage when mature to that of a protein-rich concentrate during the early stages of growth. In general, progressive maturing in the herbaceous forage plants has been found to be accompanied by a decrease in phosphorus, protein, moisture, chlorine, sodium, potassium and vitamin A; and an increase in lignin, cellulose, crude fiber and nitrogen-free extract, and in the lignin-to-cellulose ratio (Gordon and Sampson, 1939; Cook and Harris, 1950; Fraps and Fudge, 1940; and Savage and Heller, 1947).

Gordon and Sampson (1939) reported that in most of the graminaceous and broad-leaved herbaceous species there was a continuous and rather orderly decline of the more critical nutrients, such as vitamin A, protein and phosphorus, with plant maturity. On the other hand, the levels of these nutrients in nondeciduous shrubs and trees varied only slightly as the season progressed.

In studies with sheep on Utah winter ranges, Cook, *et al.* (1953) found that the unfavorable response of animals to heavy grazing was largely attributable to a lowered plane of nutrition. Under heavier utilization, the grazing animals were forced to consume more of the less palatable and stemmy forage. This decrease in the leaf-to-stem ratio of the ingested forage resulted in a decrease in ether extract, protein, ash, calcium, phosphorus and nitrogen-free extract and an increase in crude fiber, lignin and cellulose.

In contrast to these studies carried out under winter range conditions, heavy or close utilization

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TABLE 1. RATES OF STOCKING BY CATTLE, SHEEP, GOATS AND DEER OF PASTURE SAMPLED FOR FORAGE ANALYSIS.

Grazing intensity	Cattle	Sheep	Goats	Deer	Total rate of stocking[1]	
	— — — Number	— — —			Acres per AU	AU per section
Heavy	3	23	22	10	7.4	(86.7)
Moderate	2	10	10	10	13.0	(49.0)
Light	1	8	7	10	17.5	(36.6)

[1]All stocking rates are based upon the definition that an animal unit (AU) is equivalent to one cow, five ewes, six goats or six deer (Merrill, et al., 1957).

during periods of rapid growth has been found to maintain the forage in a more immature stage of growth (Campbell, *et al.*, 1954, and McCreary, 1931). Ruby (1951) reported that the phosphorus and protein contents of *Paspalum plicatulum* were increased by either more frequent or more intensive clipping. Johnson, *et al.* (1951) found a slightly higher protein content in herbage from heavily grazed pastures than from lightly grazed pastures. Newell and Keim (1947) found that in spite of the fact that frequent clipping decreased the yield of prairie hay, the total protein produced was generally as much as or more than when clipped only once at maturity.

Watkins (1940) determined that increased intensity of sunlight increased the carbohydrate but decreased the protein content of *Bromus inermis*. From studies in Wyoming, McCreary (1927) reported that shading maintained a higher level of protein, fat and ash in the plants. Cook and Harris (1950) attributed the higher protein and phosphorus content of plants on aspen sites, compared to sagebrush sites, to shade and increased soil moisture. In contrast, Campbell *et al.* (1954) were unable to find any significant differences between the nutrient content of green grass grown on open range and that of grass under scrub oak or pine forest types.

Analyses of vitamin A (carotene) were not conducted in these studies. Had this been possible it would have contributed materially to the study. However, it is assumed that vitamin A would be less likely to be deficient on Edwards Plateau rangelands where browse makes up an important part of the winter diet. Severe and prolonged drouth periods may be an exception (Watkins and Knox, 1950). It is known that vitamin A can be stored in the animal's body tissues for considerable lengths of time (Riggs, 1940, and Klosterman, *et al.*, 1951).

EXPERIMENTAL AREA AND METHODS

The studies were conducted on the Kerr Wildlife Management Area in central Kerr County, Texas. This station is located in the limestone

TABLE 2. SUMMARY OF THE CHEMICAL COMPOSITION OF TEXAS WINTERGRASS, CURLYMESQUITE, PURPLE THREEAWN AND LIVE OAK UNDER THREE INTENSITIES OF USE IN THE PRESENCE AND ABSENCE OF OAK CANOPY AT FOUR PROGRESSIVE COLLECTION DATES. DATA IN PARENTHESIS REPRESENT CANOPY SITE; OTHER DATA ARE FOR OPEN SITE.

