STUDIES OF THE DIGESTIBILITY AND NUTRITIVE VALUE OF MIDLAND BERMUDA-GRASS DURING DIFFERENT SEASONS OF THE YEAR

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INTRODUCTION

Bermuda-grass pasture has increased in Oklahoma due to the conversion of marginal farmland to improved pastures. It has been utilized on such land as the major forage and hay crop because of its high yield and favorable response to added fertilizer which results in increased carrying capacity. Although Bermuda-grass thrives best in high rainfall areas it has become popular in sections of Oklahoma once thought to be too dry for Bermuda-grass.

Due to the increase in acreage, attention has been focused on the use of Bermuda-grass as a winter pasture for beef cattle. Studies have been conducted with steers on Bermuda but little work has been reported on requirements of beef cows grazing the dry winter grass. The cow-calf system of beef production is the most predominant system in sections of Oklahoma best suited to Bermuda-grass and it is in this type of system that information on the supplementation of Bermuda-grass during the winter months is lacking.

Management of beef cattle allowed to graze Bermuda-grass pastures yearlong presents feeding problems since Bermuda, although adequate for maintenance and growth of cattle during the spring and early summer months, steadily declines in nutritive value in late summer and fall. Since the plane of nutrition for pregnant cows during the winter is important to subsequent calf performance, information concerning the proper amount and kind of supplement for wintering pregnant beef cows on Bermuda-grass is greatly needed.

The digestion and grazing trials reported herein were initiated to determine the nutritive value of Bermuda-grass at different times during the grazing period and to determine the kind (i.e. protein or energy) and amounts of supplements required by beef cows grazing dry Bermuda-grass during the late summer, fall, and winter months.

LITERATURE REVIEW

Bermuda-grass is increasing in popularity throughout Oklahoma and has become one of the major hay and forage crops on improved pastures. Extensive research has been conducted on fertilization rates, clipping response, stocking rates and the effect of these on nutrient composition, palatability, digestibility and daily gain during the growing season. However, little information can be found in the literature on the use of dry Bermuda-grass as a winter forage.

EFFECT OF FERTILIZATION AND CLIPPING INTERVAL ON COMPOSITION AND NUTRITIVE VALUE

Good management practices have been shown to have a large effect on the success of a Bermuda-grass program. The clipping interval and application of nitrogen are considered to be the most important requisites of good management.

Holt _et al_. (1951) noted that proper fertilization improved yield and chemical composition. It was also found that protein content decreased with the age of the plant and may drop below minimum requirements for grazing animals when the plant matures.

Cutting interval of hay will vary with certain conditions such as personal preference , soil, location, and variety of Bermuda-grass. Woodle (1955) studied the effect of clipping at frequencies of 2, 3, 4, 6, and 8 weeks on Coastal Bermuda-grass hay. He noted that the average protein content of Coastal hay fertilized with 300 lbs. of nitrogen at the above weekly intervals was 17.4, 16.6, 15.2, 11.3, and 10.3 percent, respectively. Hay yields ranged from 5.6 tons per acre at the 2 week clipping to 10.7 tons at 8 weeks.

Burton et al. (1955) investigated the effect of nitrogen and age of growth upon the palatability of Coastal Bermuda-grass. Ammonium nitrate was applied at rates from 0 to 1,500 lbs. per acre with adequate amounts of phosphorus and potash. Grass was clipped at 2 and 4 week intervals so that this age forage was available for each palatability test period. Results of this work revealed that as the nitrogen rate increased from 0 to 1,500 lbs. per acre forage consumption increased. This indicated that palatability was not reduced by the heavier rates of nitrogen. The protein content, moisture content, and yield increased with increasing increments of nitrogen up to 1,500 lbs. When rainfall allowed for appreciable difference in yield, cattle showed significant preference for the younger forage.

Knox et al. (1957) noted that lignin content increased with clipping interval and nitrogen application. Treatments of 0, 100, 300, 600, and 900 lbs. of nitrogen per acre and harvest intervals of 2, 3, 4, 6, and 8 weeks affected both lignin content and nutrient composition of Coastal Bermuda-grass hay. The crude protein content of Coastal hay, treated with 600 lbs. of nitrogen per acre, decreased from 20.63 to 9.94 percent when the clipping interval was increased from 2 to 8 weeks. Crude fiber and N.F.E. increased from 22.22 to 27.00 and 42.11 to 50.93 percent, respectively.

Utilizing nitrogen rates from 0 to 900 lbs. per acre and clipping intervals of 2, 3, 4, 6, and 8 weeks, Prine et al. (1956) found that generally, increases in nitrogen rate increased the hay yield, protein percentage, protein yield, and nitrate content of Coastal Bermuda-grass. Increasing the clipping interval had little effect on nitrate content, protein yield, and percent nitrogen recovery but increased the yield and lowered the protein percentage.

