I. EFFECT OF ROTATION OF LATE SEASON REST OF BLUESTEM RANGE ON CATTLE DIET AND ANIMAL PERFORMANCE,

II. CATTLE DIET CONSTITUENTS OF BIG BLUESTEM (*Andropogon gerardi* Vitman),

III. COMPARISON OF TWO METHODS FOR PREPARATION OF ESOPHAGEAL FISTULA DIET SAMPLES FOR ANALYSIS

by

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INTRODUCTION

-Part I-

Grazing systems for native rangeland are currently one of the major areas of range research. Among the goals of a grazing system a increase of range plant health and greater livestock production. In the past, overgrazing through the growing season lowered the vigor of the perennial grasses and thereby lowered gains per animal unit.

Smith (1895) lamented the overgrazed condition of the rangelands of the west and proposed a rotation-grazing system which divided the range into units and grazed each in succession allowing the grasse: to mature and set seed, thereby allowing the desired grasses to mature.

Maintenance of grass vigor requires sufficient quantity and quality of reserve carbohydrates in the storage organs of the perennial grasses (McKendrick, 1971). These reserves are used for initiation of growth each spring and replacement of topgrowth after grazing during th(season. Grazing reduces the photosynthetic area of the plant and can lower reserves (Thaine, 1964; Owensby et al., 1974).

Range forage declines in nutritional quality as the season progre (Rao, 1974; Allen, 1973), therefore it is desireable to use the forage a' its highest quality, during early growth.

Cow-calf operations do not obtain highest per animal production on intensive-rotation systems with frequent movement of animals compared to gains with continuous grazing. Considering that, along with the desireability of grazing forage to replenish food reserves, a rotation of late-season rest system was developed, wherein one pasture per year is not grazed in the last half of the growing season on bluestem range. Owensby et al. (1977) has found that early-intensive use of range with late season rest is most desirable for replacement of reserves.

The objectives of the study were to monitor animal performance, animal diet, and vegetation responses to the system.

-Part II-

Big bluestem (*Andropogon gerardi* Vitman) is the primary dominant grass of the Flint Hills True Prairie. Range management decisions often are based on the effect an action will have on big bluestem and the other prairie dominants.

Dietary value of range species is reduced with advancing maturity. Crude protein and digestibility decline with maturity while fiber content increases (Rao et al., 1973).

This study monitored the changes in crude protein, *in vitro* digestibility, phosphorus, potassium, and acid detergent fiber of big bluestem (*Andropogon gerardi* Vitman) from June to November, 1977, with bimonthly sampling.

-Part III-

Esophageal fistulated cattle are one of the preferred means of sampling forage. The technique allows the researcher to gain a more representative estimate of the diet selected by cattle than hand-plucking forage or watching the animal select its forage.

Esophageal collections are subject to certain errors imposed by mastication, leaching by saliva, and sample preparation.

This study points out the effect of washing fistula samples with distilled water to reduce salivary contamination as compared to freezing the unwashed sample intact with associated saliva and drying at a later date.

I. EFFECT OF ROTATION OF LATE-SEASON REST OF BLUESTEM RANGE ON CATTLE DIET AND ANIMAL PERFORMANCE

Study Area and Methods

Study Area

The study was located in the Flint Hills of the True Prairie, 7 miles northwest of Manhattan, Kansas. The entire area was annually late-spring burned beginning in late April, 1977. The previous grazing treatment (1970-1975) was 10 acres per animal unit, yearlong, on all units, with cows and calves.

Plant Community

Dominant perennial grasses were big bluestem (*Andropogon gerardi* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash), and little bluestem (*Andropogon scoparius* Michx.). More than 50% of the botanical composition on loamy upland and breaks range sites (described by Anderson & Fly, 1955) on each unit of the area was big bluestem, little bluestem and indiangrass. Other common species by occurrance were switchgrass (*Panicum virgatum* L.), sedges (*Carex* spp. L.), kentucky bluegrass (*Poa pratensis* L.), western ragweed (*Ambrosia psilostachya* DC.) and louisiana sagewort (*Artemisia ludoviciana* Nutt.) (Table 1). Shrubs and trees were scattered in lowlands and rocky areas of the pastures. Botanical composition and basal density estimates were measured by the modified step-point method of Owensby (1973). Herbage remaining after the grazing was estimated by clipping 15, 1/10,000 acre plots on both loamy upland and limestone breaks. Forbs and grass were clipped and placed in separate bags. The bags from each plot were dried for five days at 55°C in a forced-draft oven, then weighed to determine dry matter yields.

