SEASONAL UTILIZATION OF LEHMANN LOVEGRASS AND BLACK GRAMA IN THE DESERT GRASSLAND

by

Michael Edward Reese

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SIGNED: Michael E. Reese

APPROVAL BY THESIS COMMITTEE

This thesis has been approved on the date shown below:

Erwin M. Schmutz — Oct. 7, 1980
E. M. SCHMUTZ
Professor of Range Management — Date

Gilbert L. Jordan — Oct 6, 1980
G. L. JORDAN
Professor of Range Management — Date

William H. Hale — 8 oct 1980
W. H. HALE
Professor of Animal Science — Date

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ABSTRACT

A one year study was conducted on desert grassland in the Altar Valley of southwestern Arizona. The purpose was to characterize seasonal preferences of cattle for Lehmann lovegrass (*Eragrostis lehmanniana* Nees) and black grama (*Bouteloua eriopoda* Torr.) and to determine if preference is related to nutrient and moisture content of the grasses.

Forage utilization was considered a direct measure of animal preference and was measured for both species at one month intervals using the grazed-class method. Samples of both species were collected each month and analyzed for crude protein, phosphorus, total nonstructural carbohydrates and moisture.

Yearly cumulative utilization of Lehmann lovegrass was higher than that of black grama. Seasonal utilization of Lehmann lovegrass was significantly different ($P < 0.05$) than that of black grama during the summer only. June was the only summer month in which relative utilization of the two species was significantly different.

Percentages of total nonstructural carbohydrates and moisture showed a positive relationship to preference but crude protein and phosphorus did not.

These results indicate that the value of Lehmann lovegrass as a key forage species is higher than previous research has shown.

CHAPTER 1

INTRODUCTION

A principle goal of range management is the determination of methods and treatments to increase the productivity of the nation's rangelands to meet future demands for red meat. Part of the answer to this objective is the development of more effective livestock management systems that take advantage of seasonal changes in forage quality, that achieve proper utilization and that do not result in undesirable changes in vegetation.

Basic to improved management systems is a knowledge of the botanical composition of the grazing animals' diet. Every grazing animal selects its food from a wide range of plants in the natural vegetation. Also, there is need for knowledge of relative seasonal preferences of animals for key forage species and the causes of these differing palatabilities. This information can be an important tool in formulating management practices, determining proper use percentages, establishing stocking rates and planning range improvements to correct uneven grazing.

There is a lack of information on the palatability and preference of some dominant grass species occurring in the desert grassland of the southwestern United States. One of these is Lehmann lovegrass

(Eragrostis lehmanniana).[1] It is an introduced perennial grass used in the United States primarily for reseeding in the desert grassland. In this grassland it has shown an unusual ability to invade existing stands of native grasses and shrubs and, in the process, to replace most of the native perennial grasses (Cable, 1971). The forage value of this aggressive introduced grass has been questioned by Humphrey (1958a) and others. To answer these questions, Lehmann lovegrass needs further study to determine its forage value and preference in relation to native perennial grasses.

The objectives of this study were:

1. to determine the relative preference of cattle for Lehmann lovegrass and black grama (Bouteloua eriopoda) through an investigation of seasonal utilization patterns;

2. to determine if seasonal variation in use can be attributed to differences in moisture and nutrient content of the above-ground portions of the grasses.

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1. Scientific nomenclature follows Kearney and Peebles (1960).

CHAPTER 2

REVIEW OF LITERATURE

Determination of dietary preferences and the causes of forage selectivity provide insight into the diets of cattle grazing native rangelands. This review of literature describes the terms palatability and preference and examines related research concerning the palatability and preference of Lehmann lovegrass and black grama.

Factors Affecting Forage Preferences

Palatability and preference have been used synonymously to describe forage selectivity. Although the terms are inseparable in characterizing the grazing animals' diet, they have quite different meanings. Heady (1964) defined palatability as plant characteristics or conditions which stimulate a selective response by animals. He defined preference as a proportional choice among two or more foods. As used here, preference refers to animal reactions and palatability to plant characteristics.

Whether one speaks of palatability or preference, the measure of either is the percentage utilization observed at a particular time or place (Stoddart, Smith, and Box, 1975). Most statements about selectivity have been based on measurements, ocular estimates, or general observations of the amount or percentage of forage removed from an area, referred to as actual use (Heady, 1975). Forage utilization may be considered a direct measure of animal preference and an indirect measure of palatability (Bryant, 1971). Exceptions would be under conditions of drought or overgrazing, when the animal would be forced to utilize forage that is commonly not preferred.

Many factors besides palatability influence animal preference. Forage selectivity results from a highly complex interaction among three sets of variables operating over time: the plants being eaten, the grazing animal, and the environment of both (Heady, 1975). Associated plant species, climate, soil, topography, animal species and animal physiology may all influence animal preference (Heady, 1964).

Many studies correlate palatability and preference with various plant chemical components. Of the commonly determined chemical ingredients, high crude protein correlates most frequently with high palatability (Heady, 1975). Hoehne (1966) found that crude protein had a definite positive relation with preference for the grasses studied, especially when the diet contained less than 10% crude protein. Freyman and Van Ryswyk (1969) found that ammonium nitrate increased the crude protein content of pinegrass (Calamagrostis rubescens) which greatly improved the palatability. Bryant (1971) found that an increase in leaf crude protein above control plant levels by nitrogen fertilization or a combination of nitrogen fertilization and burning will usually result in a corresponding increase in the utilization of blue grama (Bouteloua gracilis) and curlymesquite (Hilaria belangeri).

Although phosphorus is of less importance in range forage production than nitrogen, it may influence forage palatability (Bryant, 1971). Leigh (1961) reported that grasses highest in phosphate and potash were the most acceptable to livestock. However, Hoehne (1966) found that phosphorus had a small but consistently negative correlation with palatability for grass species. Bryant (1971) found that leaf phosphorus generally has little influence on the utilization of blue grama and curlymesquite.

Foods high in carbohydrates or with sugars added have been shown to increase cattle preference. Plice (1952) found that manure affected plants were higher in protein, calcium, potassium, iron, fat, nitrates and vitamins than manure unaffected plants, but were lower in sugar content. When sugar was added to manure affected plants they became palatable and were readily eaten. Hoehne (1966) found that soluble carbohydrates positively influenced preference for needle-and-thread (*Stipa comata*) and lambsquarter (*Chenopodium album*). Also, total sugars were positively related to preference for lambsquarter and other forbs. Wagnon and Goss (1961) increased the utilization of dry forage with low palatability by spraying with cane molasses or a cane molasses-urea mixture. Reid, Jung, and Kinsey (1967) reported that increasing levels of nitrogen fertilization decreased the soluble carbohydrate content and acceptability of orchardgrass (*Dactylis glomerata*). Bryant (1971) found that under certain conditions, cattle tend to select blue grama and curlymesquite on the basis of sugar content and succulence rather than on the basis of crude protein content. He also reported that leaf total nonstructural polysaccharides generally had little influence on the utilization of blue grama and curlymesquite.

In addition to mineral and nutrient content (especially protein), moisture content may influence plant selectivity (Stoddart et al., 1975). Cable and Bohning (1959) found no difference in grazing use between introduced lovegrasses or native grasses due to moisture content of the herbage. They found that moisture content of the four native perennial grasses exhibited the same seasonal fluctuations as the lovegrasses, but with less variation among species. Bryant (1971) found that during summer, leaf moisture was highly correlated with the utilization of blue grama and had little correlation with the use of curlymesquite. During fall, leaf moisture was highly correlated with the utilization of both species in one year and had little correlation with utilization during another year.