Fisher and Caldwell (1959) compared the effects of adding 0 to 1,800 lbs. of nitrogen per acre on yield and quality of Coastal Bermuda-grass. Crude protein (dry matter basis) increased from 7.9 percent, with no fertilizer, to 14.1 percent with 1,800 lbs. Moisture, fiber, and ash increased, though somewhat erratic, while N.F.E. decreased, as nitrogen application was increased.

Hoveland (1960), Alexander _et al_. (1961), McCullough and Burton (1962), Patterson _et al_. (1963) and Smith _et al_. (1963) also reported that palatability, protein, and yield of Coastal Bermuda-grass were all improved by nitrogen fertilization and clipping.

Another advantage of fertilization was reported by Spooner and Clary (1962). They found a residual nitrogen carry over in the soil after applying fertilizer at rates of 0, 50, 100, and 200 lbs. nitrogen per acre annually over a three year period. It was noted that T.D.N. increased significantly from year to year especially at the 200 lb. treatment level. In 1959, 1960, and 1961 T.D.N. was calculated as 2,187; 2,929, and 3,029 lbs. per acre, respectively.

FEEDING TRIALS

Numerous trials have been conducted on the effect of physical form and composition of Bermuda-grass hay on palatability and steer gains. Two feeding trials were conducted by McCormick _et al_. (1957) to compare Coastal Bermuda-grass hay and silage as roughages for fattening yearling steers. Two different concentrate mixtures were fed with each form of roughage. Results showed the two roughages to be comparable in feeding value when considered on a dry matter basis. Crude protein content of the two forages was 9.04 and 8.37 percent for the hay and silage, respectively.

Miller (1960) compared the effect of physical form of Coastal Bermuda-grass hay on gain of dairy calves. The hay, along with a low, medium, and high level of concentrate, was fed finely chopped and pelleted after being harvested at 3 weeks of age. Calves fed the pelleted hay gained one-third of a pound per day more than those fed chopped hay. The lowest rate of gain was approximately 2 lbs. per day on the low concentrate, chopped hay ration.

Hogan et al. (1962) investigated effects of various physical forms of Coastal Bermuda-grass on daily gain. Fifty steers were subjected to 4 treatments utilizing Coastal as soilage, artificially dried hay, pellets and forage. Average daily gains for the first 60 days of the test period were 1.03 lbs. for soilage; 1.05 lbs. for hay; 1.37 lbs. for grazing; and 2.08 lbs. for pellets. Gains reported for the full 100 day period were 0.60 lbs. per day for the grazing treatment and 2.07 lbs. for the pellets. No figures were given for the soilage and hay treatments at the end of the 100 day treatment period.

Twenty-four lactating first calf heifers were fed in dry lot for 126 days of various treatments of Coastal Bermuda-grass hay (ad libitum) supplemented with minerals (Alexander and Hentges, 1962). The hay was treated as follows: hay fertilized with 100 lbs. of nitrogen per acre and fed in long form; hay fertilized with 200 lbs. of nitrogen per acre and fed in both long and finely ground form. These workers reported an average weight loss of 0.6 to 0.7 lbs. per day by the lactating cows but the calves nursing these cows gained from 0.7 to 1.0 lb. per day. The cows fed ground hay from the 200 lb. nitrogen fertilized treatment lost less weight, produced larger calves, and consumed more dry matter than cows fed the long hay with the same treatment.

Bermuda-grass has commonly been criticized because of its lack of palatability. In a palatability trial comparing Coastal Bermuda-grass with alfalfa hay, Hammes et al. (1962) reported that the average dry matter consumed by steers was 2.20 lbs. per cwt. of alfalfa and 1.55 lbs. per cwt. of Coastal. When the hays were fed together the average dry matter consumption was 2.2 lbs. of alfalfa and 0.4 lbs. of Coastal Bermuda.

GRAZING TRIALS

Bermuda-grass has good potential as a forage and can withstand heavy grazing if it is well established and properly managed. It has been noted that livestock will gain on Bermuda-grass until mid-summer when there is a sharp decline in daily gains. Davis (1959) demonstrated that average daily gains of steers on Common Bermuda-grass were high in April and May but dropped sharply in June and July to almost no gain and steers lost weight in some cases from July to October.

Elder and Murphy (1961) found that 70 percent of the average increase in animal weights was from April, May, and June on fertilized pastures and that steers on non-fertilized pasture made 65 percent of their total weight gains by July 1. When cows and calves were placed on Midland Bermuda-grass for 200 days beginning in April they observed that the calves gained best in the spring but their summer weight gains were higher than for yearling steers. Cow weight gains were closely correlated with steer gains on Bermuda pasture during the grazing season.

Gains of steers grazing different varieties of Bermuda-grass may vary a great deal. Godbey et al. (1959) compared daily gains on well fertilized Common and Coastal Bermuda plots from April to October and found that average daily gain per steer was 1.48 lbs. on Common compared with 1.38 lbs. per day on Coastal. Although daily gain was lower on the Coastal Bermuda it produced more beef per acre than Common due to greater carrying capacity.