Grazing Treatment

Hereford cows bred to calve in March grazed the area yearlong at

Table 1 Botanical composition and basal density of range species on loamy upland and limestone breaks on the four units of the study area, June, 1977.

	Unit 1		Unit 2		Unit 3		Unit 4	
	Botanical comp %	Basal cover %	Botanical comp %	Basal cover %	Botanical comp %	Basal cover %	Botanical comp %	Basal cover %
Loamy Upland								
Andropogon gerardi	26.7	1.77	27.1	1.49	27.9	1.54	30.0	1.41
Andropogon scoparius	9.6	0.64	8.4	0.46	9.7	0.54	12.3	0.58
Sorghastrum nutans	18.4	1.22	16.7	0.92	18.0	0.99	17.3	0.82
Panicum virgatum	3.4	0.22	3.0	0.17	1.1	0.06	1.5	0.07
Bouteloua curtipendula	5.5	0.36	7.9	0.44	2.3	0.13	4.0	0.19
Poa pratensis	3.5	0.23	5.7	0.32	5.0	0.28	6.0	0.28
Panicum scribnerianum	4.4	0.29	2.6	0.14	4.7	0.26	3.1	0.15
Sporobolus asper	4.2	0.27	2.5	0.14	2.4	0.14	2.1	0.10
Carex	12.4	0.82	11.6	0.64	11.3	0.62	10.6	0.50
Ambrosia psilostachya	3.9	0.26	3.6	0.20	4.6	0.25	4.0	0.19
Artemisia ludoviciana	1.6	0.10	2.1	0.12	2.0	0.11	2.0	0.09
Total all species	100.0	6.64	100.0	5.55	100.0	5.59	100.0	4.74
Limestone Breaks								
Andropogon gerardi	30.7	1.43	36.7	1.89	34.4	1.82	44.5	2.39
Andropogon scoparius	15.6	0.73	11.4	0.59	10.4	0.55	8.2	0.44
Sorghastrum nutans	17.7	0.83	19.4	1.00	15.9	0.84	23.3	1.25
Panicum virgatum	1.6	0.07	0.8	0.04	1.8	0.10	0.6	0.03
Bouteloua curtipendula	14.7	0.68	13.7	0.70	15.5	0.82	9.8	0.52
Poa pratensis	0.5	0.02	0.6	0.03	1.1	0.06	0.4	0.02
Panicum scribnerianum	0.0	0.0	0.5	0.02	0.9	0.05	0.2	0.01
Sorobolus asper	1.7	0.08	0.5	0.02	1.8	0.10	0.8	0.04
Carex	7.1	0.33	3.7	0.19	4.2	0.22	4.0	0.21
Ambrosia psilostachya	3.3	0.16	3.9	0.20	2.2	0.12	2.7	0.14
Artemisia ludoviciana	1.2	0.06	2.1	0.11	2.7	0.15	1.7	0.09
Total all species	100.0	4.67	100.0	5.16	100.0	5.32	100.0	5.34

8 acres per animal unit in 1976 and 1977.

A grazing system, initiated July 15, 1977 (Fig. 1), used three of the four units, (units 2, 3, and 4), while a fourth (unit 1) was grazed continuously (CG) through the year with no modifications, at 8 acre/ animal unit. The system used a late-season rest on unit 3 (R) beginning July 15, 1977, continued to November 1, 1977. The cattle on unit 3 were split equally and added to units 2 and 4 during the rest period, thereby stocking them at 5 acres per animal unit (IG). On November 1, the cattle which had been moved out of unit 3 were returned to it. July 15, the following season the next unit in the rotation would be rested (Fig. 1). That would allow one period of rest in three years, the first cycle completing in 1979.

Cattle

Winter feeding of alfalfa began on November 1, continued to April 10, with 3 lbs, alfalfa and 1 lb. range cubes per day until February 15, when 6 lbs per day of milo was fed also.

Cows and calves were weighed on the first of each month from June through November. Health of the animals was monitored on a daily basis, including any difficulties associated with calving.

Grazing Distribution

Grazing distribution surveys on each unit were collected using maps of each unit, segregated into 2.5 acre quadrats. A numerical estimate of the forage removed by grazing, ranging from 1 = lightly grazed to 5 = heavily grazed, was recorded in each square of the maps. These were used to draw generalized grazing distribution maps.