As proteins, sugars, fats and preferred components of ether extract increase in percentage composition, lignin and crude fiber decrease. Negative correlations of lignin and crude fiber with increased preference were shown by most studies (Heady, 1964). Hoehne (1966) found that acid-detergent fiber was negatively associated with preference for grasses and forbs. There seems to be considerable confusion regarding the relationship between palatability and digestibility (Garner, 1963). Some researchers consider there is a close relationship between the two, while others question it.

In addition to chemical components, Heady (1964) found that factors such as proportion of leaves, stems, and fruits; plant growth stages; past grazing use; climate; topography; soil moisture and fertility have been related to palatability mainly through their influence on chemical components. Little information is available on external form, texture, and odor as they may influence preference.

There are conflicting results in studies conducted to determine what chemical components influence forage preference. Many workers (Hardison et al., 1954; Heady, 1964; Freyman and Van Ryswyk, 1969) feel that possibly the combination of chemical compounds is more significant than the amount of any one chemical component.

Relative Preference for Lehmann Lovegrass and Black Grama

Lehmann lovegrass is an introduced warm-season perennial grass with cool-season tendencies. This species has been widely used to revegetate dry southwestern ranges and burned areas on public and private lands (Crider, 1945). Lehmann lovegrass is well adapted to semidesert ranges between 3500 and 4500 feet elevation, and 13 to 17 inches of annual rainfall, where it often develops into almost pure stands and crowds out the more palatable native perennial grasses (Cable, 1971). At lower elevations, and 13 inches or less rainfall, lovegrass persists in scattered stands, spreads very slowly, and appears to be no great threat to native perennial grasses.

The prevailing attitude toward Lehmann lovegrass is that it's palatability, while variable, is generally low (Cable, 1971). Humphrey

(1958a) stated that during the summer when native grasses are growing and during the fall when both Lehmann lovegrass and the native species were dried up, little use was made of the lovegrass. He also stated that on an area containing both Lehmann lovegrass and native species cattle may severely overgraze the natives while leaving the lovegrass largely untouched. Cable (1971) reported that cattle definitely preferred the predominant native perennial grasses to Lehmann lovegrass during the summer growing season. During the winter, however, he found that lovegrass remained greener than native grasses and was grazed readily.

Cable and Bohning (1959) concluded that differences in palatability were as great among the several natives on the Santa Rita Experimental Range as between Lehmann lovegrass and native grasses. Utilization of Lehmann lovegrass lagged behind all other species until late in the spring.

Galt et al. (1969) noted marked differences between species composition of a desert grassland range and that of forage collected from rumen fistulated steers. In this study, the predominant range species, Lehmann lovegrass, accounted for less than 12% of the diet until late November, when cattle switched to a diet consisting primarily of this species.

Black grama was reported to be the most important forage grass on the 89 million acres of desert grassland in the southwest (Campbell and Crafts, 1939). Also, Wright and Streetman (1958) reported that it is palatable and nutritious, both in summer and winter, making it particularly outstanding as a year-round forage plant. However, Galt (1972) found that on a desert grassland range with 31% of available herbage by weight from black grama, rumen-fistulated steers consumed only an average of 3% black grama, as measured by fistula samples obtained at 8 different times during a 12-month study. Maximum amount of black grama found in fistula samples was 7% by weight in the winter grazing season. Also, Galt et al. (1969) found that black grama was not grazed appreciably until late December, even though it comprised 13% of available herbage.

Other researchers (Humphrey, 1970; Bell, 1973) feel that a significant value of black grama is that it carries much of its green chlorophyll and carotene content through the winter months. Thus, it is considered to be valuable for winter use.

CHAPTER 3

DESCRIPTION OF STUDY AREA

The field study was located on the Santa Margarita Ranch in the Altar Valley of southwestern Arizona. The study area was confined to the Entrance pasture, S21 and 22, T20S, R8E, Gila and Salt River Base and Meridian (Figure 1). The vegetation of the area is classified as desert grassland (Humphrey, 1958b), the principle species being Lehmann lovegrass, black grama and broom snakeweed (Xanthocephalum [formerly Gutierrezia] sp.). Other species which are common but less abundant are blue grama, curlymesquite, desert Indianwheat (Plantago sp.), and annual threeawns (Aristida sp.). Velvet mesquite (Prosopis juliflora var. velutina) is common along drainages.

The Entrance pasture has a topography of relatively flat uplands divided by intermittent drainages. The pasture is at an elevation of 3500 feet and encompasses 5480 acres. There are two water sources in the pasture located 1.7 miles apart. The pasture receives continuous year-round use from 120 cows.

Climate for the area is typical of the desert grassland. Climatalogical data for the Santa Margarita Ranch is only available for 1933 to 1950, consequently, the data reported here is from the station at Sasabe, Arizona, 13.2 miles southwest of the ranch. The twenty-year average annual precipitation for this area is 40 cm,

Figure 1. View of study area on the Santa Margarita Ranch, Arizona

with 65% falling between May and October. The precipitation pattern for the area is bimodal, the second wettest period being during the winter months (Figure 2).

The soils of the area are of the White House-Bernardino Caralampi Association. These are deep, thermic, semiarid soils formed from a parent material of granitic and rhyolitic alluvium (U.S. Soil Conservation Service, 1974). All soils in this association have slow permeability and slow percolation.