Hoveland (1960) and Spooner and Clary (1960) found Coastal to be more desirable than Common for grazing steers but average daily gains on Coastal were low averaging from 0.80 to 1.25 lbs. per day. Beef gains on differentially fertilized pastures was investigated by Suman et al. (1961) who reported that with adequate fertilization average daily gains on Common and Coastal Bermuda-grass were 1.39 and 1.33 lbs., respectively. Hogan et al. (1962) reported 1.37 lbs. average daily gain per steer on Coastal from June to October.

Little work has been conducted on grazing dry winter Bermuda-grass. There have been some indications that this dry grass could be utilized as roughage during the winter months. Woodle (1954) stated that beef cattle readily eat and do well on frosted Coastal Bermuda-grass until about Christmas. Elder and Murphy (1961) studied the effect of wintering steers on dry Midland Bermuda-grass and reported that on a two year trial steers gained from 35 lbs. per season (140 days) to 62 lbs. per season (124 days). Beginning in November Ray et al. (1962) initiated a wintering study, using ninety steers, on pasture consisting mainly of mature dry Bermuda-grass. The steers received 1.11 lbs. of cottonseed meal per head daily for 56 days and were then raised to 2.22 lbs. daily after showing signs of protein deficiency. Average gain per steer for the 126 day wintering period was 1.0 lb.

Brown et al. (1963) compared the effect of various supplements on the utilization of Coastal Bermuda pasture during the growing season and reported that there was no true supplemental effects of protein, energy, or minerals on gain of steers. The average grazing season was 129 days and average daily gain was from 1.02 to 1.31 lbs. per day.

CHEMICAL COMPOSITION AND DIGESTIBILITY

Chemical composition of Bermuda-grass varies with maturity and fertilization. If the grass is allowed to mature it gets tough and wiry and the protein percentage decreases along with its palatability and nutritive value. Crude protein content of Midland, Coastal, and Common Bermuda-grass was checked at three different dates, May 31, July 18, and January 26 by Harlan et al. (1954). Midland was found to have crude protein contents, for respective dates, of 14.50, 11.75, and 7.38 percent. Coastal averaged 15.94, 11.31, and 6.94 percent and Common averaged 16.25, 12.38, and 7.31 percent, respectively.

As previously mentioned the nutritive value of Bermuda-grass declines sharply from about July to October even though growth is abundant. Why livestock generally gain poorly and sometimes lose weight during these months is not known.

Numerous digestion trials have been conducted to determine nutritive value and digestibility of hay and silage but little work has been done with the green grass or dry weathered grass. In a digestion trial, utilizing sheep as test animals, Knox et al. (1957) reported that digestibility of Coastal Bermuda-grass decreased as length of clipping period increased. He suggested that clipping at 6 week intervals gives optimum digestibility of Coastal hay. Digestion coefficients (percent) for hay harvested at six and eight weeks were: dry matter, 66.49 and 59.14; protein, 70.99 and 63.38; ether extract, 64.19 and 55.19; fiber, 66.00 and 58.94; N.F.E., 67.57 and 60.56; T.D.N., 67.24 and 59.07. Coastal hay was also used in steer digestion trials by McCormick et al. (1957) who reported the following digestion coefficients: organic matter, 50.35 percent; protein, 46.80 percent; ether extract, 17.80 percent; and cellulose, 57.50 percent.

Alexander et al. (1961) investigated the digestibility of Coastal Bermuda hay at various levels of fertilization and two different cutting intervals using sheep as experimental animals. Digestion coefficients for hay which had been treated with 100 lbs. of nitrogen and cut before frost were as follows: protein, 63.4 percent; crude fiber, 60.4 percent; ether extract, 52.3 percent; N.F.E., 58.7 percent; and T.D.N., 58.4 percent. Hay which also had been treated with 100 lbs. of nitrogen but cut following frost yielded digestion coefficients as follows: protein, 57.3 percent; crude fiber, 59.9 percent; ether extract, 58.3 percent; N.F.E., 60.4 percent; and T. D. N., 59.0 percent.

Hammes et al. (1962) studied the digestibility of Coastal and alfalfa hay utilizing the conventional digestion trial in which both hays were fed to eight steers for a ten day preliminary period and a seven day collection period. Results of this study showed that Coastal hay was comparable to alfalfa hay in T.D.N. with Coastal averaging 55.0 percent and alfalfa 57.8 percent T.D.N.

Information is greatly lacking on the digestibility of fresh green Bermuda-grass forage. Beardsley et al. (1961) used five steers in digestion stalls to determine nutrient digestibility of fresh, 5 week old Coastal Bermuda-grass. Feces was collected for a 7 day period at 4 week intervals. Dry matter digestion coefficients for the 5 collection periods were 59.3, 57.8, 58.6, 59.8, and 59.7 percent. Average digestion coefficients for all periods were: crude protein, 71.0 percent; ether extract, 46.0 percent; cellulose, 67.0 percent; lignin, 12.0 percent; other carbohydrates, 65.0 percent; and T.D.N., 59.0 percent.