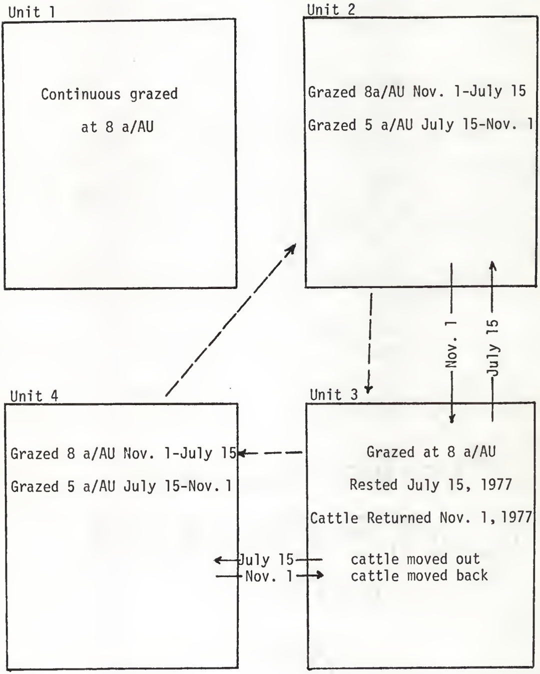

Fig. 1 Diagram of rotation of late-season rest grazing system, acres per animal unit, beginning and ending dates of rest, and dates of cattle movements, during 1977 study.

Cattle Diets

Four esophageally-fistulated steers were grazed on the four units in the first and third weeks of each month from July to November, 1977. The fistulas were of the type described by Van Dyne and Torrell (1964). The animals were fasted overnight with water prior to collection of samples to avoid contamination by rumen contents. The animals were trailered to an area where the cow herd was grazing or had grazed within the last two days. The steers were paired randomly with each other, one pair grazed units 1 and 2, and the other pair grazed units 3 and 4. Thirty minutes grazing time was allowed per unit, yielding about 1 kg. of grazed forage and saliva.

The collected samples were immediately frozen in the bag and stored at -23°C.

Analysis

December 15, all samples were dried in a forced draft oven at 55°C for five days, ground in a Wiley mill (1 mm screen), and stored in glass bottles in the dark.

Two stage *in vitro* dry matter digestibilities (IVDMD) (Tilley and Terry, 1963) were obtained for each sample. Digestibilities were reported as percentages of a standard sample of big bluestem, to correct for variations over time due to rumen inoculum changes which altered indicated digestibility. The standard sample was collected May 15, 1977, dried at 55°C, ground in a Wiley mill at 1 mm, homogenized, and stored in a sealed container in the dark. Digestibilities were calculated as follows:

$$\frac{\text{Sample Digestibility}}{\text{Standard Digestibility}} \times 100 = \text{Corrected Digestibility}$$

Acid detergent fiber (ADF) was estimated by the method described by Goering and Van Soest (1970).

Total nitrogen, potassium and phosphorus were determined using aliquots from sulfuric acid digest of the samples (Isaac and Johnson, 1976). Total nitrogen was determined from the sample digest colorimetricly with an ammonia salycilate complex (Anonymous, 1976). Crude protein was estimated from total N (%N x 6.25). Phosphorus was determined colorimetrically using ammonium molybdate-ammonium vanadate reagent (Jackson, 1958). Potassium was determined by diluting the acid digest 1:10 and reading on a flame-emission spectrometer.

Data analysis was by the least squares method (Barr and Goodnight, 1972), with means separated by Duncan's new multiple range test (P$<$.05) Duncan, 1955).

Results and Discussion

Animal Performance

Cattle under each treatment exhibited no differences in health problems which could be determined by observation. The mature cows mean weight among treatments was not different ($P<.05$). Cows gained an average of 52 pounds from June to October, 1977, however the gain was not significant ($P<.05$).

Bred heifers were significantly heavier in the herd which was removed from the rested unit (R) than in the herds in the intensely grazed units (IG) ($P<.05$), when averaged over all dates. The continuous grazed unit (CG) cattle weights were not significantly different from IG or R ($P<.05$) (Fig. 2). Weights of all heifers were significantly greater each date, June through November, averaged over all treatments ($P<.05$) (Fig. 3).

Calf weight was greater on CG unit, averaged over all dates, than on the rested unit, while calf weights on the two IG units were not different from calf weights on CG and R ($P<.05$) (Fig. 4). Calf weights were significantly higher on each date, averaged over all treatments ($P<.05$) (Fig . 5).