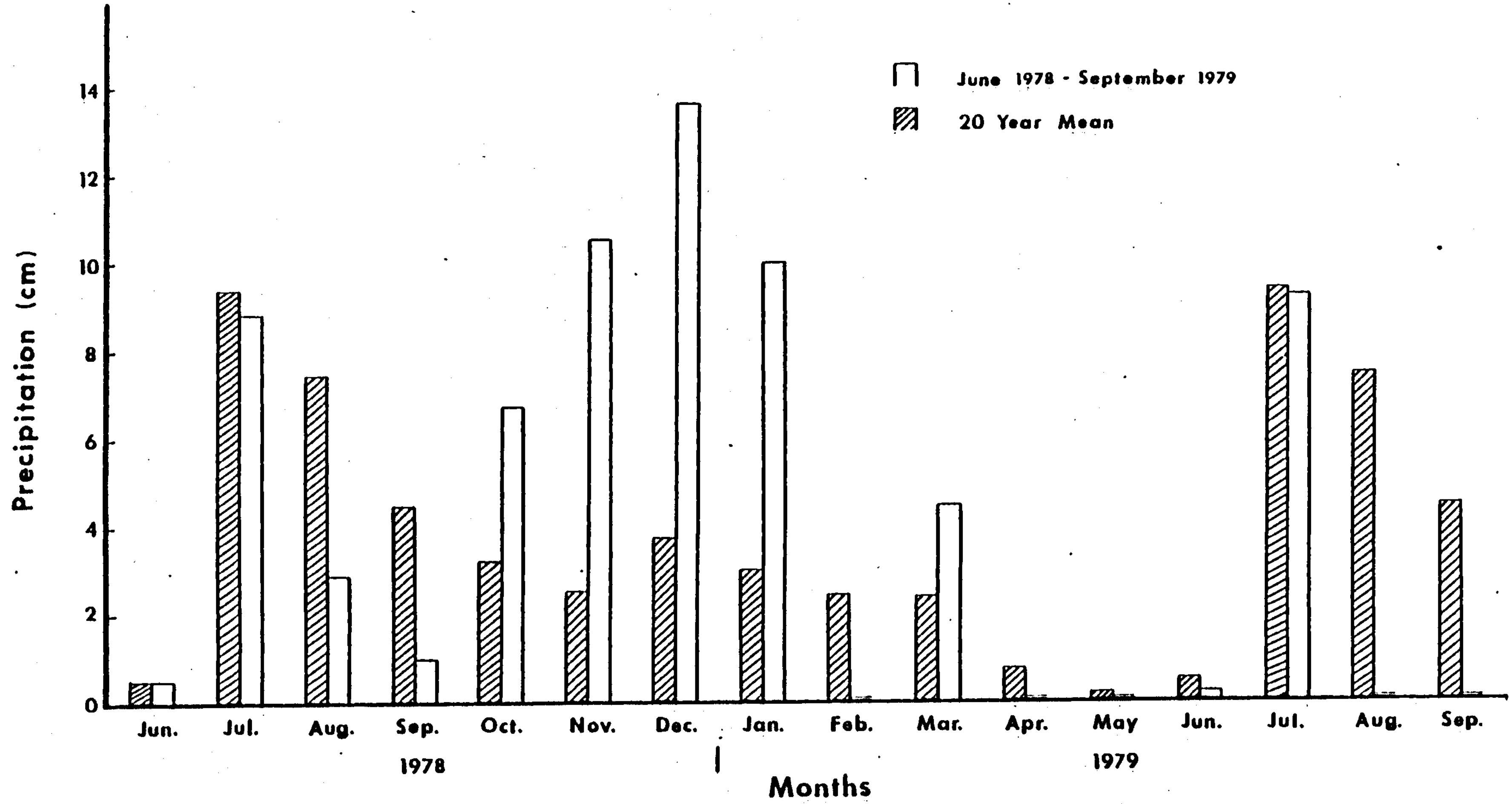

Figure 2. Monthly precipitation totals for Sasabe, Arizona, from June 1978 to September 1979

CHAPTER 4

METHODS

Characterizing utilization of a pasture for management purposes requires delineation of key areas. The principle behind this theory is that no range of appreciable size can be uniformly utilized. Selection of a key area permits control of factors that may cause variation in measurements and provides an index to correct use of the area as a whole. The same principle applies in selecting an area to study seasonal forage preferences based on utilization.

The area selected for this study met the following general requirements of a key area: Accessible at intermediate distances from water but not where livestock naturally concentrate -- usually 1/4 to 1/2 mile from water, on better soil areas, on level to intermediate slopes, and having no important obstructions to grazing (Schmutz, 1978). To permit study of seasonal utilization, a pasture was selected that received continuous year-round use.

In addition to choosing a key area, it was necessary to select two or more key species for relative preference determinations. A key species is usually a good forage-producing perennial that provides site protection. To be used to estimate utilization, the species must furnish substantial grazing and plants must be present in sufficient numbers to be easily found to estimate utilization (Schmutz, 1978).

The most preferred key species, as determined from the highest utilization percentage, must be used properly (about 50%). Exceeding the proper utilization of the most preferred key species will result in a misleading representation of relative preferences.

To satisfy the study objectives and assure statistical validity the experimental design included two sites selected from the Entrance pasture. Selection of the pasture and the two sites, hereafter referred to as east and west, was based on the criteria described above.

Sites east and west were approximately 1 acre each in area, and one-half and three-quarters of a mile from water, respectively. The key species on both sites were Lehmann lovegrass and black grama. To facilitate use of the sites as treatment replications, variation in botanical composition between sites was minimized. Composition was based on ocular estimates.

Field Procedures

Utilization of both Lehmann lovegrass and black grama by livestock was determined at each site at thirty-day intervals beginning October, 1978 and ending September, 1979. To determine utilization, a single zig-zag transect was randomly located at each site. Every two paces a plant was selected and its utilization determined using the grazed-class method developed by Schmutz, Holt, and Michaels (1963). A separate transect was run to obtain data for each of the species on each site even though plants of both species would occur in any one transect. Utilization was estimated for 100 plants of each species on each 1-acre plot.

The above-ground portions of Lehmann lovegrass and black grama were collected to determine if a relationship between utilization and nutrient and moisture content could be found. Many researchers have shown that cattle selectively graze plant parts, most often leaves (Van Dyne, 1963; Galt et al., 1969; Galt, 1972). It is difficult, however, without the use of esophageal or rumen fistulated animals to sample forages representative of that ingested by livestock. Consequently, to meet the study objectives, clipping of plant species was done to simulate grazing on the sites.

Utilization estimates and clippings were made on the same sampling dates. To collect plant samples toe-pace transects were run on the outer edges of the sites to insure that clippings did not influence future utilization estimates. At each two-pace interval a few stems and leaves were collected from the nearest plant. Two samples of each species, approximately 50 g each were obtained at each site. The species and samples were collected on separate transects. The leaves were placed in a paper sack and frozen in a chest of dry ice. The plant samples were frozen with dry ice immediately after collection in the field to slow down or stop enzymatic action that might have caused interconversions of the carbohydrates present at the time of leaf collection (Smith, 1969). Samples were collected at or near the same time of day on each sampling date.

Laboratory Procedures

Herbage samples were kept frozen until oven-dried at 70°C for 48 hours. The samples were weighed before and after oven-drying, and the moisture content was calculated as a percentage of the wet weight. Plant samples were ground in a Wiley mill to pass a 40-mesh screen and stored in plastic vials with snap-on caps for chemical analyses. Analyses for the three chemical components were as follows: total nitrogen by the standard Kjeldahl technique (Bremmer, 1965); total phosphorus by the vanadomolybdophosphoric yellow colorimetric method (Jackson, 1958; Chapman and Pratt, 1961) and total nonstructural carbohydrates by an enzymatic colorimetry method (White, 1973; Silveira, 1977). Nutrient contents were converted to percentage of dry weight. Kjeldahl nitrogen values were converted to crude protein by multiplying by 6.25. All laboratory analyses were done by the author.

Statistical Analyses

To initially characterize year-round use of Lehmann lovegrass and black grama, cumulative monthly utilization percentages obtained by the photo-guide were plotted against time for each species. A simple linear regression was performed and a regression line drawn for each species. A t-test was used to test for significant differences in slopes of respective regression lines.

Utilization, as measured on the range, is a cumulative value in that any use measurement takes into account all previous use on the plant during that grazing year or season. As a result, monthly cumulative utilization figures cannot be directly compared to monthly percentages of nutrients and moisture. Therefore, for comparison with monthly nutrient and moisture data, monthly utilization percentages were determined by subtracting the cumulative use for that month (taken near the first of the month) from the subsequent month.

To meet the study objectives, months were grouped into conventional seasons, with June, July and August representing summer; September, October and November representing fall; December, January and February representing winter; and March, April and May representing spring. Monthly utilization percentages for the three months in any season were added to give seasonal utilization. Seasonal percentages of nutrients and moisture were analyzed statistically as mean monthly percentages within each season. The data were analyzed using a two-way factorial analysis of variance (ANOVA). When significant treatment effects appeared at the 0.05 level of probability, a least significant difference (LSD) test was employed to isolate differences among treatments.

CHAPTER 5

RESULTS AND DISCUSSION

To meet the study objectives, seasonal utilization values were compared to seasonal nutrient and moisture contents. Patterns for each species and between species are discussed. Where significant seasonal differences between species occurred, monthly values are presented to aid in understanding any apparent relationships.

