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CHEMICAL COMPOSTTION AND DIGESTIBILITY OF LEHMANN LOVEGRASS (ERAGROSTIS LEHMANNIANA) IN RESPONSE TO GRAZING AND CLIPPING INTENSITIES.

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CHEMICAL COMPOSITION AND DIGESTIBILITY OF LEHMANN LOVEGRASS (*ERAGROSTIS LEHMANNIANA*) IN RESPONSE TO GRAZING AND CLIPPING INTENSITIES

by

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ABSTRACT

Lehmann lovegrass (Eragrostis lehmanniana, Nees), a warm-season exotic grass dominates much of the Santa Rita Experimental Range. To evaluate its grazing potential, the dry matter, digestibility, crude protein and moisture content were measured.

Forage samples were taken from periodically grazed and continuously grazed plots at the third and fourth week of every four weeks from August 22, 1980 to May 23, 1981. Other protected plots were subjected to 10-, 20- and 30-gram rates of herbage removal at monthly intervals from September to November of 1980.

In the summer-fall period, all measures of forage quality were constantly higher in the continuous grazing. This was probably due to presence of more new growth initiated by the constant defoliation of the plants in the growing period.

In late fall and early winter, however, forage quality was higher in the periodic grazing in the first few weeks. After February, the process was reversed to the advantage of the continuous grazing.

Mean standing crop sampled from protected plots averaged 1550 kg/ha to 1600 kg/ha. Monthly removal of 10-, 20- and 30-grams of the available herbage resulted a reduction in forage quality with the increase of the intensity of herbage removal. The 10 gram intensity had the highest quality followed by the 20- and 30-gram rates. Obviously as intensity of clipping increased more of the older material was included. Consequently, the forage quality was reduced.

INTRODUCTION

Lehmann lovegrass (Eragrostis lehmanniana, Nees)[1], an exotic plant introduced from South Africa some forty years ago, now dominates parts of the Santa Rita Experimental Range especially on Whitehouse soils. Since seeding, it has spread far beyond the boundaries of planting and is one of the most successful grasses for revegetating arid rangelands of Arizona and New Mexico (Stoddart and Smith, 1955; Cable, 1976).

The plant is stemmy and usually rated low in palatability for livestock (Cable and Bohning, 1959; Cable, 1971). Compared to native grasses, however, its production is much higher under the harsh environment and sites where it grows (Cable, 1976; Martin and Morton, 1980; Martin, 1963). Furthermore, the plant responds to winter precipitation and provides more green herbage during winter and early spring than the common warm-season native species during this critical period (Galt et al., 1969; Cable, 1976). The nutritive value of Lehmann lovegrass is about the same as the native species it often replaces (Crider, 1945; Galt et al., 1969).

Despite the vast research done on native grasses in the hope of solving some of the basic problems in range management caused by the seasonal and periodical fluctuations in forage quality and quantity, two other inversely related factors, relatively little is known about

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

Lehmann lovegrass. This lack of enough information and the growing importance of the species as a forage plant, particularly in the semi-desert rangelands of the Southwest area of the United States, necessitated this study. The main objectives of the study were to determine the seasonal changes in the levels of crude protein, moisture content and digestibility of the grass in response to the following grazing and clipping intensities:

(1) continuous grazing

(2) grazing one week out of four (periodic grazing)

(3) clipping ungrazed plants on plots to simulate various levels and schedules of grazing.

REVIEW OF LITERATURE

The literature reviewed in this study was limited to the attributes of digestibility, moisture content, protein content and herbage production of native and introduced forage grasses of the southwestern United States.

Digestibility

Various factors affect intake and digestibility of range forage. The most extensively studied are the changes that take place in the chemical composition of the plants as they undergo processes of maturation (Watkins, 1955; Campbell and Kartchner, 1979). Also, Cook, Stoddart and Harris (1956) observed that forage digestibility was high in the early stages when plants were tender and succulent and decreased as they approached maturity.

Another factor which influences forage digestibility and nutritive value of animal diets is the intensity of grazing (Cook, 1971). Studying typical desert forage plants in Utah, Cook (1971) observed that as intensity of clipping increased, ash and lignin increased while protein, cellulose and gross energy decreased. Similar results were reported by Pieper, Cook and Harris (1959). Using sheep at various stocking levels on Salt-Desert Shrub ranges in Utah, these authors reported increased amounts of lignin in the diets of the animals grazing in the heavily stocked plots. This phenomenon was more obvious where animals grazed only pure stands. On mixed forage, however, opposite results often were observed. In the case of the pure stands, the authors explained their findings to be the result of animals being forced to consume more coarse, undesirable plant parts. In the mixture, the animals could be more selective about their diets.

Other workers (Crider, 1945; Hardison, Linkous and Ward, 1957) demonstrated that different parts of individual forage plants had different digestibility. Hardison and his coworkers observed that dry matter in the bottom portion of the alfalfa plant was only 87% as digestible as that in the top portion. As the stage of growth advanced, digestibility of the dry matter in the base decreased at the rate of 0.6% per day, but digestibility in the upper portion of the plant remained unchanged.

Similarly, Crider (1945) showed that the digestibility of the leaves of Lehmann lovegrass was comparable to digestibility of leaves of sideoat grama (Bouteloua curtipendula) and slender grama (B. filiformis). The importance of lovegrasses as forage for livestock, particularly in the arid western U.S., was also demonstrated in the works of Stanley and Hodgson (1938) and Patton (1943). These authors found that leaves of lovegrass at comparable stages were lower in lignin than those of blue grama (Bouteloua gracils), one of the most important native grasses.

Moisture

Moisture content in forage plants varies with the stage of growth. Cable and Shumway (1966) observed that Lehmann lovegrass completed two growing cycles each year as a result of the two rainy seasons in southern Arizona. The major wet season is the summer when growth starts in late June or July and foliage dries by December. The minor wet season starts in the spring when growth begins in January and the plants mature and dry by June.