Grazing Effects

Grazing distribution estimates of all units on July 15, 1977 showed quite localized areas of utilization (Fig. 6). All units had been lightly grazed on 30% of their area. Unit R had the largest area of moderate use with 30%; the IG units had the least with 10%. R and IG units each had 15% moderate use. On November 1, 1977, underutilized areas of the

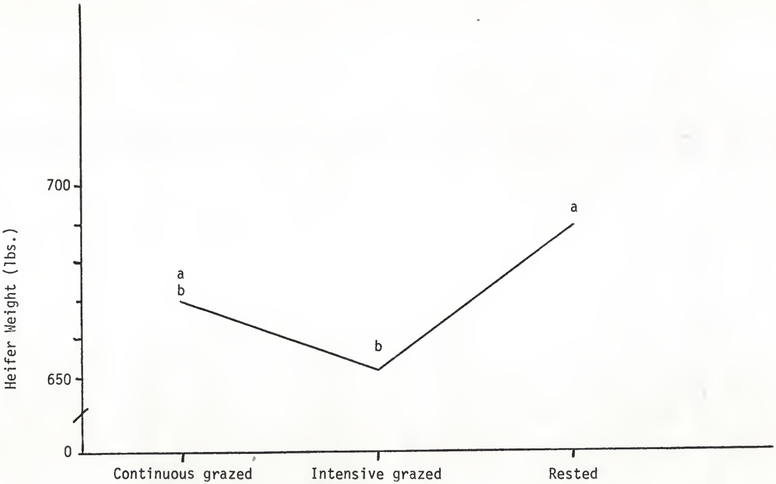

Fig. 2 Heifer weight on continuous grazed unit (CG), intensely grazed unit (IG), and rested unit (R), averaged over dates (June 1 - October 1, 1977). 1/ Treatments with common letter are not significantly different ($P<.05$)

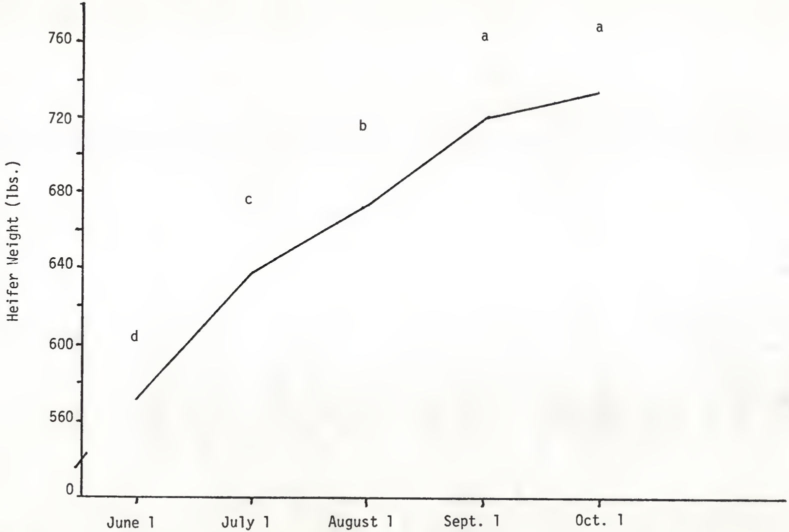

Fig. 3 Heifer mean weight averaged over treatments, (June 1 - October 1, 1977).
1/ Dates with common letter are not significantly different ($P<.05$).

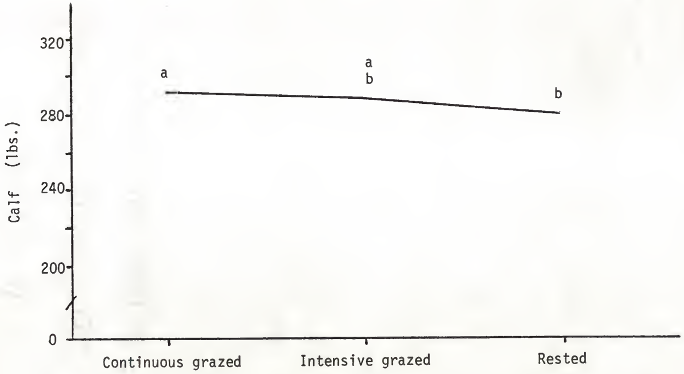

Fig. 4 Calf weights, averaged over all dates, for continuous grazed unit (CG), intensely grazed (IG), and deferred (R), June 1 - October 1, 1977). 1/ Dates with common letter are not significantly different ($P<.05$).