Growth Patterns of Lehmann Lovegrass and Black Grama

Lehmann lovegrass completed two growth cycles during the year of the study -- a minor cycle in the spring and a major one in the summer. Both cycles were in response to the winter and summer rainy seasons (Figure 2). In the spring, new leaf growth began in late February, seedheads emerged in early May and the foliage was mature by early June. The main growing season was in the summer. Growth was rapid. New leaf growth began in late July and plants were in flower by late August.

Black grama growth occurred primarily during July and August in response to summer rainfall. This species made a relatively minute amount of regrowth in the spring.

Regrowth of grass can be a problem in estimating utilization by the grazed-class method because growth will mask previous utilization. In this study, regrowth of Lehmann lovegrass during March and April was confined to the lower portions of the plants. As a result, regrowth was easily distinguished from utilization based on height alone. In May, June and July regrowth made up a substantial portion of the entire plant, preventing visual separation of current year's growth and regrowth. Regrowth may have obscured previous utilization, possibly resulting in an underestimation of utilization. Regrowth of black grama was not substantial enough to hinder utilization estimates.

In August difficulty was encountered in determining utilization of both species. During the latter part of July and throughout August both species were growing rapidly. Any utilization that occurred during this period would have been compensated for by new growth. The photo guide was developed on the basis of height-weight curves constructed to represent mature plants, consequently it could not be used to measure use for the August measurement. The utilization percentage for August was obtained by proportion using percent-of-ungrazed plants (Roach, 1950) for August and September and utilization by the photo guide for September.

Utilization of Lehmann Lovegrass and Black Grama

Cumulative utilization figures for Lehmann lovegrass and black grama were plotted against time (Figure 3). In all months, percentage utilization was higher on Lehmann lovegrass. A t-test showed that slopes of respective regression lines were significantly different at

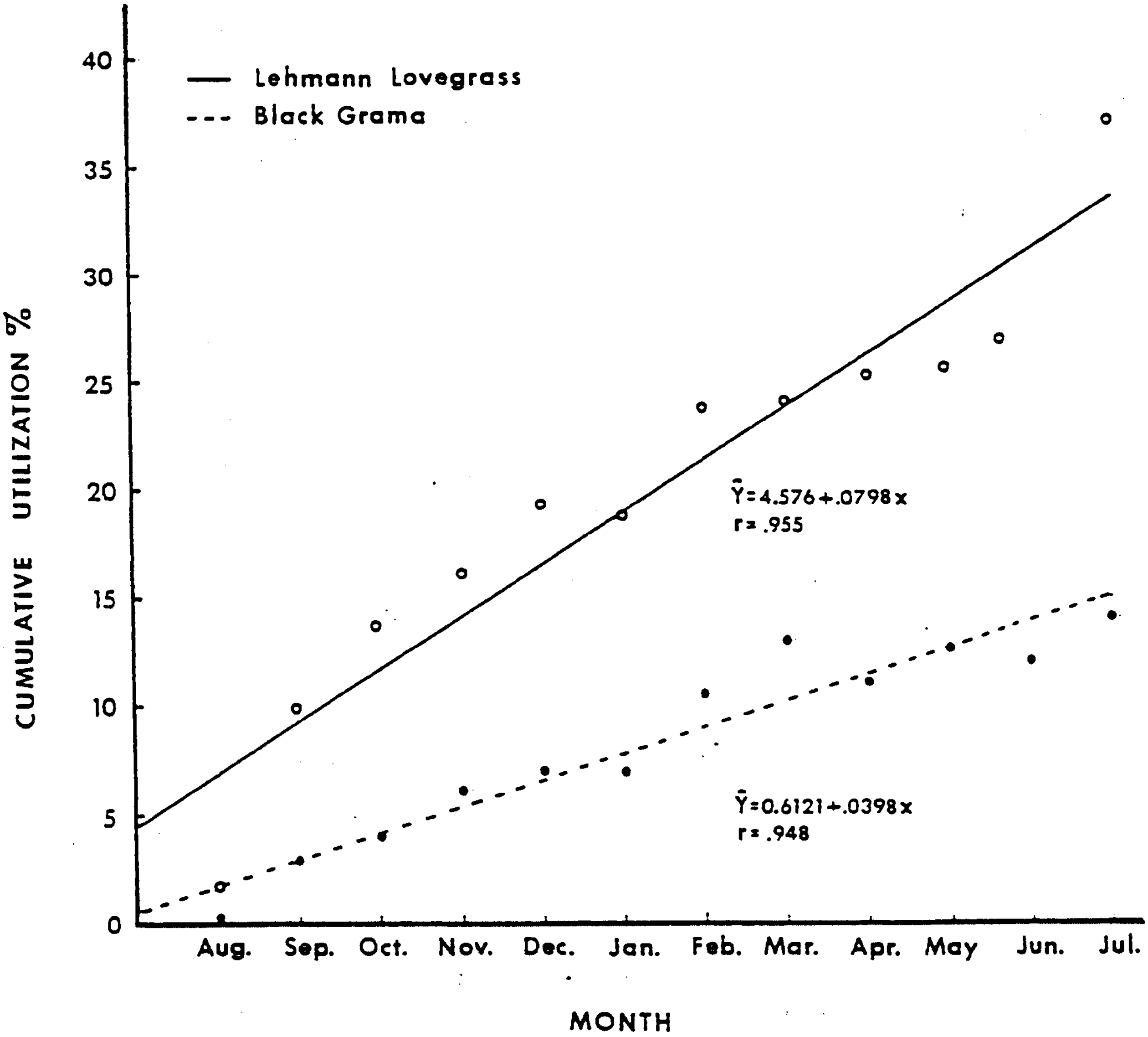

Figure 3. Regression lines for monthly cumulative percentage utilization of Lehmann lovegrass and black grama

the 0.01 level of probability. From cumulative utilization data alone there is evidence of cattle preference for Lehmann lovegrass.

An ANOVA of percentage monthly and seasonal utilization (Appendix) indicated a significant difference between species at the 0.05 level of probability. The ANOVA of percentage seasonal utilization also indicated a significant difference between seasons.

Species, seasons and months served as treatments in the analyses of variance. Consequently, a LSD test was run to isolate differences in utilization for each species and between species. The LSD test of differences in seasonal utilization for each species showed that use of Lehmann lovegrass was significantly greater ($P < 0.01$) in the summer than in other seasons (Figure 4, Table 2). In contrast, utilization of black grama did not differ significantly between seasons at the 0.05 level of probability.

The LSD test of differences in seasonal utilization between species revealed that summer was the only season in which utilization of Lehmann lovegrass and black grama was significantly different (Figure 4, Table 1). Use of Lehmann lovegrass was 20.1% and black grama 5.4%, a highly significant difference at the 0.01 level of probability.