In a 10-month study (September 1956 through June 1957), Cable and Bohning (1959) found that moisture content for three lovegrasses namely, Lehmann lovegrass, Boer lovegrass (Eragrostis chloromelas) and Wilman lovegrass (E. superba), was the highest in September (34% to 49%). Average moisture contents for the three species were: 17%, 26.9% and 22.6% for Wilman, Boer and Lehmann, respectively. They observed that moisture content dropped rapidly after the September peak. During November and December, moisture decreased slowly. From late January through early March average moisture content increased as new growth developed. In all three species, the lowest points coincided with the driest month of May. Comparing the three lovegrasses with Arizona cottontop (Trichachne californica), hairy grama (Bouteloua hirsuta); side-oats grama and tangle head (Heteropogon contortus), Cable and Bohning (1959) found that the lovegrasses contained more moisture than the native grasses from October through March.

Cable (1971 and 1976) observed that, unlike native grasses, Lehmann lovegrass responded to winter precipitation and produced more green herbage in early spring. This may suggest that Lehmann lovegrass is superior to the native grasses in moisture content during this period. Reese (1980), however, noted that Lehmann lovegrass had lower moisture content than black grama (Bouteloua eriopoda) in January and

February. On a seasonal basis, the lovegrass was superior in all seasons except winter when both species reached the same low level of moisture content.

Protein

Henzell and Oxenham (1964) studied the seasonal changes of nitrogen content in warm-climate grasses. These authors observed that nitrogen content was highest in young leaves and stems and declined with time. They suggested that the decline might be caused by the tissues accumulating increasingly large amounts of non-nitrogenous cell-wall materials with age and the combination of these with nitrogen compounds.

Similarly, Farrington (1973) noted that nitrogen content in weeping lovegrass (Eragrostis curvula) varied inversely with the stage of plant development. In a two-year study period, he found that nitrogen content reached a peak in late spring and early summer when plants were actively growing and fell to the lowest level in the winter when the plants were dormant. The fluctuation of nutrient content with season and age of plants was also investigated by Cable and Shumway (1966). Studying Arizona cottontop and Lehmann lovegrass, they found that the protein content of whole clipped plants was highest in young succulent growth. As the plants matured, protein content rapidly declined. In both species, the highest points were recorded during the summer growing period and the lowest points in the winter dormant period and in the late spring drought of May and June. A significant increase in protein content was recorded for Lehmann lovegrass during the spring, but not for Arizona cottontop. In other studies, Cable (1971 and 1976) confirmed that, unlike native grasses, Lehmann lovegrass benefited from winter rains to produce green herbage. Crude protein in Lehmann lovegrass for example, averaged 11% to 38% higher than in Arizona cottontop.

The superiority in feed value of Lehmann lovegrass during winter and early spring was also shown in the works of Cable and Shumway (1966), Humphrey (1958) and Crider (1945). These authors observed that Lehmann lovegrass had higher protein content in the dormant periods of the fall, winter and early spring compared to most of the associated native grasses.

Animal requirement for protein varies with age and physiological state of the animal. Shumway and Hubbert (1963) estimated that normal, growing 400 lb to 600 lb steers or heifers require about 9.3% to 11.7% protein in their diet and 800 lb or 1000 lb animals need about 7.8% protein. However, Cable and Shumway (1966) reported a 7.5% crude protein requirement for wintering 600 lb steers, based on recommendations of the National Research Council. Considering these figures, these authors and others like Shumway and Hubbert (1963), studying typical semidesert grasses like Lehmann lovegrass and Arizona cottontop, concluded that animals consuming only such grasses would be short of crude protein in their diets in all months except August and September. On the other hand, Cable and Shumway (1966) found that the green parts of Lehmann lovegrass contained adequate protein during the months of March and April.

Although protein deficiency in desert grasses is well documented in the literature, comparison of clipped plants and rumen ingesta show that the latter contains more protein (Shumway and Hubbert, 1963; Cable and Shumway, 1966; Campbell and Kartchner, 1979). These investigators explained their findings mainly on the basis of animal selectivity or consumption of forbs or shrubs which contain higher protein. These results suggest that mechanically harvested forage does not accurately represent animal diets.

Herbage Production

Forage production in most arid rangelands varies from year to year and from season to season. The most important and obvious factor causing herbage fluctuations is precipitation as pointed out by Cable (1975 and 1976), Farrington (1973), Sneva and Hyder (1962) and Culley (1943). These authors found that a significant correlation existed between precipitation and the subsequent herbage yields in semi-arid lands.

Cable (1975 and 1976), Stroehlein, Ogden and Billy (1968), Schmutz, Holt and Michaels (1963) and Culley (1943) confirmed that the volume of herbage produced in a particular period was influenced by the rainfall of the current growing season plus the rainfall of the preceeding growing season. Cable (1975), for example, reported that about 64% to 91% of the yearly fluctuations in grass production in four semiarid range units for the years 1957 to 1966 was due to the influence of the interaction between the previous summer rains and the current summer rains.

Warm-season grasses have their highest herbage production during the summer. However, some, like lovegrasses, produce some forage in the winter and early spring (Cable, 1976). In a 27-year study period at the Santa Rita area, Culley (1943) observed that the average starting date of the effective summer rains was the fourth of July. The author, however, concluded that enough green forage for cattle could be expected only after the 10th of July or later. He further reported that about 83% of the summer growth occurred between July 20 and September 10. Similarly, Cable (1975) showed that, though summer rainfall constituted about 50% to 60% of the total, 90% of the herbage was produced during this period.

Workers at the Santa Rita area have shown that herbage production of Lehmann lovegrass was influenced by elevation. In areas cleared of velvet mesquite (*Prosopis juliflora* var *velutina*), Lehmann lovegrass produced 1110 kg/ha, 588 kg/ha, 101 kg/ha and only 9 kg/ha, respectively, at 1250 m, 1128 m, 1036.6 m and 960.4 m elevations (Martin, 1963). These results were supported by Cable (1971) who showed that Lehmann lovegrass represented 21% of the perennial grass production at 960.4 m, 49% at 1036.6 m, 95% at 1128 m and 88% at 1250 m. Elevation effects may be mainly precipitation effects, as mean annual rainfall was 4.9 cm, 5.3 cm, 5.7 cm and 6.7 cm, respectively, for the 960.4 m, 1036.6 m, 1128 m and 1250 m elevations.