Item	Nitrogen-free extract	Crude protein	Ether extract	Crude fiber	Ash	Calcium	Phosphorus
	— — — — —	— — — —	— — Percent	— — — —	— — — —	— — — —	— — —
Pasture 1 Heavy	44.56	9.86	2.31	28.07	8.79	.563	.123
	(43.54)[1]	(9.24)		(27.19)			(.109)
Pasture 2 Medium	45.16	9.09	2.33	27.54	9.10	.582	.116
	(44.09)	(8.50)			(8.59)		(.103)
Pasture 3 Light	43.83	8.52	2.30	28.81	9.50	.555	.103
				(27.89)	(8.96)		
Open site	44.53	8.57	2.41	28.67	9.06	.581	.106
Canopy site	44.51	9.74	2.22	27.61	9.20	.552	.121
Texas wintergrass	41.67	10.78	2.86	27.31	10.77	.435	.120
		(10.10)	(2.31)	(26.29)	(10.16)	(.363)	(.104)
Curlymesquite	43.64	8.77	2.36	27.32	11.54	.378	.124
	(42.42)	(8.15)	(1.83)	(26.25)	(10.91)	(.313)	(.107)
Purple threeawn	42.68	7.49	2.03	32.41	8.47	.311	.103
	(41.52)		(1.53)	(31.30)	(7.89)		
Live oak	50.08	9.59	2.00	25.52	5.74	1.142	.108
	(48.82)	(8.93)				(1.068)	(.093)
April 2	44.20	13.41	2.48	24.95	8.95	.598	.146
	(43.04)	(12.73)			(8.37)	(.526)	(.129)
June 6	44.39	8.04	2.01	30.09	8.56	.501	.116
	(43.17)	(7.42)		(28.98)		(.433)	(.100)
August 1	45.81	6.20	2.31	29.24	9.05	.487	.082
	(44.55)			(28.17)	(8.41)		
October 25	43.68	8.98	2.46	28.28	9.96	.680	.111
		(8.32)		(27.26)	(9.33)	(.606)	(.095)

[1]A mean value is significantly lower at the .05 level than all other means having a lower mean value than the least significant limit for that particular mean.

oak-cedar savannah region of the southern and eastern extremities of the Edwards Plateau.

The vegetation of the area is characterized by an overstory of cedar (*Juniperus ashei*) and various species of oak (*Quercus* spp.). The vegetation understory consists largely of mixed grasses —such as curlymesquite (*Hilaria belangeri*), Texas wintergrass (*Stipa leucotricha*) and various species of threeawn grass (*Aristida* spp.).

The elevation of the experimental area is about 2,200 feet. The limestone soils of the Kerr Area are mainly rough, stony, clay types of varying depth overlying bedrock. The average annual rainfall is about 28 inches. However, during the year of study (1957) a total of 34 inches was received, which was distributed as follows:

January	0.80	July	0.40
February	1.66	August	1.36
March	2.69	September	5.06
April	4.90	October	5.40
May	6.42	November	3.15
June	1.60	December	0.56

The chemical composition of the available forage at four different dates from April to October 1957 was determined for Texas wintergrass, curlymesquite, purple threeawn (*Aristida purpurea*) and live oak (*Quercus virginiana*). Calendar dates rather than plant development determined the times of collection. The primary interest was in the relationship of seasons of the year to the expected chemical composition of animal diets.

The plant unit selected was the entire portion of the grasses and the leaves and twigs up to one-eighth inch in the live oak. Forb samples included the entire plants minus the stems below the lower lateral branches. The samples collected represented the portion of the plants actually available for livestock grazing and approximated the amounts commonly consumed. No attempts were made to simulate artificially grazing intensities in the various pastures in clipping and collecting herbage for chemical analysis.

Samples for forage analysis were taken from pastures grazed yearlong by cattle, sheep, goats and deer at three grazing intensities, Table 1. Two composite samples of each species were taken each day from each pasture under canopy and in the open. Sampling was limited to one soil type. Each composite sample was air-dried in the laboratory, thoroughly ground mixed previous to analysis.