Alexander *et al.* (1962) investigated the difference in digestibility of nutrients by cattle and sheep by feeding seventeen different rations including two silages, and Bermuda-grass pellets and long hay for comparison. Environmental conditions were maintained equally for all animals on trial. Results showed there was no significant difference between sheep and cattle with regard to digestibility of nutrients.

In recent years *in vitro*, or artificial rumen techniques have been used successfully in forage evaluation studies. Despite considerable variation in the methods used in the *in vitro* fermentation trials the results compare very well with those obtained through the use of *in vivo* procedures. LeFevre and Kamstra (1960) compared digestibility of cellulose in 22 rations by *in vivo* (conventional digestion trial) and *in vitro* methods. The 48-hour *in vitro* fermentations yielded cellulose digestion coefficients similar to the values obtained *in vivo*. Digestion coefficients for the artificial rumen averaged 50.2 percent with sheep inoculum and 49.6 percent with steer inoculum. Cellulose digestibility *in vivo* averaged 45.9 percent. Salsbury *et al.* (1958), Donefer *et al.* (1959), Quicke and Bentley (1959), Kuhlman (1963), to name only a few, also used the disappearance of cellulose as a measure of forage digestibility.

Another common *in vitro* method currently in use for forage digestibility determination is dry matter disappearance. Reid *et al.* (1959) conducted concurrent *in vitro* and *in vivo* digestibility trials in studies with grass hays to establish a quantitative relationship between digestion coefficients for dry matter, cellulose, crude fiber, and protein. They reported that *in vivo* digestibility was most accurately predicted from *in vitro* dry matter digestibility of oven dried samples. Walker (1959) found dry matter digestibilities *in vitro* for various grass hays to range from 37.2 to 57.3 percent. Baumgardt and Hill (1956), Church and Peterson (1960), Clark and Mott (1960), and Hogan (1963) also used dry matter disappearance in the artificial rumen as a method of evaluating forage crops.

EXPERIMENTAL PROCEDURE

In Vivo and *In Vitro* Digestion Trials

A pure stand of Midland Bermuda-grass was selected as the source of grass to be used in this study. The grass, which had been fertilized in July with 60 lbs. of nitrogen per acre, was clipped in August, November, and February.

Ten grade, cross-bred, wether lambs averaging 7 months of age were purchased from the Oklahoma City Stockyards or the Fort Reno Experiment Station prior to each trial. A different group of lambs was used in each study so as to be approximately the same age and weight at the beginning of each trial. It was felt that this procedure would result in less between trial variation in animals than if the same lambs were used in all trials. However, Blaxter (1962) stated that these and other factors are of little consequence in digestion studies.

Two weeks prior to the initiation of Trial 1 the lambs were drenched with 2 oz. of phenothiazine. At the end of the two week period they were placed in digestion stalls (described by Briggs and Gallup, 1949) for a 5 day adjustment period, followed by a 10 day preliminary and a 7 day total collection period. The lambs were fed freshly clipped Bermuda-grass (*ad libitum*) twice daily with free access to water and a mineral mixture composed of two parts salt and one part steamed bone meal. A 100 gm. sample of grass was taken at each clipping and placed in a forced draft oven (90°C.) for 48 hours to determine percent dry matter.

Refusals were collected from the previous feeding and treated in a similar manner as the feed. Feces and urine were collected and prepared for analysis as described by Tillman and Swift (1953). Cellulose and proximate analysis of feed, feces, and urine were determined by the methods of Crampton and Maynard (1938) and A.O.A.C. (1960), respectively. Composition of the grass samples fed are shown in Table I.

The procedure used in Trials 2 and 3 were the same as in Trial I with the exception that the dead grass was clipped once daily. Also, due to inclement weather and accessibility, the plot of grass used in Trial 1 was reclipped for Trial 3 resulting in younger forage being fed for this experiment than in Trial 2 (Table I). One lamb was removed from Trial 3 due to urinary calculi.

Dry matter and cellulose digestibilities were also determined using the artificial rumen technique outlined by Kuhlman (1963). The rumen fluid used as inoculum was obtained from an Angus steer fitted with a permanent rumen fistula. The steer was maintained on mature, weathered, Bermuda-grass hay (<u>ad libitum</u>) in an attempt to feed a diet similar to that being tested in the artificial rumen.

In each of the five <u>in vitro</u> trials rumen fluid was collected at approximately the same time of day and placed in a thermos jug prewarmed to 39°C. The fluid was strained twice through 8 layers of cheesecloth and added to the fermentation vessels which contained the forage sample and nutrient solution. The nutrient solution, shown in Table II, was that described and used by Kuhlman (1963).

Residual cellulose determinations were made following the procedure outlined by Crampton and Maynard (1938). Analysis of variance and orthogonal comparisons were employed to analyze the results of this experiment.