In a 5-year study period at the Santa Rita Range, Martin and Morton (1980) reported that Lehmann lovegrass produced 1647 kg/ha in an untreated plot. Similarly, Stroehlein et al. (1968) found a high production of 1205 kg/ha on unfertilized plots on the Santa Rita area at an elevation of 1250 m. It should be noted, though, as indicated in the works of Cable (1971), that Lehmann lovegrass tends to accumulate large quantities of old growth as carry over from previous years. A large percentage of the herbage production reported by Martin and Morton and Stroehlein and his co-workers could fall in this category.

Most of the literature cited agree on the seasonal fluctuation of forage quality and quantity with precipitation. Moisture content, crude protein, digestibility of the forage and the dry matter yield increase during the rainy seasons (summer and spring) and decrease in the dry periods (fall and early winter). There was very little literature dealing with the response of the species to grazing treatments.

DESCRIPTION OF THE STUDY AREA

The field study was conducted in Pasture 12A on the Santa Rita Experimental Range about 60 km south of Tucson. The vegetation of the area is classified as desert grassland (Martin and Reynolds, 1973). Lehmann lovegrass makes up over 80% of the perennial grass composition. Other species include *Aristida* spp. Rothrock grama (*Bouteloua rothrockii*), black grama and Arizona cottontop. The major shrubs are Ocotillo (*Fouquieria splendens*) and false mesquite (*Calliandra eriophylla*). Other shrubs include velvet mesquite, acacias (*Acacia greggii* and *A. angustissima*), cholla cactus (*Opuntia fulgida*), prickly pear (*O. engelmannii*) and mimosas (*Mimosa biuncifera* and *M. dysocarpa*). Most shrubs are common along the dry washes. However, mesquite, calliandra and ocotillo are scattered all over the area.

The pasture has a topography of fairly flat uplands divided by shallow dry washes. The elevation is about 1097 meters. There are two water sources in the pasture located approximately 3 km apart. South tank (earthen dam) dried up during the study period, forcing the cattle to drink at the newly established water in the northeastern corner of the pasture. Historically, the pasture received light grazing from about 30 cows on a year-round basis, but 60 animals were allowed during the study period.

The climate of the area is a typical desert grassland. Rainfall data for the area (1923-1978) indicates a mean annual precipitation of

36 cm. The data reported here are the average of the nearest three rain gauges around the pasture. About 60% of the rain comes between July 1st and the end of September. The rest of the precipitation falls during the winter. The rainfall pattern is, thus, bimodal which characterizes southern Arizona (Fig. 1).

The soils of the area are of the Whitehouse series. These are deep, thermic, gravelly or cobbly soils with medium permeability. These semiarid soils were formed from a parent material of mainly granitic or other quartz-bearing rocks from the Santa Rita Mountains (Youngs et al., 1936).

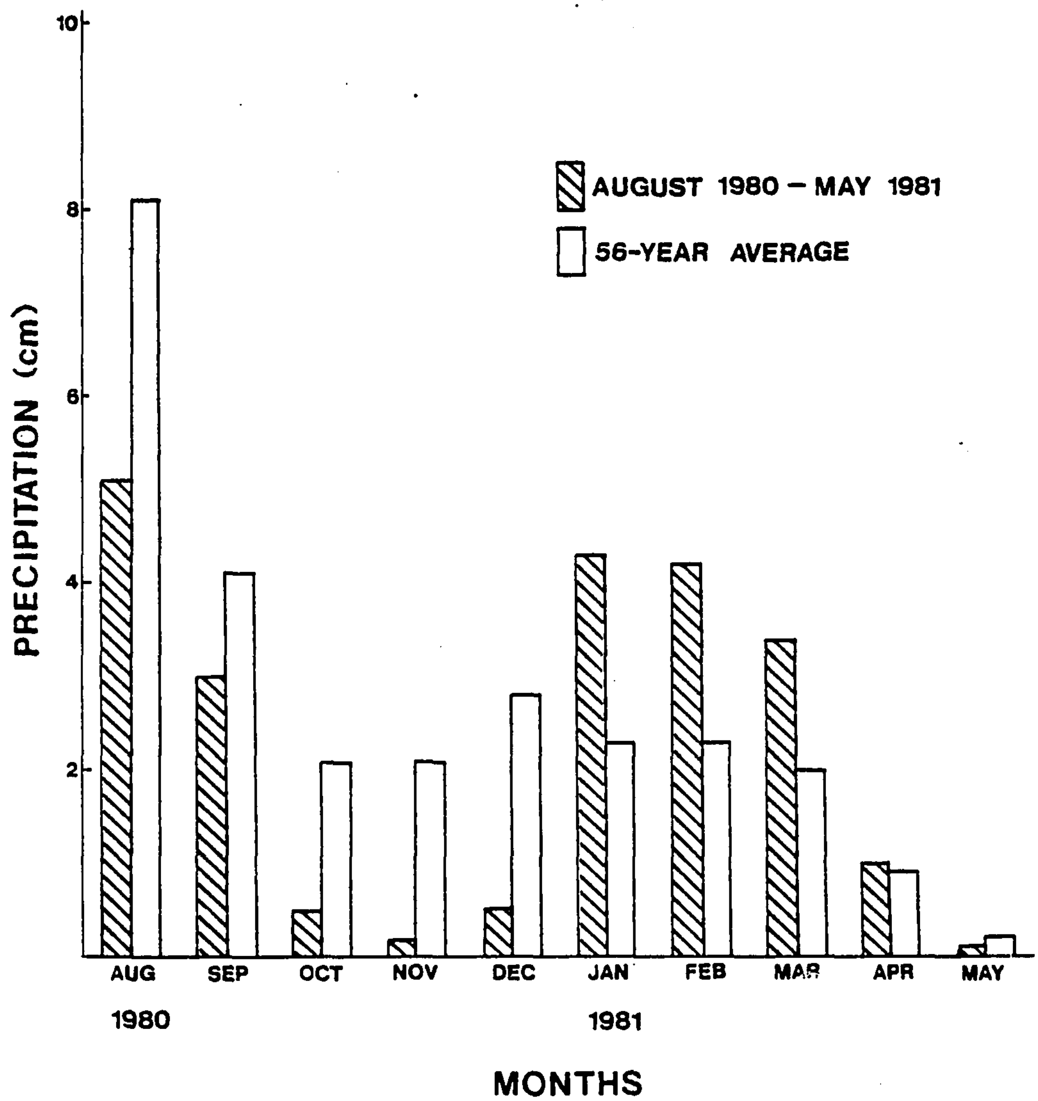

Figure 1. Average monthly precipitation (cm) derived from three rain gauges in or near Pasture 12A, Santa Rita Experimental Range, Arizona, 1980-81 and 56-year average.