Routine feed analyses plus calcium and phosphorus determinations were carried out on all forage samples by the Texas State Chemists' office. All determinations were in accordance with the recommendations of the Association of Official Agricultural Chemists (1955) with slight modifications.

RESULTS

Date of Clipping

The major factor influencing chemical composition of the herbage available for livestock consumption was the date of clipping, Table 2. In general, from April 2 to August 1 there was a pronounced decline in the percent composition of the more valuable nutrients. However—because of heavy rains in late August and in September and the resulting fall regrowth — the herbage collected during the latter part of October showed a distinct increase in nutritive value over that clipped on August 1. This points to the fact that on the Edwards Plateau rainfall is an important factor in determining chemical composition of the range forage.

Date of clipping had a highly significant effect on the amount of all nutrients sampled except ether extract, Table 3.

The crude protein content of the grasses varied from a high of 20 percent in the Texas wintergrass sampled on April 2 to a low of slightly less than 5 percent in the purple threeawn sampled on August 1, Table 4.

Under open conditions the average protein content of sampled forage decreased from 13.41

TABLE 3. ANALYSIS OF VARIANCE OF THE CHEMICAL COMPOSITION OF TEXAS WINTERGRASS, CURLYMESQUITE, PURPLE THREEAWN AND LIVE OAK AT FOUR COLLECTION DATES

Sources of variation	D.F.	Nitrogen-free extract	Crude protein	Ether extract	Crude fiber	Ash	Calcium	Phosphorus
Total	191	18.784	14.129	1.296	17.145	7.647	.157	.00165
Pastures	2	28.059*	29.079**	.013	26.312*	8.082*	.012	.00652*
Sites	1	.019	66.317**	1.769	54.838**	.836	.039	.01110**
Species	3	692.012**	91.712**	7.651**	423.548**	326.478**	7.200**	.00470*
Dates	3	39.718**	449.836**	2.248	243.052**	17.005**	.391**	.03357**
S X Sp	3	25.408*	3.225	.906	40.044**	12.456**	.003	.00371
S X D	3	5.197	18.748**	.689	10.635	10.496**	.071	.00484*
Sp X D	9	39.290**	60.267**	1.762	26.120**	12.680**	.304**	.00244
S X Sp X D	9	6.784	9.765	.640	17.448**	4.469**	.120**	.00250
Error a	62	8.197*	2.747**	.558	6.159**	2.021**	.037**	.00143**
Error b	96	3.361	.864	1.616	2.514	.673	.010	.000174

*Significant at the .05 level.

**Significant at the .01 level.

percent on April 2 to 6.2 percent on August 1. However, following the late summer and early fall rains the protein content rose to 8.98 percent. Live oak showed this trend under canopy but not in the open.

The calcium content of the grasses in both canopied and open sites showed a trend similar to that for crude protein. In all three species and on both sites, the calcium content was highest on April 2 and consistently lowest on August 1. The only exception was purple threeawn grown on open sites in which the calcium content was only slightly lower on June 6 than on April 2. The calcium content of the grasses on October 25 exceeded that on June 6. In live oak the calcium content on both sites was highest on October 25. This difference in response of grasses and live oak to date of clipping resulted in a highly significant interaction of species times date.

The phosphorus content in the grasses followed the same general trend as those of calcium and protein—from a high on April 2 to a low on August 1. Phoshorus content in total forage was significantly higher (.01 level) on April 2 and significantly lower (.01 level) on August 1 than on the other collection dates. This trend was also in evidence in live oak. In all cases early fall rains brought an increase in phosphorus content over the August 1 levels. The phosphorus levels in live oak in the open, consisting of a larger and more uniform component of mature leaves, showed little response to clipping dates beyond a somewhat higher level on June 6.

The percent composition of nitrogen-free extract in all grass species rose from a low on April 1 to a high on August 1. N.F.E. was lowest on October 25 and April 2 during the periods of fast growth. Crude fiber showed similar trends.