TABLE I

PROXIMATE COMPOSITION OF MIDLAND BERMUDA-GRASS USED IN DIGESTIBILITY STUDIES

	Percent, Dry Matter Basis					
	Dry Matter	Crude Protein	Ash	Ether Extract	Crude Fiber	N.F.E.
Trial 1	28.18	15.73	7.97	2.93	25.47	47.89
Trial 2	77.38	4.14	5.32	1.11	30.42	59.01
Trial 3	84.25	9.73	6.29	1.10	29.76	53.13

TABLE II

COMPOSITION OF NUTRIENT SOLUTION

Ingredient	Grams per liter
Na_2HPO_4	0.631
KH_2PO_4	0.303
$NaHCO_3$	5.250
KCL	0.750
NaCL	0.750
$MgSO_4$	0.225
$CaCL_2$	0.075
$FeSO_4 \cdot 7H_2O$	0.015
$MnSO_4$	0.008
$ZnSO_4 \cdot 7H_2O$	0.008
$CuSO_4 \cdot 5H_2O$	0.004
$CoCL_2 \cdot 6H_2O$	0.002
Urea	2.000

Grazing Trial

A pilot trial was initiated November 7, 1963 at the Agronomy Research Station near Perkins, Oklahoma to study the supplemental feed requirements of spring-calving beef cows wintered on dry Bermuda-grass pasture. Effects of energy and protein supplements on cow weights, and on birth weights and gains of calves were compared.

Twenty, high quality, grade Hereford cows approximately 4 years of age were selected from the experimental herd at the Fort Reno Experiment Station. These cows, bred to calve in late February or March, were divided into two uniform lots of 10 each on the basis of weight and condition. The cows were started on test November 7, 1963 and allowed to graze 3 acres of Bermuda-grass pasture per lot until January 1, 1964 (Pasture 1). The pastures consisted of approximately equal amounts of Common, Midland, and Greenfield varieties of Bermuda-grass. On January 1, the cows were moved a short distance to a 5 acre pasture (Pasture 2) divided into 2-2.5 acre plots. Forage in these plots consisted of a pure stand of Midland Bermuda-grass. Samples of grasses were taken at the initiation of grazing of the respective pastures for chemical analysis. Chemical composition data are shown in Table III. None of the pastures were fertilized, clipped, or grazed during the growing season.

Cows in Lot 1 were fed 2 lbs. of cottonseed cake per head daily and Lot 2 cows were fed 2 lbs. of crimped milo per head daily. Supplements were fed in bunks every other day in twice the daily amounts. All cattle had access to a mineral mixture of two parts salt and one part steamed bone meal. Lots 1 and 2 were rotated between pasture plots at monthly

TABLE III

PROXIMATE COMPOSITION OF BERMUDA-GRASS UTILIZED DURING GRAZING TRIAL

		Percent, Dry Matter Basis				
	Date of Sampling	Crude Protein	Ash	Ether Extract	Crude Fiber	N.F.E.
Pasture 1						
Midland	11-7-63	4.28	5.66	1.98	32.07	56.01
Common	11-7-63	4.79	5.52	1.84	29.45	58.40
Midland	12-30-63	2.88	4.45	1.90	32.99	57.88
Greenfield	12-30-63	3.28	5.37	1.88	29.68	59.79
Pasture 2						
Midland	2-17-64	3.07	5.69	1.67	31.54	58.03

intervals. On January 16 all cows were injected with one million international units of Vitamin A.

By February 17, the grass had been grazed excessively heavy so it became necessary to provide additional feed in order to carry the cows until spring. Approximately 8 lbs. per head daily of Bermuda-grass hay was fed to each lot. This amount was increased on March 18, to 16 lbs. per head daily.

Birth weights of calves were recorded beginning in early March with the onset of calving. Sixteen of the twenty cows calved during this month. Supplemental feeding of the cows was stopped when green grass became available in the spring (first of April). Cows and calves were transported at this time to the Agronomy Research Station at Heavener, Oklahoma and allowed to graze mixed Bermuda-legume pasture for the duration of the grazing season.

Weights of cows and calves were recorded at monthly intervals. Milk production records were obtained on all cows on June 9, and July 8, by the method reported by Drewry et al. (1959), and Dawson et al. (1960). The data were analyzed statistically by analysis of variance.

RESULTS AND DISCUSSION

Digestion Trials

IN VIVO: The proximate composition of Midland Bermuda-grass used in the three lamb digestion trials is presented in Table I. As previously mentioned the grass fed in Trial 3 was approximately six weeks younger than the grass fed in Trial 2. The crude protein content of the Trial I (August) grass was 11.59 percentage units greater than in Trial 2 (November) grass and 6.00 percentage units greater than in the grass fed during Trial 3 (February). Differences in grass composition for N.F.E. content were approximately the same but Trial 1 was 11.12 percentage units less than Trial 2 and 5.88 percentage units less than Trial 3. Crude fiber differences were smaller with Trial 1 having 1.29 and 4.95 percentage units less than Trials 2 and 3, respectively. These data are in agreement with those reported by other workers (Holt et al., 1951; Harlan et al., 1954; Knox et al., 1957; Alexander et al., 1961).