METHODS

The field study was conducted in Pasture 12A. According to the distance from water, period of study and characteristics of the site, three locations were selected:

Study Site A - continuous vs. periodic grazing (August 22, 1980-November 22, 1980) at South tank.

Study Site B - continuous vs. periodic grazing (Dec. 29, 1980-May 23, 1981) at new northeastern water trough.

Study Site C - clipping study (Aug. 22, 1980 - Nov. 15, 1980) at South tank.

Study Site Locations

South Tank provided the only source of water in the pasture prior to the study period. The animals, therefore, often grazed around this area. Consequently Study Site A, located only 40 meters from water, was closely grazed. Three paired plots each 6 m x 6 m were set up in this area. Each plot contained 20 subplots 10 of which were used for nutritional studies and the other 10 (by another student) for phenology and root growth studies. Three of the paired plots were periodically grazed (1 week out of 4) and the other three were continuously grazed. Movable pipe and wire panels were used to control the grazing schedules.

When South Tank dried up in December 1980, plots in Study Site A were moved to the northwestern corner of the pasture where a new water was established. This area (Study Site B) had very light use in the past. Consequently, the grass was dense and tall. Forage production was much greater than at Study Site A but the quality was much lower due to the large accumulation of older growth. Separating this old growth from current years growth was a major problem. This site, though close, was separated from water by a steep-walled wash, but this did not prevent animals from reaching the area.

About 500 meters from the South Tank, another location (Study Site C) was selected. This area, like Study Site B was lightly grazed. Forage quantity was high, but the quality was lowered by the presence of large amounts of old growth. The site was well protected from erosion by the thick cover of litter accumulated over the years. This area was used for the clipping study. Three caged plots with the same dimensions and number of subplots as Study Sites A and B were set up. These plots were protected from animals, but were subjected to various clipping intensities from August 22, 1980 through November 15, 1980.

Field Data Collection Procedure

On specified dates beginning on August 22, 1980 and ending November 22, 1980, one subplot (1 m^2) was clipped to ground level in each periodically grazed and continuously grazed plot at Study Site A to provide samples for analysis. Observations were made at the end of the 3rd and 4th weeks of each 4-week period. In other words, the periodically grazed plots were rested 3 weeks and opened to animals one week in every 4 weeks. Thus, samples were taken when cages were removed and when replaced after a week. The continuously grazed plots followed the same schedule, though no cages were used.

The periodically grazed and the continuously grazed plots at the northeastern corner of the pasture (Study Site B) were subjected to similar sampling intervals as in Study Site A from December 29, 1980 to May 23, 1981.

The three plots at Study Site C were used for clipping studies and were protected from cattle during this period (i.e., August 22, 1980-November 15, 1980). In each plot, two subplots were clipped on August 22, 1980 and these were reclipped on November 15, 1980 to obtain and evaluate the regrowth during the study period. Another two subplots were clipped only at the end of the study period (November 15, 1980). These were used as checks for the study.

Starting from September 13, 1980 through November 15, 1980, the remaining six subplots in each plot were subjected periodic removal of the following quantities of herbage (field weight basis):

(1) Remove 10 grams/square meter

(2) Remove 20 grams/square meter

(3) Remove 30 grams/square meter

Samples were collected at 4-week intervals. On November 15, 1980, subplots previously subjected to 20 grams and 30 grams of herbage removal were clipped to ground level. However, only 10 grams were harvested on this date from subplots previously subjected to 10 grams herbage removal.

Many researchers have shown that cattle selectively grazed certain desirable plant parts, especially leaves and younger stems

(Galt et al., 1969). It is not easy, however, to sample forages that are representative of that ingested by livestock without the use of esophageal or rumen fistulated animals. Therefore, the 10-, 20- and 30-gram rates of forage removal represented light, medium and heavy grazing respectively, were done to simulate the manner of a grazing animal on the range.

Laboratory Procedures

Clipped plant material from each subplot was collected in a paper bag, weighed in the field then oven dried at 60 C for 48 hrs. The oven dried samples were again weighed and the moisture content of each sample was calculated as a percentage of the field weight. Herbage samples were then ground in a Wiley mill to allow the plant material to pass a 40-mesh screen. The ground samples were then stored in clean plastic bottles for chemical analysis. Chemical components and digestibility were analyzed. Percentage crude protein was determined by the semi-micro-kjeldahl method (Bremmer, 1965) and digestibility analyzed by the *in vitro* digestion method (Tilly and Terry, 1963).

Statistical Analysis

For the periodical and the continuous grazing treatments at Study Sites A and B, the data were statistically analyzed using a split plot design. The ANOVA for each area is as shown below:

Study Site A

Source	df
Trt	1
Rep = 2*	4 (Error A)
Rep x Trt = 2	
Date	6
Date x Trt	6
Date x Rep = 12	24 (Error B)
Date x Rep x Trt = 12	
Total	41

Study Site B

Source	df
Trt	1
Rep = 2*	4 (Error A)
Rep x Trt = 2	
Date	9
Date x Trt	9
Date x Rep = 18	36 (Error B)
Date x Rep x Trt = 18	
Total	59

*Only 2 replications were analyzed for protein determination.

Treatment effects of each variable were statistically analyzed between grazing treatments at each sample date.