The LSD test of monthly utilization indicated that June was the only month in which utilization of the two species was significantly different (Figure 5, Table 3). These results indicated an early summer preference for Lehmann lovegrass. The differences in this period may

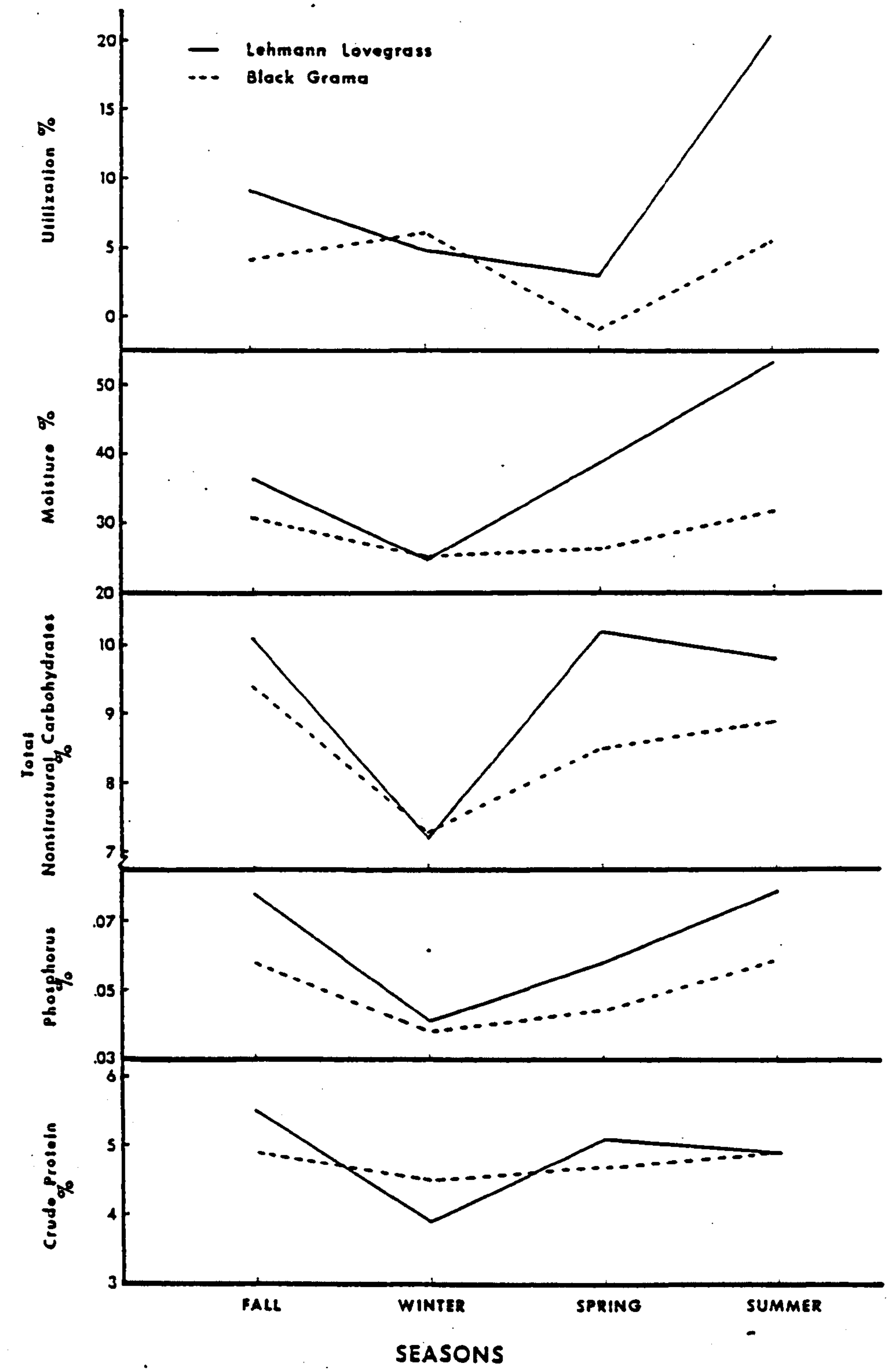

Figure 4. Seasonal changes in percentage utilization and nutrient and moisture content of Lehmann lovegrass and black grama

Table 1. Differences in percentage utilization and nutrient and moisture content between Lehmann lovegrass and black grama by seasons.

Season	Species	Forage Use	Moisture	Carbohydrate	Phosphorus	Crude Protein
		percent				
Fall	Lehmann lovegrass	9.1	36.3	10.1*	.078**	5.5*
	Black grama	4.1	30.5	9.4	.058	4.9
Winter	Lehmann lovegrass	4.9	24.8	7.2	.041	3.9
	Black grama	6.1	25.1	7.3	.038	4.5**
Spring	Lehmann lovegrass	2.7	38.9**	10.2**	.058**	5.1*
	Black grama	-1.1	26.4	8.6	.044	4.7
Summer	Lehmann lovegrass	20.1**	53.5**	9.8**	.079**	4.9
	Black grama	5.4	31.7	8.9	.059	4.9

* indicates a significant difference between species in that season at the 0.05 level of probability

** indicates a highly significant difference between species in that season at the 0.01 level of probability.

Table 2. Differences in percentage utilization and nutrient and moisture content of Lehmann lovegrass and black grama among seasons

	Fall	Winter	Spring	Summer
	percent			
Lehmann lovegrass				
Forage use[1]	9.1	4.9	2.7	20.1[a]
Moisture	36.3	24.8[a]	38.9	53.5[b]
Carbohydrate	10.1	7.2[a]	10.2	9.8
Phosphorus	.078	.041[b]	.058[a]	.079
Crude protein	5.5[a]	3.9[c]	5.1[ab]	4.9[b]
Black grama				
Forage use[1]	4.1	6.1	-1.1	5.4
Moisture	30.5[ab]	25.1[b]	26.4[ab]	31.7[a]
Carbohydrate	9.4[a]	7.3[c]	8.6[b]	8.9[ab]
Phosphorus	.058	.038[a]	.044[a]	.059
Crude protein	4.9[a]	4.5[b]	4.7[ab]	4.9[a]

[1]Values in the same rows without letters or with the same letter are not significantly different at the 0.05 level of probability.