Average initial lamb weights, daily feed consumptions, apparent digestion coefficients, and nitrogen balance data are reported in Table IV. The digestibility of dry matter, organic matter, crude protein, crude fiber, ether extract, N.F.E., cellulose, and T.D.N. content of the forage fed in Trial 1 was significantly greater than that of the grass fed in Trials 2 and 3 ($P<.01$) as determined by orthogonal comparisons. These digestion coefficients were also higher ($P<.01$)

TABLE IV

IN VIVO APPARENT DIGESTION COEFFICIENTS OF MIDLAND BERMUDA-GRASS

Trial No.	1	2	3
Clipping Date	AUGUST	NOVEMBER	FEBRUARY
Number of Animals	10	10	9
Ave. Weight, lb.	85.0	70.1	79.1
Ave. Daily Feed, gm.[a]	640.1	332.7	466.6
Digestibility, %			
Dry Matter[b]	60.1± .63[c]	31.9±1.26	42.4±1.75
Organic Matter[b]	62.2± .61	34.7±1.29	45.6±1.61
Crude Protein[b]	73.0± .55	-1.9±1.92	50.4±3.06
Crude Fiber[b]	65.4± .87	37.0±1.58	48.0±1.73
Ether Extract[b]	40.8±1.37	1.0±1.95	11.6±2.84
N-Free Extract[b]	58.2± .60	36.8±1.23	44.0±1.62
Cellulose[b]	64.0± .79	40.4±1.59	47.4±1.59
T.D.N.[b]	58.8± .59	32.9±1.25	42.9±1.54
Nitrogen Balance			
Nitrogen Intake, gm.	16.20	2.18	7.27
Nitrogen Retained, gm.	1.46±.30	-2.47±.09	-.67±.27
Nitrogen Balance[b], %	9.01	-113.30	-9.20

[a] Dry Matter Basis.

[b] Trial 1 significantly different from Trials 2 and 3 ($P<.01$), and Trial 2 significantly different from Trial 3 ($P<.01$), as determined by Orthogonal comparisons.

[c] Standard Error of the Mean.

in Trial 3 than in Trial 2. The digestibility of dry matter, crude protein, cellulose, and the T.D.N. content of the grass fed in Trial 1 is in close agreement with the digestibility data reported for Coastal Bermuda-grass by Beardsley et al. (1961). Digestion coefficients for grass fed during Trials 2 and 3 are similar to those reported for Bermuda-grass hay of poor to good quality (McCormick et al., 1957; Ray et al., 1962).

Since the grass fed in Trial 2 was approximately 2 months older than that in Trial 1 the data indicate that digestibility decreased as the age of the grass increased. This trend is supported by the work of Burton et al. (1955), Prine et al. (1956), Knox et al. (1957), and Harris et al. (1962). Digestion coefficients averaged approximately 10 percentage units higher for Trial 3 than Trial 2, even though the grass in Trial 3 had been weathered for an additional two months. This difference may be due to the higher crude protein content of the grass in Trial 3 (Table I). A relationship between dry matter digestibility and crude protein content of forages was reported by Gallup and Briggs (1948) and Burroughs and Gerlaugh (1949). These workers stated that crude protein content of six to eight percent was necessary for maximum utilization of the ration. The protein, or nitrogen, content of winter Bermuda-grass appears to be the most critical constituent in determining its nutritive value to livestock during the fall and winter months. As shown in Table IV nitrogen intake for Trials 2 and 3 was 2.18 gms. and 7.27 gms., respectively. Intake of nitrogen for Trial 3 appeared adequate but was extremely low for Trial 2 and would be considered by most workers to be inadequate for maximum activity of rumen bacteria. It has been shown that bacterial action is depressed, thus limiting breakdown of all ration constituents, when the protein content of high roughage rations is low (Mitchell, 1942; Maynard and Loosli, 1956; Holter and Reid, 1959).

According to these data a 1000 lb. pregnant beef cow would have to consume 22-24 lbs. (6-8 lbs.dry matter) of the August grass to meet the daily digestible protein requirements for maintenance (Morrison, 1956). Grass such as that clipped in November would not meet the protein requirement and the entire digestible protein requirement would have to be furnished by supplemental feed. However, grass from pastures mowed later in the growing season so that the grass is younger at the start of the winter season, such as that fed in Trial 3, could theoretically meet the digestible protein requirement if the cow ate 18-20 lbs. (14-16 lbs. dry matter) of grass per day.