Two types of analysis were used for the clipping study (ungrazed plots) at Study Site C. In order to investigate the cumulative effect of the various degrees of successive herbage removal on chemical components, digestibility and dry matter, the November 15, 1980 data were separately analyzed using a randomized complete block design. The ANOVA for the variables was as shown:

Source	df
Trt	4
Rep*	2
Trt x Rep	8
Total	14

Similarly the 10-gram, the 20-gram and the 30-gram rates of removal were statistically compared by date. A split plot design was used for the analysis of variance as described below:

Source	df	
Trt	2	
Rep = 2*	6	(Error A)
Rep x Trt 4		
Date	2	
Date x Trt	4	
Date x Rep = 4	12	(Error B)
Date x Rep x Trt = 8		
Total	26	

*Only 2 replications were analyzed for protein determination

In all studies, whenever a significant treatment effect appeared at the 0.05 level of probability, a least significant difference (LSD) or confidence interval test was made to isolate differences between means.

RESULTS AND DISCUSSION

Seasonal Changes Under Continuous and Periodic Grazing

Standing Crop

Changes from late summer to fall in standing crop available to the cattle at Study Site A increased from Aug. 22 to Sept. 13 then declined rather steadily until late November (Table 1). In both treatments the highest level was recorded on September 13. The lowest was reached in mid-November with periodic grazing and in late October under continuous grazing. The standing crop was always higher under periodic grazing but differences between treatment means were significant ($P = 0.05$) only from September 13 through October 18. For the entire study period, the standing crop averaged 16.7 gm/m^2 and 6.3 gms/m^2, respectively, for periodic and continuous grazing.

Obviously the constantly lower forage quantity in the continuously grazed plots was mainly due to consumption by the cattle. On periodically grazed plots, the 3-week rest periods permitted the accumulation of more regrowth than occurred on continuously grazed plots.

When plants were actively growing, August 22 through September 20, the standing crop increased and plants started to mature. Afterwards, as soil moisture decreased, standing crop declined. This kind of growth pattern by Lehmann lovegrass agrees with the findings of Cable and Shumway (1966).

Table 1. Dry matter available (g/m^2) by dates of observation from August 22, 1980 to May 23, 1981.

Late Summer-Fall (Study Site A)			Winter Spring (Study Site B)		
Sample Date	Periodic	Continuous	Sample Date	Periodic	Continuous
Aug. 22	16.0	12.3	Dec. 29*	181.0	126.0
Sep. 13*	30.3	13.7	Jan. 17	125.0	110.0
Sep. 20*	23.3	6.0	Jan. 24	104.3	122.7
Oct. 18*	15.0	2.3	Feb. 21	97.0	90.3
Oct. 25	10.7	1.0	Feb. 28	88.3	83.7
Nov. 15	8.0	4.2	Mar. 28	107.0	99.0
Nov. 22	13.7	4.3	Apr. 4	83.0	89.7
			Apr. 25	66.3	44.3
			May 2	62.0	70.3
			May 23	67.3	44.3
Mean*	16.7	6.3	Mean	98.1	88.1

*Denotes significant differences between means at that date (P = 0.05).

From December through May, the standing crop (Study Site B) was almost always higher on the periodically grazed plots but the differences were not as great as in the fall and average values were several times greater than in the late summer and fall (Table 1). Standing crops were greatest for both treatments from December 29 to April 4. But the higher values ($P = 0.05$) for periodic grazing was significant only on December 29.

Several factors could have caused the higher dry matter from December to April. First, since the cows were not accustomed to using this part of the pasture, they often went back to the South Tank area (Study Site A) even after water was available at the new site. Second, the grass in this study site had scarcely been grazed for several years, because it was far from water. As a result, a large quantity of dead, relatively unpalatable material had accumulated and the cattle passed this up at first in their search for more palatable forage.

Later, when the winter rains started and the forage began to green up, the cattle gradually were attracted to the site. The subsequent decline in dry matter after April 4, in both grazing treatments, (Table 1) probably was the result of forage removal by grazing. In late winter and early spring, the cattle were particularly attracted to the green basal leaf growth. Consequently, the utilization pressure increased greatly from April to the end of the study.

Moisture Content

From late summer to fall (Study Site A) moisture content was about the same in the first three weeks for both treatments (Table 2).

Table 2. Moisture content (%) by dates of observation from August 22, 1980 to May 23, 1981.

Late Summer-Fall (Study Site A)			Winter-Spring (Study Site B)		
Sample Date	Periodic	Continuous	Sample Date	Periodic	Continuous
			Dec. 29	8.6	10.0
Aug. 22	54.6	48.9	Jan. 17	24.9	20.8
Sept. 13	50.0	50.8	Jan. 24	23.3	21.7
Sept. 20*	60.6	80.2	Feb. 21	29.3	24.1
Oct. 18	40.0	52.2	Feb. 28	24.0	24.0
Oct. 25*	37.3	66.7	Mar. 28	29.4	32.3
Nov. 15*	32.3	49.3	Apr. 4	35.5	35.4
Nov. 22	29.8	35.7	Apr. 25*	31.9	39.7
			May 2	32.1	32.5
			May 23*	23.8	29.9
Mean*	43.8	54.8	Mean	26.3	27.1

*Denotes significant difference between means at that date ($P = 0.05$).

In both grazing treatments, the peak was reached September 20 and the low was recorded November 22. After September 20, the moisture content of the periodically grazed forage dropped rapidly at first then gradually declined from October 18 through November 22.

Moisture content of the continuously grazed plant samples followed a pattern similar to the periodically grazed plants in the first four weeks of the study period. On October 18, however, the moisture again rose sharply to reach another peak October 25; then declined slowly till it reached its lowest point in late November. After the third week of the study period, the continuously grazed plots were constantly higher in moisture content than those grazed periodically (Table 2). This higher moisture content was significant ($P = 0.05$) only on September 20, October 25 and November 15 (Table 2).

It appears that the higher moisture content observed on the continuously grazed plots was due to the fact that grazing often initiated a flush of new, short, tender leaves and shoots that escaped cattle grazing. Another possibility is that as the taller and relatively more mature stems were removed the proportion of more succulent plant material increased. As a result, the moisture content increased.