Thus it appears that N.F.E. as well as crude fiber is negatively related to the crude protein content in grasses. This trend for crude fiber was also indicated in live oak, but not for N.F.E. The high protein content of 15.6 percent in the live oak clipped under canopy on April 2 was associated with the very low crude fiber content of 16.8 percent.

Analysis of variance indicated highly significant differences in ash content in total forage

TABLE 4. INDIVIDUAL CHEMICAL ANALYSES OF TEXAS WINTERGRASS, CURLYMESQUITE, PURPLE THREEAWN AND LIVE OAK IN CANOPIED AND OPEN SITES

Site	Collection date	NFE	Protein	Water	Fat	Crude fibre	Ash	CA.	P	Ca:P
		———	———	———	Percent—	———	———	———	———	Ratio
				Texas wintergrass						
Open	April 2	41.85	19.27	5.11	3.46	21.29	9.01	.563	.172	3.3
	June 6	44.02	6.92	6.87	1.83	31.93	8.43	.424	.098	4.3
	August 1	43.41	5.31	7.60	4.21	29.56	9.92	.352	.090	3.9
	October 25	40.75	10.13	6.76	2.98	26.69	12.79	.444	.123	3.6
Canopy	April 2	38.76	20.32	5.19	3.09	22.63	10.00	.655	.183	3.6
	June 6	40.55	7.90	6.67	2.14	31.08	11.67	.380	.107	3.6
	August 1	43.12	6.06	7.73	2.60	28.15	12.33	.298	.083	3.6
	October 25	41.00	10.41	7.06	2.41	27.14	11.98	.364	.113	3.2
				Curlymesquite						
Open	April 2	42.85	11.24	5.29	2.43	26.25	11.93	.470	.147	3.2
	June 6	44.58	7.52	6.30	2.39	27.88	11.33	.377	.128	2.9
	August 1	46.88	5.24	6.97	2.11	28.18	10.82	.253	.073	3.5
	October 25	41.42	8.83	6.65	2.52	27.21	13.38	.427	.132	3.2
Canopy	April 2	41.93	12.59	6.44	2.37	25.24	11.43	.463	.155	3.0
	June 6	42.08	9.43	6.19	2.44	28.31	11.55	.296	.140	2.1
	August 1	47.28	6.39	6.80	2.11	27.61	9.80	.276	.090	3.1
	October 25	42.17	8.94	6.28	2.56	27.94	12.11	.440	.137	3.2
				Purple threeawn						
Open	April 2	41.50	9.19	6.69	1.64	30.03	10.96	.390	.108	3.6
	June 6	41.85	6.28	7.28	1.91	35.53	7.14	.288	.102	2.8
	August 1	45.38	4.88	7.54	1.76	33.13	7.31	.295	.072	4.1
	October 25	41.18	8.04	6.80	2.70	31.43	9.86	.378	.108	3.5
Canopy	April 2	42.01	11.09	5.84	2.29	30.75	8.08	.393	.123	3.2
	June 6	42.05	7.59	6.88	1.83	33.25	8.39	.259	.130	2.0
	August 1	44.66	5.49	7.40	1.86	32.76	7.83	.198	.082	2.4
	October 25	42.72	7.51	6.84	2.34	32.41	8.18	.289	.098	2.9
				Live oak						
Open	April 2	51.35	8.08	6.56	2.45	26.66	4.90	1.122	.077	14.6
	June 6	48.25	9.57	7.44	1.90	27.54	5.30	1.091	.103	10.6
	August 1	47.63	8.11	7.74	2.17	27.85	6.51	.899	.082	11.0
	October 25	49.55	8.76	6.44	2.10	27.65	5.49	1.501	.087	17.3
Canopy	April 2	50.87	15.60	6.88	2.02	16.78	5.23	.705	.207	3.4
	June 6	51.61	9.08	7.75	1.66	25.23	4.66	.898	.122	7.4
	August 1	48.18	8.11	7.46	1.63	26.68	7.92	1.326	.083	16.0
	October 25	50.54	9.40	4.98	2.05	25.76	5.94	1.598	.102	15.7

between clipping dates. Multiple range tests indicated that the ash content on October 25 was significantly higher than on the other dates. However, the highly significant interaction of dates and species and the difficulty of relating ash levels to animal nutrition greatly limits the importance of this finding.