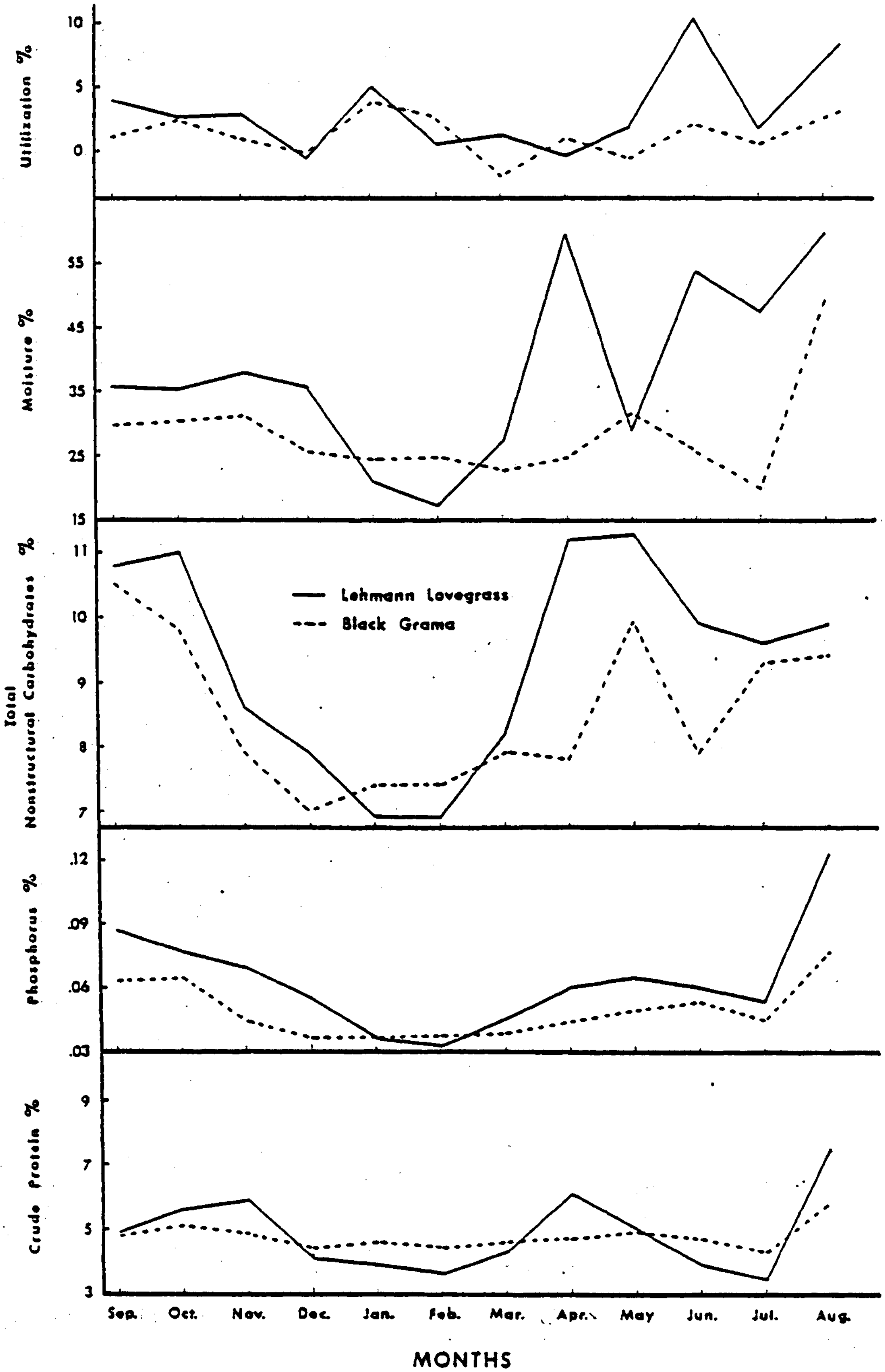

Figure 5. Monthly changes in percentage utilization and nutrient and moisture content of Lehmann lovegrass and black grama

Table 3. Differences in percentage utilization and nutrient and moisture content between Lehmann lovegrass and black grama by months

Month	Species	Forage Use	Moist-ure	Carbo-hydrate	Phos-phorus	Crude Protein
		----	----	percent	----	----
Sept.	Lehmann lovegrass	3.9	35.6	10.8	.087*	4.9
	Black Grama	1.0	29.8	10.5	.063	4.8
Oct.	Lehmann lovegrass	2.5	35.4	11.0**	.078	5.6
	Black grama	2.3	30.4	9.8	.065	5.1
Nov.	Lehmann lovegrass	2.8	38.0	8.6*	.070**	5.9**
	Black grama	.8	31.4	7.9	.046	4.8
Dec.	Lehmann lovegrass	-.6	35.8*	7.9	.055*	4.1
	Black grama	-.2	25.9	7.0	.037	4.4
Jan.	Lehmann lovegrass	5.0	21.1	6.9	.037	3.9
	Black grama	3.6	24.6	7.4*	.038	4.6
Feb.	Lehmann lovegrass	.5	17.4	6.9	.033	3.6
	Black grama	2.6	24.9	7.4	.038	4.4*
March	Lehmann lovegrass	1.2	28.1	8.2	.047	4.3
	Black grama	-2.0	22.7	7.9	.039	4.6

Table 3. -- Continued

Month	Species	Forage Use	Moist-ure	Carbo-hydrate	Phos-phorus	Crude Protein
April	Lehmann lovegrass	-.3	59.4**	11.2**	.061*	6.1**
	Black grama	1.6	24.8	7.8	.044	4.7
May	Lehmann lovegrass	1.9	29.0	11.3**	.065	5.0
	Black grama	-.6	31.6	9.9	.051	4.9
June	Lehmann lovegrass	10.2*	53.7*	9.9**	.060	3.9
	Black grama	2.0	25.8	7.9	.054	4.7*
July	Lehmann lovegrass	1.7	47.5*	9.6	.055	3.4
	Black grama	.5	20.1	9.3	.046	4.3*
August	Lehmann lovegrass	8.3	59.5*	9.9	.123**	7.5**
	Black grama	3.0	49.1	9.4	.077	5.8

* indicates a significant difference between species in that month at the 0.05 level of probability.

** indicates a highly significant difference between species in that month at the 0.01 level of probability.

have been even greater than indicated because summer utilization of Lehmann lovegrass was probably underestimated due to regrowth.

Similar results were obtained by Cable and Bohning (1959) who found that utilization of Lehmann lovegrass lagged behind all other species studied until late spring when its use began to exceed that of some native perennial grasses. Although their study did not include black grama, it showed that Lehmann lovegrass may be a preferred grass in late spring. Cable and Bohning also found that utilization of Lehmann lovegrass was generally lower than other grasses studied in fall, winter and early spring. In the present study, relative utilization of the two species was not significantly different in those seasons.

The results of the present study do not agree with the findings of Cable (1971) who stated that cattle definitely prefer the predominant native grasses to Lehmann lovegrass during the growing season. Cable also found that during the winter, the lovegrass remains greener than the native grasses and is readily grazed. However, black grama also retains its green growth in the winter (Humphrey, 1960).

Wright and Streetman (1958) believe that black grama is palatable and nutritious in summer and winter, while Humphrey (1960) and Bell (1973) report that black grama is less palatable than most native perennials in the summer, but cures well and provides excellent fall, winter and spring feed. Galt (1972) found that on a desert grassland range with 31% of available herbage by weight from black grama, rumen-fistulated steers consumed from 0% black grama by weight in the summer to 7% by weight in the winter. In another study Galt et al. (1969)

showed that in the winter cattle consumed more Lehmann lovegrass and black grama, relative to other native grasses and relative to the fall season. Results of the present study are similar, in that utilization of the two species was nearly equal in winter, with black grama slightly but not significantly preferred (Figure 4, Table 1).

It is interesting to note that cumulative utilization of Lehmann lovegrass was significantly different ($P < 0.01$) than that of black grama year-round (Figure 3), yet significant seasonal differences only appeared in the summer season. However, in the fall and spring, seasonal utilization of Lehmann lovegrass was more than twice that of black grama yet the differences were not significant at the 0.05 level. A possible reason for these nonsignificant differences between seasons is that utilization on the study sites was too low to result in substantial changes in percentage utilization from month to month. As a result, mean utilization was often less than the corresponding standard deviation. This resulted in a high coefficient of variation and a high error term in the LSD procedure. More observations of utilization would probably have given a lower error term which would have given a lower LSD statistic. This would possibly have shown significant differences in utilization of the two species in these seasons.

Factors Affecting Utilization of Lehmann Lovegrass and Black Grama

Crude Protein

The LSD tests indicated that crude protein content of Lehmann lovegrass was significantly lower in winter than in any other season

(Figure 4, Table 2). Summer values were lower but not significantly different than spring values. These seasonal trends are similar to those described by Cable and Shumway (1966).

The LSD test also showed that black grama was highest in crude protein in fall, spring and summer (Figure 4, Table 2), and that spring values were slightly but not significantly higher than winter values. Stanley (1938), Watkins (1943) and Watkins and Knox (1945) found similar results in their studies on black grama.

The LSD tests of relative differences between species showed that Lehmann lovegrass was significantly higher than black grama in crude protein in fall and spring, yet utilization was not significantly different between species in those seasons (Figure 4, Table 1). In winter, black grama had a significantly greater ($P < 0.01$) crude protein content than Lehmann lovegrass, yet utilization was not significantly different. The higher winter crude protein content of black grama may have been due to its ability to retain green stems even when the plant is not actively growing (Humphrey, 1970).