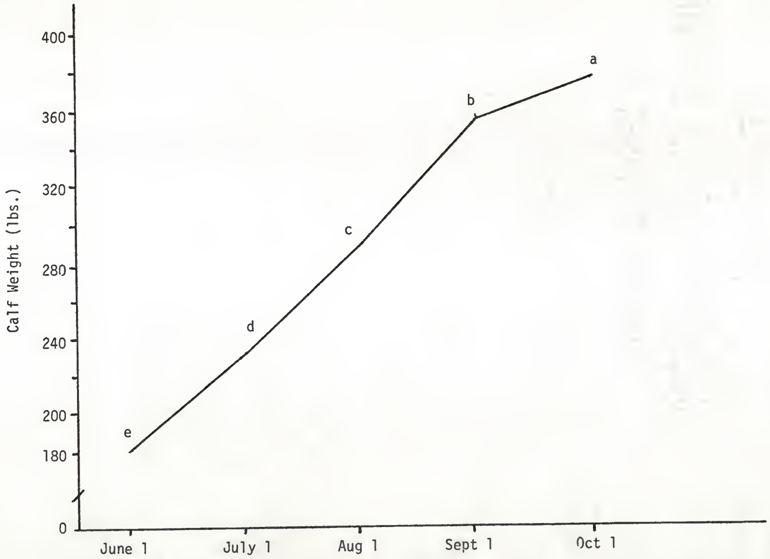

Fig. 5 Calf weight, averaged over all treatments, (June 1 - October 1, 1977).
1/ Dates with common letter are not significantly different ($P<.05$).

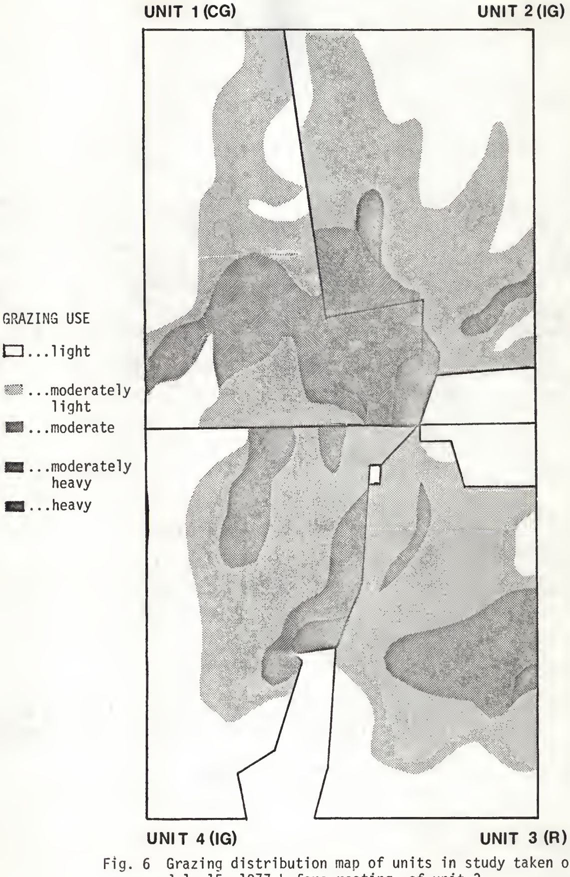

Fig. 6 Grazing distribution map of units in study taken on July 15, 1977 before resting of unit 3.

IG units averaged 5%. The CG unit was underutilized on 24% of its area. The rested unit showed no signs of its previous grazing treatment during the 1978 season. The heavier grazing rate on the IG units resulted in more uniform grazing distribution (Fig. 7).

Herbage remaining (lbs. D.M./acre) on loamy upland prior to resting (July 15, 1977) was 2325 lbs. on the rested unit and 1932 lbs on the CG unit (Table 2), however none of the treatments (CG, IG, and R) were significantly different in grass herbage remaining on loamy upland ($P<.05$). Breaks in the IG units had more herbage remaining in July than the CG unit ($P<.05$). In November at the end of the rest period, grass herbage remaining on loamy upland and breaks was not different on CG, IG, or R ($P<.05$). The continuous grazed unit was over-grazed in the southeast corner, an area of limestone breaks, and was reflected in the herbage remaining following grazing in July. Increased grazing rate of the intensely grazed units did not cause a decrease in grass herbage remaining ($P<.05$) from July - November. Forbs decreased on all grazed units, compared to the rested unit ($P<.05$).

Cattle Diets

Diet constituents among treatments did not differ between the four fistulated steers in the study for crude protein ($P<.98$); IVDMD ($P<.47$); phosphorus ($P<.71$); potassium ($P<.64$), or ADF ($P<.72$). That indicates the paired animals selected similar diets when in a unit together, and any differences noted between treatments were due to treatment.