During the winter and spring (Study Site B) moisture content of grass samples was about the same for both treatments except on April 25 and May 23 when the continuously grazed plots were significantly higher at the 5% level of probability (Table 2). For both treatments, the lowest moisture content was recorded December 29 and the highest in April. In the first 7 to 8 weeks of the winter-spring period (except

December 29), moisture content was slightly higher in the periodically grazed plots. After that, the pattern was reversed to the advantage of the continuous grazing. In the first case, the small quantity of green forage produced in the period between January and February was protected on the periodically grazed plots while in the continuously grazed plots it was readily picked up by the cows. Consequently the moisture content on continuously grazed plots was reduced by selective removal of the new green herbage.

Later, from March through May, the amount of green herbage produced was relatively larger, particularly in the continuously grazed plots because removal of older material stimulated new growth and, as a result, moisture content increased.

Crude Protein

Protein content in late summer and fall (Study Site A) was constantly higher in grass collected from the continuously grazed plots (Table 3). This higher protein content was significant ($p = 0.05$) August 22 through October 18 and on November 22. Unlike moisture content (Table 2), the gap between the two treatments was much wider in the first 3 to 4 weeks of the study period. Possibly, moisture content might not be as closely related to protein as some researchers have reported (Cable and Shumway, 1966); or probably, nitrogen in the periodically grazed plots may already have been transferred elsewhere (roots or stem bases) or could be fixed by lignin. This would agree with the findings of Perry and Moser (1974). Another possible interpretation could be that young shoots and leaves increased

Table 3. Crude protein content (%) by dates of observation from August 22, 1980 to May 23, 1981.

Late Summer-Fall (Study Site A)			Winter-Spring (Study Site B)		
Sample date	Periodic	Continuous	Sample date	Periodic	Continuous
	%	%		%	%
Aug. 22*	9.8	12.0	Dec. 29	4.1	3.3
Sept. 13*	10.4	12.3	Jan. 17	4.3	3.4
Sept. 20*	10.9	12.7	Jan. 24	4.0	3.6
Oct. 18*	9.3	11.4	Feb. 21	4.4	4.7
Oct. 25	9.3	9.8	Feb. 28	4.6	4.7
Nov. 15	9.0	9.1	Mar. 28	5.7	5.8
Nov. 22*	7.8	9.2	Apr. 4	5.2	5.9
			Apr. 25	5.8	6.0
			May 2	5.5	5.5
			May 23	5.4	5.7
Mean*	9.2	10.9		4.9	4.8

*Denotes significant difference between means at that date (P = 0.05).

their protein content by increasing nitrogen uptake from the soil or other storage parts of the plant. Henzell and Oxenham (1964) observed that nitrogen uptake by a plant during the growing season or after defoliation increased exponentially. This might be true in the case of the continuously grazed plots.

Crude protein in both grazing treatments increased in the first four weeks of the study period, reached a peak September 20, then gradually declined to their lowest points, November 15 for continuous and November 22 for periodic grazing. The slight rise observed in late November (Table 3) could have resulted from growth initiated by November rains. This pattern of protein content fluctuation in the course of plant development was expected and was supported by the works of Henzell and Oxenham (1964), Pieper et al. (1959) and Cable and Bohning (1959).

Protein content from winter through spring (Study Site B) followed the same pattern as the moisture (Table 3 and Table 2). In the first four weeks, the periodically grazed plants were slightly higher in protein. Later from February through May the process was reversed to the advantage of the continuously grazed plots. Differences, however, were not significant ($P = 0.05$) between treatment means at any sampling date (Table 3). For both grazing treatments, the lowest protein content was recorded in the December-January period and the highest in late April. This agrees with the findings of Cable and Shumway (1966).

In early winter (December-January), the little green forage that was produced was concealed under litter and by taller old growth.

When the cows started to graze the area, they were usually attracted to the regrowth on previously clipped subplots. As this small quantity was harvested, they shifted to adjacent unclipped subplots where they carefully selected the basal growing leaves and culms. This preference was very pronounced in January and February. Since the continuously grazed plots were always accessible to the cows, the selective pressure was greatest there and this may account for the lower protein content of herbage from these plots in December and January.

In the second half of the winter-spring period, protein levels were higher on continuously-grazed plots. This could be due to more regrowth as well as to reduced grazing pressure as green forage became more generally available in the pasture.

Digestibility

The digestibility of Lehmann lovegrass from late summer to fall (Study Site A) was influenced both by the stage of development and by the type of grazing treatments. Like protein the continuously grazed plots were constantly higher in digestibility (Table 4). In both treatments, digestibility slowly increased in the first four weeks, reached a peak on September 20, then gradually decreased until it reached the lowest points in late November. Digestibility values were significantly (P = 0.05) higher for continuous grazing on September 20, October 18 and November 22 (Table 4). For the study period, digestibility averaged 60.4% and 61.3%, respectively, for periodic and continuous grazing.

Table 4. Digestiblity (%) by dates of observation from August 22, 1980 to May 23, 1981.

Late Summer-Fall (Study Site A)			Winter-Spring (Study Site B)		
Sample date	Periodic	Continuous	Sample date	Periodic	Continuous
Aug. 22	61.0	61.8	Dec. 29	48.3	47.6
Sept. 13	62.6	63.0	Jan. 17*	51.0	49.3
Sept. 20*	63.8	65.3	Jan. 24	48.6	48.6
Oct. 18*	60.7	62.3	Feb. 21*	51.8	49.7
Oct. 25	59.6	60.3	Feb. 28	52.7	53.4
Nov. 15	58.4	58.7	Mar. 28*	53.5	56.7
Nov. 22*	56.8	57.8	Apr. 4*	55.0	57.8
			Apr. 25*	54.3	58.7
			May 2*	53.8	56.4
			May 23*	51.6	54.0
Mean*	60.4	61.3	Mean*	52.0	53.2

*Significant differences between means at that date (P=0.05).

Evidently the constantly higher digestibility observed for continuous grazing was due to the presence of new growth. As old material was harvested by the cattle, new growth often started. This was particularly true during the growing season. The result was less lignified material available on the continuously grazed plots.