In summer, when Lehmann lovegrass was preferred forage, crude protein values of the two species were equal (Figure 4, Table 1). On a monthly basis the crude protein content of Lehmann lovegrass was significantly lower in June than that of black grama (Figure 5, Table 3). Yet in June, utilization of Lehmann lovegrass was significantly greater than that of black grama. In July, crude protein content of Lehmann lovegrass was significantly lower than that of black grama, but utilization was not significantly different. In August, crude protein content of Lehmann lovegrass was significantly greater than that of black grama, but utilization was still not significantly different. In addition, the crude protein levels of Lehmann lovegrass were also significantly higher in November and April, and crude protein levels of black grama were significantly higher in February, but utilization levels between species were not significantly different in those months.

These results indicated that crude protein content was not significantly related to preference for Lehmann lovegrass. The results of this study do not agree with those of numerous other studies which show that crude protein is the plant component most often highly correlated with preference (Heady, 1964; Hoehne, 1966; Freyman and Van Ryswyk, 1969).

Total Nonstructural Carbohydrates

The LSD test indicated that the TNC content of Lehmann lovegrass was significantly lower in winter than in any other season (Figure 4, Table 2). However, there was no significant difference in spring, summer and fall levels of TNC in Lehmann lovegrass. Black grama was significantly lower in TNC in winter than in any other season. Fall TNC levels were significantly higher than spring levels but not significantly higher than summer levels.

Limited information is available on seasonal TNC content of these two grasses. Humphreys (1966) says that seasonal cycles of TNC concentrations is a succession of three conditions: a gradual decline during the dormant season; a rapid decline with the onset of new growth, continuing until photosynthetic products become greater than immediate needs; and a sharp rise during maturation and onset of dormancy. These two species follow that general trend (Figures 4 and 5). There were two peaks of TNC content for both species, both following spring and summer regrowth. Lehmann lovegrass made the greatest amount of both spring and summer regrowth and Figure 4 and Table 1 show that TNC levels of Lehmann lovegrass were significantly greater than black grama in the fall, spring and summer. There was no difference in the winter.

Monthly values for the summer season indicated that June was the only month in which TNC levels of the two species were significantly different, that difference being highly significant (Figure 5, Table 3). As stated previously, June was the only month in which utilization of the two species was significantly different. In contrast, the TNC levels of Lehmann lovegrass were also significantly higher in October, November, April and May, and TNC levels of black grama were significantly higher in January, but utilization levels between species were not significantly different in those months.

These results indicated that preference for Lehmann lovegrass was related to TNC content during early summer. Other researchers have found that plant carbohydrates (especially the soluble sugars) and sweet substances are often highly correlated with palatability, preference or utilization (Plice, 1952; Wagnon and Goss, 1961; Heady, 1964; Hoehne, 1966; Bryant, 1971). TNC content did not indicate levels of soluble sugars only, but it did give an index to total food reserves in the above-ground portion of the plant and provides a basis for comparing the two species. Further research is needed to indicate which of the carbohydrate fractions are the most closely related to preference.

Moisture Content

The LSD test indicated that moisture content of Lehmann lovegrass was significantly higher in summer than in other seasons. Fall and spring values were not significantly different (Figure 4, Table 2). Moisture content of black grama was not significantly different during the spring, summer and fall but was significantly lower in winter than summer.

Cable and Bohning (1959) compared moisture content of three exotic lovegrasses to moisture content of native perennial grasses in all months except July and August. The moisture patterns for their species were similar to those for Lehmann lovegrass and black grama in the present study (Figure 5). However, in the present study Lehmann lovegrass had a higher peak and black grama a lower peak in spring moisture content than that found by Cable and Bohning. These differences may be due to a more substantial spring regrowth by Lehmann lovegrass in response to above average winter rainfall (Figure 2) and a lower response by black grama to winter precipitation than the perennials studied by Cable and Bohning.

Moisture content of Lehmann lovegrass was significantly higher ($P < 0.01$) than black grama in the spring and summer but there was no significant difference in fall and winter (Figure 4, Table 1). The significantly higher summer moisture content of Lehmann lovegrass corresponded with the significantly higher ($P < 0.01$) utilization during the summer season. Also, monthly values for the summer season showed that Lehmann lovegrass was significantly higher than black grama in moisture content during June, corresponding with the significant difference in utilization during that month (Figure 5, Table 3). In contrast, Lehmann lovegrass was significantly higher than black grama in moisture content in December, April, July and August, but relative utilization during these months was not significantly different.

The results of this study indicated a relationship between moisture content and preference for Lehmann lovegrass in early summer. However, Cable and Bohning (1959) did not find a relationship between grazing use and moisture content of herbage for either the lovegrasses or native grasses studied but Bryant (1971) did find that cattle may select blue grama and curlymesquite on the basis of succulence.

Phosphorus

The LSD test indicated that Lehmann lovegrass is significantly higher in phosphorus content in summer and fall, and that winter values were significantly lower than spring values (Figure 4, Table 2). The same seasonal differences were found for black grama except winter and spring values were not significantly different. These results agree with those found by Watkins (1937, 1943) and Watkins and Knox (1945) for black grama. Comparable information is not available for Lehmann lovegrass. Both species appeared to be highest in phosphorus during the growing seasons and lowest during the dormant periods (Figure 5).

Lehmann lovegrass had a significantly higher ($P < 0.01$) phosphorus content than black grama in fall, spring and summer but the content in the winter was not significantly different (Figure 4, Table 1). Monthly phosphorus content of both species during summer indicated that in June, when relative utilization of the two grasses was significantly different, relative phosphorus content was not significantly different. In contrast, in September, November, December, April and August, phosphorus content of Lehmann lovegrass was significantly higher than that of black grama, but relative utilization was not significantly different.

These results indicated that preference for Lehmann lovegrass was not significantly related to phosphorus content. Similar results were reported by Hoehne (1966) who reported a small but consistently negative correlation between phosphorus and cattle preference for grass species. Bryant (1971) found that leaf phosphorus generally had little influence on the utilization of blue grama and curlymesquite. In contrast, Leigh (1961) found that grasses highest in phosphorus and potash were most acceptable to livestock.

CHAPTER 6

CONCLUSIONS

This study showed that yearly cumulative utilization of Lehmann lovegrass was higher than that of black grama. Slopes of respective regression lines for percentage utilization by species versus time were significantly different ($P < 0.01$). This indicated that utilization of Lehmann lovegrass increased at a faster rate than did utilization of black grama (Figure 3).

On a seasonal basis, relative percentage utilization of Lehmann lovegrass was significantly different than that of black grama during the summer only ($P < 0.05$). The preference for Lehmann lovegrass over black grama in summer was due in part to the consistently higher utilization of Lehmann lovegrass during all three summer months but especially due to its significantly greater ($P < 0.01$) use during June (Figure 5, Table 3).

Percentages of total nonstructural carbohydrates and moisture were the two chemical factors that showed a significant relationship to preference for Lehmann lovegrass. In June both factors were significantly higher for Lehmann lovegrass than for black grama. Crude protein and phosphorus contents did not show a significant relationship to preference.

There are several management implications of this study. Previous research indicates a cattle preference for Lehmann lovegrass over certain native perennials in winter. In the present study, a preference for Lehmann lovegrass over black grama was shown in summer only. Utilization of Lehmann lovegrass was greater than black grama in fall and spring, but differences were not significant. In addition, it was found that Lehmann lovegrass is generally more valuable than black grama from a nutritional standpoint, particularly in fall, spring and summer. Both species were about equal in nutritive value during winter.