Minimum total digestible nutrient (T.D.N.) requirements for a 1000 lb. pregnant beef cow, grazing forage such as that clipped for Trial 1, would be met by the consumption of 46 lbs. (13 lbs. dry matter) of the grass daily. If the grass were similar to that fed in Trials 2 and 3 the cow would need to consume 30 lbs. (23 lbs. dry matter) and 21 lbs. (18 lbs. dry matter), respectively, to meet daily T.D.N. requirements.

These data indicate that grass comparable to that fed in Trials 1 and 3 would theoretically be sufficient to meet daily T.D.N. requirements for maintenance. However, a grass such as that used in Trial 3 needs to be supplemented with a high protein feed such as cottonseed meal to meet the digestible protein requirements for maintenance. Although daily T.D.N. requirements could be easily met with the Trial 2 grass a source of protein supplement would be necessary to meet the maintenance requirements for protein for a 1000 lbs. pregnant beef cow.

IN VITRO: The digestibility of dry matter and cellulose for the grass fed in the three digestion trials are shown in Table V. Digestion coefficients for dry matter and cellulose in the grass fed in Trial 1 were significantly greater ($P<.01$) than for those from grass fed in Trials 2 and 3, as shown by orthogonal comparisons. Furthermore, the digestion coefficient for cellulose in grass fed in Trial 3 was significantly greater ($P<.01$) than for that fed in Trial 2. All digestion coefficients obtained by the *in vitro* procedure were consistently lower than those determined in the sheep digestion trials. Kuhlman (1963) also reported lower digestion coefficients with the *in vitro* technique compared with *in vivo* digestibility data. However, a correlation of means of 0.98 and 0.95 was found between the two methods for determining digestibility of cellulose and dry matter, respectively. These correlations suggest that digestion coefficients obtained by this *in vitro* technique may be used to estimate dry matter and cellulose digestibility in Bermuda-grass. High correlations between the two procedures have been reported by many workers (Asplund *et al.*, 1958; Baumgardt *et al.*, 1958; Hershberger *et al.*, 1959; Bowden and Church, 1962b).

Intra class correlations for *in vitro* cellulose and dry matter digestibilities were 0.97 and 0.91, respectively, which are indicative of the high repeatability of this technique.

Grazing Trial

A summary of wintering data, calving performance, and winter supplementation is given in Table VI. Since three cows calved late in

TABLE V

IN VITRO DIGESTIBILITY OF DRY MATTER AND CELLULOSE IN BERMUDA-GRASS FORAGE

	DRY MATTER DIGESTIBILITY[a] (%)			CELLULOSE DIGESTIBILITY[b] (%)		
Run No.	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
1	42.50	26.76	28.93	57.02	21.63	27.37
2	45.26	29.38	29.90	55.95	25.03	27.49
3	50.17	32.95	33.06	60.10	28.85	30.20
4	45.66	26.95	28.01	61.66	31.11	32.77
5	43.14	26.18	26.89	61.44	26.76	31.87
$\bar{X}$	45.35±1.35[c]	28.44±1.25	29.36±1.02	59.23±1.17	26.68±1.62	29.94±1.10

[a] Trial 1 significantly different from Trials 2 and 3 ($P < .01$).
[b] Trial 1 significantly different from Trials 2 and 3 ($P < .01$). Trial 2 significantly different from Trial 3 ($P < .01$).
[c] Standard Error of the Mean.

TABLE VI

EFFECT OF WINTER SUPPLEMENT ON THE PERFORMANCE OF SPRING CALVING BEEF COWS GRAZING DRY BERMUDA-GRASS

Lot No. Supplement	Lot 1 2lbs. C.S.C./Day	Lot 2 2 lbs. Milo/Day
No. Cows per lot[a]	9	10
Average Weights, lbs.[b]		
Initial (11-7-63)	856	869
Spring (11-7-63 to 4-6-64)	744	709
Winter Weight Loss (11-7-63 to 4-6-64)	112	160[c]
Average Gain (11-7-63 to 7-1-64)	-35	-35
(1964) Calving Performance		
No. of cows calving	9	10
Average Birth Date	3/18	3/26
Average Birth Weight, lb.[d]	64	65
Average Gain to July 1, lb.	152	154
Average Daily Gain to July 1, lb.	1.81	1.77
Supplemental Feed/Cow, lb.		
Cottonseed Cake	316	
Crimped Milo		316
Bermuda Hay[e]	504	504
Mineral[f]	198	63

[a] One cow aborted and was taken off trial in Lot 1.
[b] Only data from cows calving in March are included in cow weight changes (9 in Lot 1 and 7 in Lot 2).
[c] Lot 2 significantly greater than Lot 1 ($P < .05$).
[d] Corrected for sex by the addition of 4 lbs. to the birth weight of each heifer.
[e] Both Lots were supplemented with 8 lbs. of Bermuda hay per head daily in February and 16 lbs. per head daily in March.
[f] 2 parts salt, 1 part bonemeal.

the season, the cow data are based only on those that calved during the month of March.