Like moisture and crude protein, the digestibility of the forage during winter and spring (Study Site B) was higher for periodically grazed plants in the first four to five weeks of the study period (Table 4). The process was reversed afterwards to the advantage of the continuously grazed plots. The same reasons used to explain changes in moisture and crude protein levels apply here. In January and February the periodically grazed plants were significantly higher in digestibility (P = 0.05). In the rest of the study period, digestibility of grass on the continuously grazed plots were significantly higher (P = 0.05) than for the periodically grazed plots at all sampling dates except February 28 when digestibility was about equal in both treatments. For both treatments digestibility was lowest in late December and highest in early or late April (Table 4). The December low coincided with the late fall-winter dormancy and the April high with peak spring growth.

Responses to Clipping Schedules (Study Site C)

Standing Crop

In order to estimate production and standing crop, at the beginning and at the end of the experiment, six subplots were clipped to the ground level. The standing crop August 22, at the beginning of the experiment, was 149.5 $\pm$ 45.6 g/m^2. Regrowth from August 22 to Nov. 15 on these plots averaged (10.5 g/m^2) to bring the total dry matter yield to 160 $\pm$ 45.3 g/m^2. The mean standing crop at the end of the experiment on plots that had not been clipped previously was 155.8 $\pm$ 16.0 g/m^2.

Estimated standing crop for the whole pasture (900 hectares) in July 1980, was 155 g/m^2. These figures give clear evidence that the values for standing crop on the study area were representative of the whole pasture.

It should be noted, though, that much of the standing crop was composed of old material. In the 10-, 20- and the 30-gram rates of herbage removal, much of the dead material was discarded in order to better represent forage as selected by the cows. By November 15, however, there was so little herbage left on plots subjected to the 20- and 30-gram herbage removal rates that they were clipped to ground level. A total standing crop value for the 10-gram removal rate was not obtained because some old and new growth remained on the plots after the 10-gram sample was taken. However, the total amount of herbage taken from the 10-gram plots during the study period was 27.9 g/m^2.

Moisture Content

The moisture content of the 10 gram herbage-removal intensity was significantly the highest (P = 0.05) at all sampling dates. The 20-gram and 30-gram intensities were not significantly different

(Figure 2). Among the three clipping treatments, the moisture content was inversely related to the degree of herbage removal. As more herbage was removed the moisture content declined. This was expected because the most succulent material was taken first and more mature leaves and stems were added to make up the 20- or 30-gram samples. These results agree with those of Pieper et al. (1959) who observed that plant nutrients decreased with heavy herbage removal.

Crude Protein

Protein content followed a pattern similar to moisture content (Figure 2). Again, the crude protein of the 10-gram intensity of herbage removal was significantly the highest ($P = 0.05$) except in September, the first clipping date, when there had been no previous clipping to stimulate regrowth. The 20-gram and the 30-gram intensities of herbage removal were not significantly different.

The study showed that, as the intensity of herbage removal increased, the crude protein decreased. This inverse relationship between forage quality and higher intensities of herbage removal was also observed by Pieper et al. (1959). Obviously, by taking more of the old top growth whether by clipping or grazing, nutritive value of the samples or the diet is reduced. This is particularly true when there is little or no regrowth.

Digestibility

Forage digestibility was significantly different ($P = 0.05$) between the clipping treatments in October and November (Figure 2).

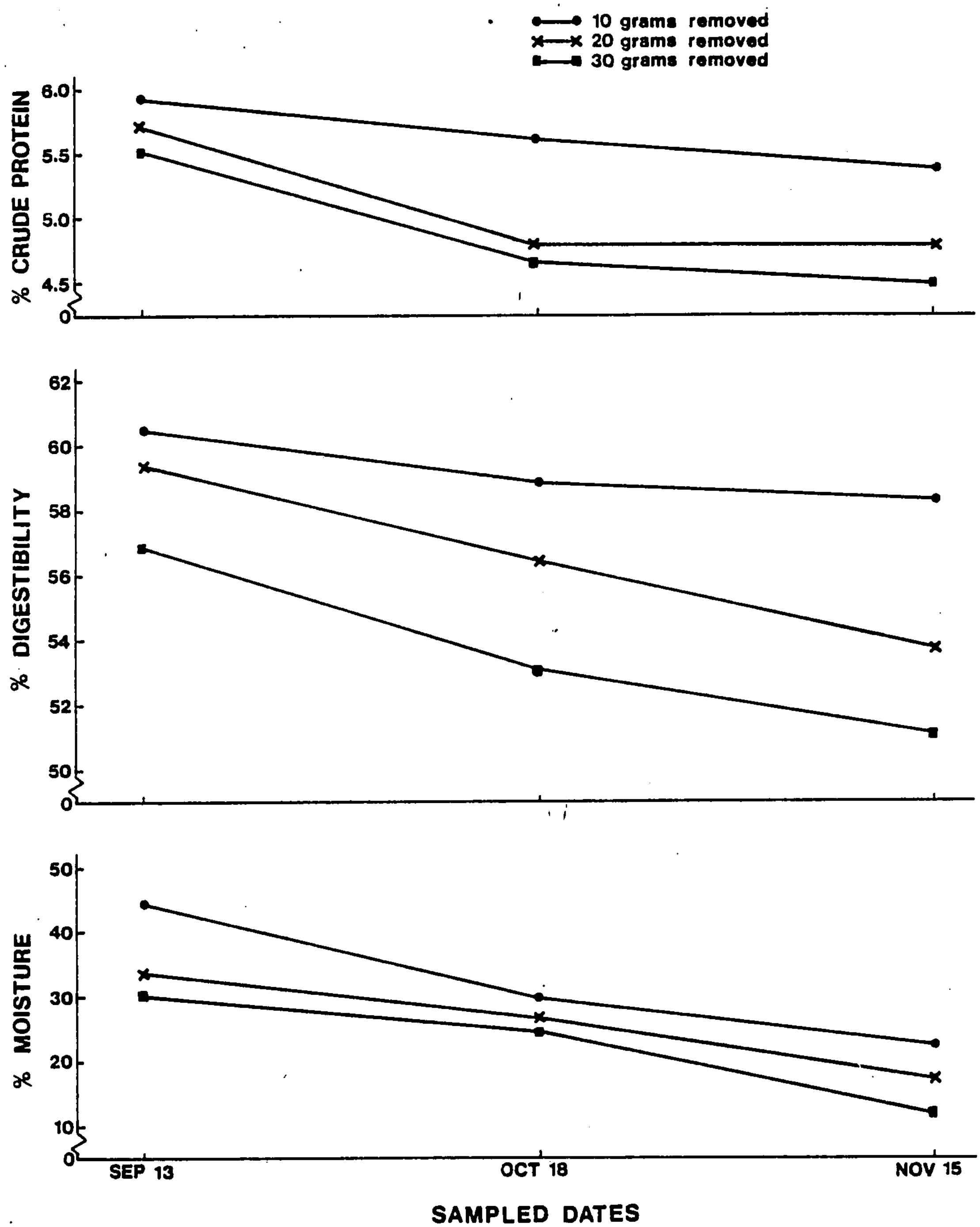

Figure 2. The effect of clipping intensities on forage quality by date of sampling at Study Site C.