Correct intensity of use of key forage species is likely more important than any other range management practice. Based on the results of this study, the value of Lehmann lovegrass as a key forage species is greater than previous research indicates, particularly in relation to black grama.

APPENDIX

SEASONAL AND MONTHLY ANALYSES OF

VARIANCE OF PERCENTAGE UTILIZATION

Seasonal ANOVA

Sources of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Test[1]
Within + Residual	350.945	38	9.235	
Site	.460	1	.460	NS
Species	41.627	1	41.627	S
Site by Species	.017	1	.017	NS
Season	95.542	3	31.847	S
Season by Species	44.032	3	14.677	NS

Monthly ANOVA

Sources of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Test
Within + Residual	192.248	22	8.738	
Site	.460	1	.460	NS
Species	41.626	1	41.627	S
Site by Species	.017	1	.017	NS
Month	204.775	11	18.616	NS
Month by Species	93.495	11	8.500	NS

[1] NS indicates a non-significant difference at the 0.05 level of probability, S a significant difference.

LITERATURE CITED

Bell, H. M. 1973. Rangeland management for livestock production. Univ. Okla. Press, Norman, Okla., 303 pp.

Bremmer, J. M. 1965. Total nitrogen, pp. 1149-1178. In C. A. Black (ed.) Methods of soil analysis. Part 2. Chemical and microbiological properties. Amer. Soc. Agron., Monograph No. 9.

Bryant, D. A. 1971. Fertilization and burning effects on the use of desert grassland by cattle. Ph.D. Diss., Univ. Ariz., Tucson, Ariz., 157 pp.

Cable, D. R. 1971. Lehmann lovegrass on the Santa Rita Experimental Range, 1937-1968. J. Range Manage. 24:17-21.

________ and J. W. Bohning. 1959. Changes in grazing use and herbage moisture content of three exotic lovegrasses and some native grasses. J. Range Manage. 12:200-203.

Cable, D. R. and R. P. Shumway. 1966. Crude protein in rumen contents and in forage. J. Range Manage. 19:124-128.

Campbell, R. S. and E. C. Crafts. 1939. How to keep and increase black grama on southwestern ranges. U.S. Dept. Agr. Leaflet 180, 8 pp.

Chapman, H. D. and P. F. Pratt. 1961. Methods of analysis for soils, plants and waters. Univ. Calif., Div. Agr. Sci., Riverside, Calif., 309 pp.

Crider, F. J. 1945. Three introduced lovegrasses for soil conservation. U.S. Dept. Agr. Circ. 730, 90 pp.

Freyman, S. and A. L. Van Ryswyk. 1969. Effect of fertilizer on pinegrass in southern British Columbia. J. Range Manage. 22:390-395.

Galt, H. D. 1972. Relationship of the botanical composition of steer diet to digestibility and forage intake on a desert grassland. Ph.D. Diss., Univ. Ariz., Tucson, Ariz., 234 pp.

Galt, H. D., B. Theurer, J. H. Ehrenreich, W. H. Hale, and S. C. Martin. 1969. Botanical composition of steers grazing a desert grassland range. J. Range Manage. 22:14-19.

Garner, F. H. 1963. The palatability of herbage plants. J. Brit. Grassl. Soc. 18:79-89.

Hardison, W. A., J. T. Reid, C. M. Martin, and P. G. Woolfolk. 1954. Degree of herbage selection by grazing cattle. J. Dairy Sci. 37:89-102.

Heady, H. F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17:76-82.

________. 1975. Rangeland Management. McGraw-Hill, New York, 460 pp.

Hoehne, O. E. 1966. Cattle preference as related to chemical components of native range plants. Diss. Abstr. 27:1677B-1678B.

Humphrey, R. R. 1958a. Lehmann's lovegrass, pros and cons. Ariz. Cattlelog 13:16-18.

________. 1958b. The desert grassland. Univ. Arizona Press, Tucson, Ariz., 74 pp.

________. 1960. Forage production on Arizona ranges. V. Pima, Pinal and Santa Cruz Counties. Arizona Agr. Exp. Sta. Bull. 302, 137 pp.

________. 1970. Arizona Range Grasses. Univ. Ariz. Press, Tucson, Ariz., 159 pp.

Humphreys, L. R. 1966. Pasture defoliation practice: A review. J. Aust. Inst. Agr. Sci. 32:93-105.

Jackson, M. S. 1958. Soil chemical analysis. Prentice Hall, Englewood Cliffs, N. J., 498 pp.

Kearney, T. H. and R. H. Peebles. 1960. Arizona Flora. Univ. Calif. Press, Los Angeles, Calif., 1085 pp.

Leigh, J. H. 1961. The relative palatability of various varieties of weeping lovegrass (*Eragrostis curvula* [Schrad.] Nees). J. Brit. Grassland Soc. 16:135-140.

Plice, M. J. 1952. Sugar versus the intuitive choice of foods by livestock. J. Range Manage. 5:69-75.

Reid, R. L., G. A. Jung, and C. M. Kinsey. 1967. Nutritive value of nitrogen-fertilized orchardgrass pasture at different periods of the year. Agron. J. 59:519-525.

Roach, Mack E. 1950. Estimating perennial grass utilization of semi-desert cattle ranges by percentage of ungrazed plants. J. Range Manage. 3:182-185.

Schmutz, E. M. 1978. Estimating range use with grazed-class photo guides. Ariz. Agr. Exp. Sta. Bull. A-73, 14 pp.

________, G. A. Holt, and C. C. Michaels. 1963. Grazed-class method of estimating forage utilization. J. Range Manage. 16:54-59.

Silveira, A. J. 1977. Cotton fruiting from sensitivity to shade trees. M.S. Thesis, Univ Ariz., Tucson, Ariz., 60 pp.

Smith, D. 1969. Removing and analyzing total nonstructural carbohydrates from plant tissue. Univ. Wisconsin Coll. of Agr. and Life Sci. Res. Rep. 41., 11 pp.

Stanley, E. B. 1938. Nutritional studies with cattle on a grassland type range in Arizona. Ariz. Agr. Exp. Sta. Tech. Bull. 79:129-164.

Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Range Management. 3rd Ed. McGraw-Hill, New York, 532 pp.

U.S. Soil Conservation Service. 1974. Report and interpretations for the general soil map, Pima County, Arizona, 32 pp.

Van Dyne, G. M. 1963. Forage intake and digestion by cattle and sheep on a common dry foothill annual range. J. Range Manage. 17:92.

Wagnon, K. A. and H. Goss. 1961. The use of molasses to increase the utilization of rank, dry forage and molasses-urea as a supplement for weaner calves. J. Range Manage. 14:5-9.

Watkins, W. E. 1937. The calcium and phosphorus contents of important New Mexico range forages. N. Mex. Agr. Exp. Sta. Tech. Bull. 246, 75 pp.

________. 1943. Composition of range grasses and browse at varying stages of maturity. N. Mex. Agr. Exp. Sta. Tech. Bull. 311, 43 pp.

________ and J. H. Knox. 1945. The monthly protein and phosphorus contents of two important range grasses of southern New Mexico. J. Anim. Sci. 4:297-305.

White, L. M. 1973. Carbohydrate reserves of grasses: A review. J. Range Manage. 26:13-18.

Wright, N. and L. J. Streetman. 1958. Past performance and future potential of black grama for southwestern ranges. J. Range Manage. 11:207-214.