The cows in Lot 1 supplemented with 2 lbs. of cottonseed cake per head daily lost significantly less weight ($P<.05$) through calving than those in Lot 2 supplemented with 2 lbs. of milo per head daily (112 lbs. and 160 lbs., for Lots 1 and 2, respectively). Average adjusted birth weights were approximately the same for calves in both lots. Average weight gains for calves through July 1 were 152 and 154 lbs. for Lots 1 and 2, respectively. Total weight losses averaged 35 lbs. for cows in both lots. Although cows in Lot 2 lost more weight through calving, they regained a larger percent of their winter weight loss by July 1 than did the cows in Lot 1.

Since winter weight losses were less in Lot 1 than in Lot 2, indications are that a protein supplement was more effective as a winter supplement than an energy supplement for wintering pregnant beef cows grazing low quality Bermuda-grass forage (Table III). A possible explanation is that the total protein content in the diet of Lot 1 cows was sufficient to permit proper utilization of nutrients, whereas, in the Lot 2 diet rumen bacterial activity was reduced due to an insufficient nitrogen supply (Table III). This has been observed by other workers (Gallup and Briggs, 1948; Burroughs and Gerlaugh, 1949; Holter and Reid, 1959). It appeared that cows in Lot 1 grazed more than the Lot 2 cows, indicating an effect of protein upon appetite. Furthermore, cows in Lot 1 ate approximately three times as much mineral mixture as those in Lot 2 (Table VI).

Table VII gives a summary of the milk production date obtained in

June and July. This summary includes all the cows on the test which raised calves regardless of calving date. The first milk production estimates were obtained on June 9, about 85 days following the average calving dates for the two lots. At this time an average of 8.5 lbs. of milk per cow was recorded for Lot 1 and 8.6 lbs. for Lot 2. The yield decreased noticeably on July 8 when an average of 6.6 and 7.3 lbs. was obtained for Lots 1 and 2, respectively.

TABLE VII

ESTIMATES OF MILK PRODUCTION OF SPRING CALVING BEEF COWS GRAZING DRY BERMUDA-GRASS

Supplement	Lot 1 2 lbs. C.S.C./Day	Lot 2 2 lbs. Milo/Day
No. Cows Per lot	9	10
Pounds of Milk Produced in 24 Hours		
June 9	$8.5 \pm .64$ [a]	$8.6 \pm .78$
July 8	$6.6 \pm .50$	$7.3 \pm .79$

[a] Standard Error of the Mean

Although cows in Lot 2 produced slightly more milk in July than those in Lot 1,differences in milk production between treatments were not statistically significant. Furthermore, the additional milk production of cows in Lot 2 did not result in more rapid weight gain of their calves. The decrease in milk production between June and July, as well as low production for both periods, could possibly be explained by the severe drouth conditions prevailing during the late spring and summer.

SUMMARY

Three lamb digestion trials were conducted during August (Trial 1), November (Trial 2), and February (Trial 3) of 1963-64 to determine the composition, digestibility, and nutritive value of freshly clipped Midland Bermuda-grass at various times during the year. Forages used in the digestion trials were later used in an artificial rumen study to compare the two methods for evaluating Bermuda-grass forage.

A pilot trial was initiated during the fall of 1963 at the Agronomy Research Station near Perkins, Oklahoma to study the supplemental feed requirements of spring calving beef cows wintered on dry Bermuda-grass pasture.

In vivo digestibilities of dry matter, organic matter, crude protein, ether extract, N.F.E., cellulose and the T.D.N. content of the grass fed in Trial I were significantly greater ($P<.01$) than that used in Trials 2 and 3. The grass fed in Trial 3 was approximately six weeks younger at the start of winter than that fed in Trial 2. Consequently, digestibilities of all constituents were significantly greater for Trial 3 grass than for grass fed in Trial 2. Thus, the additional two months of weathering of Trial 3 grass appeared to have less effect on digestibility than the additional two months of summer growth of the grass used in Trial 2.

In vitro cellulose and dry matter digestibilities were significantly greater for Trial 1 than Trials 2 and 3 and greater for Trial

3 than Trial 2 ($P<.01$). Digestion coefficients obtained by the *in vitro* technique were consistently lower than those determined in the *in vivo* study. However, mean correlations of 0.95 and 0.98 were obtained between the two procedures for dry matter and cellulose digestibilities, respectively, indicating that the artificial rumen may be used successfully in estimating nutrient digestibility of of Bermuda-grass.

Cows supplemented with two pounds of pelleted cottonseed meal per head daily lost significantly less weight ($P<.05$) during the winter than cows fed two pounds of crimped milo per head daily (112 lbs. and 160 lbs., respectively). Average total weight loss of the cows through July 1, 1964 was 35 lbs. for each lot. There were no significant differences in milk production between the two groups of cows. Calf birth weights and weight gains were approximately the same for both groups. A protein supplement appeared to be more effective than an energy supplement for cows grazing low quality Bermuda-grass forage, based on winter weight loss of cows.

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