In these months the 10-gram intensity was significantly the highest followed by the 20-gram and the 30-gram intensities in a decreasing order of forage digestibility. In September, however, the 30-gram rate was significantly lower than the 10- and 20-gram rates of herbage removal which were not significantly different from each other.

Like crude protein and moisture contents, forage digestibility decreased both with the increase in amount of herbage removed and the plant maturation. As mentioned earlier, forage quality decreased as more and more relatively indigestible and less nutritious material was included, in the samples. This phenomenon was expected and agrees with statements by other investigators like Pieper et al. (1959).

Mean values for moisture content, crude protein and digestibility for the 10-, 20- and 30-gram forage removal rates support earlier statements to the effect that the quality of the diet or the samples is decreased as highly nutritious succulent forages is diluted with older mature or dead material (Table 5).

Samples taken on the last day of the field experiment (November 15, 1980) show the cumulative effects of the various schedules of herbage removal on forage quality (Table 6). The new growth clipped November 15 from plots previously clipped August 22 had significantly the highest moisture, protein and digestibility ($P = 0.05$). Differences among the other treatments were not significant. The second highest quality levels were recorded for the 10-gram intensity followed by the 20-grams intensity. Samples taken November 15 from plots clipped only at the end of the experiment and from the 30-gram intensity plots, ranked lowest in forage quality.

Table 5. Means (for 3 sampling dates) in moisture content, crude protein and digestibility of herbage collected at 3 intensities of clipping.

Herbage Removed Each Date	Moisture Content	Crude Protein	Digestibility
(g/m^2)	(%)	(%)	(%)[1]
10	32.5a	5.6a	59.5a
20	26.3b	5.1b	56.8b
30	22.9b	4.9b	54.0c

1. Means in the same column not followed by a common letter are significantly different (P = .05).

Table 6. Mean values for moisture content, crude protein and digestability for samples collected November 15, 1980, the last sampling date, from plots subjected to different clipping schedules.

Clipping Treatment	Moisture Content	Crude Protein	Diges- ability
	(%)	(%)	(%)
New growth[2]	30.1a[1]	8.7a	61.7a
Clipped only on last sampling date	13.5b	4.0b	53.6b
Take 10 grams each date	23.3b	5.4b	58.5b
Take 20 grams each date[3]	18.3b	4.8b	54.2b
Take 30 grams each date[3]	13.4b	4.5b	51.6b
Mean	19.7b	5.5b	55.9b

1. Means in the same column not followed by a common letter are significantly different (P = .05).

2. All old growth was removed on the first sampling date.

3. These plots were clipped to the ground line on the final dates because the amount of available herbage was less than the scheduled quantity.

CONCLUSIONS

The purpose of this study was to determine changes in moisture content, crude protein and digestibility of Lehmann lovegrass forage from August 22, 1980 to May 23, 1981 under: continuous grazing, periodic grazing and six clipping schedules.

Comparisons between continuous and periodic grazing showed that the standing crop was constantly higher on the periodically grazed plots. This was obviously due to forage accumulation in the three-week rest periods. In the winter-spring period (Study Site B) grazing use was light even on continuously grazed plots from December to February because past use of the area had been extremely light leaving an accumulation of old herbage and because the cows had not become familiar with this part of the pasture.

Crude protein levels were consistantly higher on continuously grazed plots, because grazing stimulated new growth which was higher in nutrient contents and because taller and relatively more mature plant material was not allowed to develop or accumulate. Consequently, the proportion of more nutritious succulent forage (mainly basal leaves and young culms) was increased. This was true, however, only when the plants were actively growing.

During late summer and fall (Study Site A), moisture content, crude protein, and digestibility were the highest in September and declined to their lowest levels in November. Active growth in September was followed by maturity and drying in October and November due to lack of precipitation. As a result, all measures of forage quality declined.

Similarly quality in the winter-spring period (Study Site B) was low in December due to the early winter and late fall drought combined with winter dormancy. With the onset of rains (January-March) quality gradually increased to a peak in March and April. Thus, Lehmann lovegrass responded to both summer and winter-spring rains.

In the clipping study (Study Site C), the standing crop averaged 1500 to 1600 kg/ha. When 10, 20, and 30 grams, respectively, were removed from the available standing crop at monthly intervals, moisture content, crude protein and digestibility decreased with each increase of the amount of forage removal. This is explained by the fact that the clipping procedure was to take the readily available green succulent forage from previously clipped plants first then add enough mature herbage to reach the desired weight of 10, 20 or 30 grams. Hence, the 20- and 30-gram samples contained relatively more of the low value dry herbage.

The results of these studies suggest that forage quality and quantity are inversely related. The reason for this apparent relationship is that high standing crop values in this study were always composed largely of over-mature or dead herbage and the high-quality low yields were made up mainly of regrowth from plots that had been previously clipped or grazed. Lack of either quantity or quality may limit livestock production. However, since animals are known to enhance the nutrient level of their diets by selective grazing (when there is enough to select from), quantity is more often the limiting factor. Therefore, in my opinion, the best range management practice may be the one that ensures adequate forage quantity.

In this study, three-week's rest out of four (periodic grazing) and the clipping level of (10 g/m^2 herbage removal per month), seem to meet this requirement. This is only preliminary, however, and much more research is needed to develop efficient grazing systems and utilization standards for pure stands of Lehmann lovegrass.

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