Sites

The forage produced under canopied sites contained significantly more crude protein and phosphorus but significantly less crude fiber than the forage collected in the open at the .01 level of probability, Table 3. In all four species protein and phosphorus contents were higher under canopy than in the open, while the crude fiber content was lower under canopy, Table 4.

The differences in analyses of live oak between sites have already been noted. The oak growing under canopy and available for clipping was largely limited to tender succulent sprouts and leaves as a result of grazing pressures upon the browse during the preceding winter. The live oak herbage growing in the open included a much higher complement of matured leaves exposed to the elements throughout that winter.

The presence or absence of canopy had no apparent effects upon the N.F.E., the ash, or the calcium content of the total forage plants. However, the ether extract content was approximately 9 percent greater on the open sites. This difference approached significance at the .05 level.

Clipping dates did not markedly influence the chemical composition of the live oak samples (largely matured leaves) taken from the open. Although the canopied samples of live oak closely followed the rise and fall of nutrient content in the grasses, the chemical constituents from the open site remained quite constant. This is an important factor where live oak is an important constituent in the diet by helping to maintain satisfactory nutrient levels during the nongrazing seasons since live oak is nondeciduous.

Species

In all nutrients studied except phosphorus there was a highly significant difference between species (.01 level). In phosphorus, however, a significant difference was found at the .05 level.

Purple threeawn forage available to livestock contained significantly less protein, calcium and phosphorus than the other grasses studied. It was generally less nutritious and contained significantly more crude fiber than the other grasses.

Texas wintergrass contained significantly more crude protein than any of the other three species. Maximum values were obtained on April 2 but on subsequent clipping dates the protein content of Texas wintergrass differed little from that in the other grass species. On August 1 live oak averaged 2.5 percent higher in protein content than the other species. The species x dates interaction for crude protein for all species was highly significant.

Live oak contained significantly less crude fiber but significantly more N.F.E. than the three grasses. This was a somewhat unexpected finding, inasmuch as browse is commonly associated with a high crude fiber and lignin content. Live oak contained more than 2.5 times as much calcium as any of the grass species. This difference was highly significant.

The calcium-to-phosphorus ratio was little affected by species of grass or sites. The calcium-to phosphorus ratio in the grasses ranged from 1.5 to 6.7 in the individual samples. It was much higher in live oak than in grasses and averaged 11.1. Under all intensities the ratio was greater on the open site than on the canopied site, Table 4.

Grazing Intensities

Intensity of grazing use (more properly current utilization) affected the chemical content of the range forage. Significant differences were found in N.F.E., crude protein, crude fiber, ash and phosphorus. These differences were seldom great but rather consistent.

The crude protein and phosphorus contents of forage under heavy use were significantly higher than under light use, Table 2. Under moderate grazing they were intermediate. On both sites and in all species heavy grazing produced forage higher in percent crude protein than either moderate or light grazing. The protein content in all cases was lowest under light grazing. This trend was less consistent in phosphorus.

The increase in crude protein and phosphorus contents under heavy stocking rates may be partially attributed to greater immaturity of the forage plants and the greater previous removal of weathered herbage under heavier utilization. It should be noted that all clipping periods (April 2 to October 25) were characterized by weather conditions conducive to at least some forage growth.

Cook, *et al.* (1953) found an inverse relationship between intensity of use during the nongrowing season and the phosphorus and crude protein content of the ingested herbage. When animals grazed matured plants they selected the more palatable and nutritious plant parts first. This resulted in a progressively greater increase in the relative proportions of stems to leaves under heavy grazing.

Forage samples taken from pasture 2 (moderate use) were significantly higher in N.F.E. and significantly lower in crude fiber than those

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taken from pasture 3 (light use). Samples from pasture 1 exhibited intermediate values in both constituents. It appears that these differences resulted from inherent pasture differences rather than different grazing intensities or from chance sampling vagaries.

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