Crude protein of fistula samples was significantly higher in the continuous grazed unit at 7.5%, than in the IG units, at 6.71% or the R unit at 6.3%, averaged over all dates. Intensively grazed units were

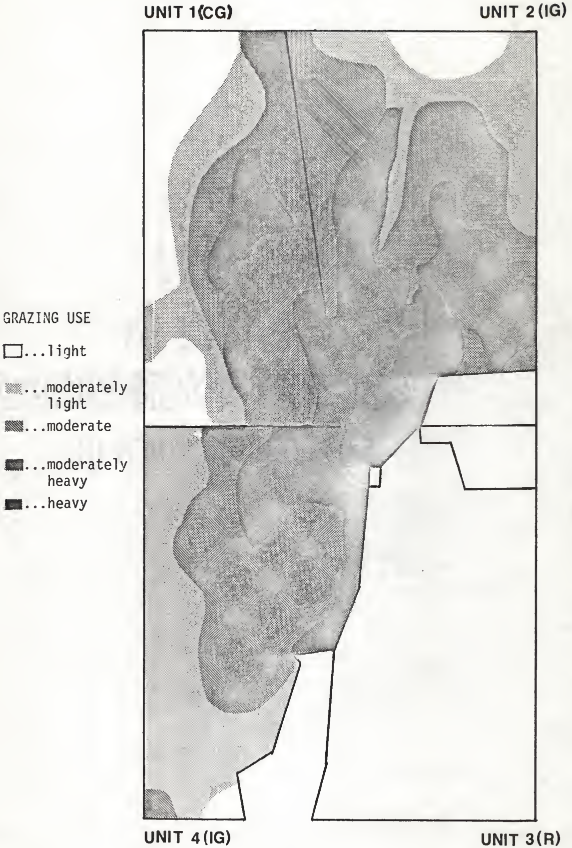

Fig. 7 Grazing distribution map of units in study, taken on November 1, 1977, at time of replacement of cattle in unit 3.

Table 2. Herbage remaining on treatments CG, IG and R on the rest date (July 15) and at the end of the rest period (November 1), pounds per acre dry matter yield. 1/ Weights of grass or forbs in same column with same letter are not significantly different (P<.05).

		Date			
		July 15, 1977		November 1, 1977	
Treatment	Component	Loamy Upland	Breaks	Loamy Upland	Breaks
		lbs/acre		lbs/acre	
Continuous grazed	Grass	1939[a]	1591[b]	2194[a]	1767[a]
	Forb	307[a]	179[a]	140[a]*	110[a]
Intensively grazed	Grass	2229[a]	2162[a]	1995[a]	1912[a]
	Forb	420[a]	289[a]	193[a]*	158[a]
Rested	Grass	2325[a]	2001[ab]	2692[a]	2414[a]
	Forb	518[a]	113[a]	211[a]	137[a]

*signifies a significant change from July to November (P<.05).

not different from the rested unit (P<.05) (Fig. 8).

The cattle in the CG unit favored the southeast end, grazing it heavily. That would introduce a higher percentage of regrowth material in the animal's diet which would elevate the crude protein estimate. Cogswell and Kamstra (1976); Hopper and Nesbit (1930); and Kamstra et al. (1966), all show that maturity and increased time since grazing lowers protein levels. When the steers were grazed with the cows they often were in this area. Crude protein in August clippings of bluestem was lower than on July 15 (P<.05), however, by October 1, the crude protein levels were significantly higher than in July, perhaps due to a shift to cool-season grasses and higher protein forbs (Fig. 9).

In Vitro Dry Matter Digestibility (IVDMD)

There were no differences in IVDMD due to treatment (P<.69). IVDMD of the diet was highest on August 15 among the different collection dates. September 1 samples had the lowest digestibility of any date (Fig. 10). Quicke and Bently (1959), and Rao et al. (1973), have shown a decline in digestion of forage with increased maturity. The decrease in digestibility in late August and early September could be attributed to either maturation or lack or regrowth from perennial warm-season species. A shift to forbs in the diet (Jeffries and Rice, 1969) and cool-season grasses could be a factor.

Phosphorus

Diet phosphorus for CG was not different from that of IG or R, however diet phosphorus under IG was greater than that of R (P<.05) (Fig. 11). Lack of regrowth in the rested unit could have caused the phosphorus (P) levels to be lower. Results reported in part II showed

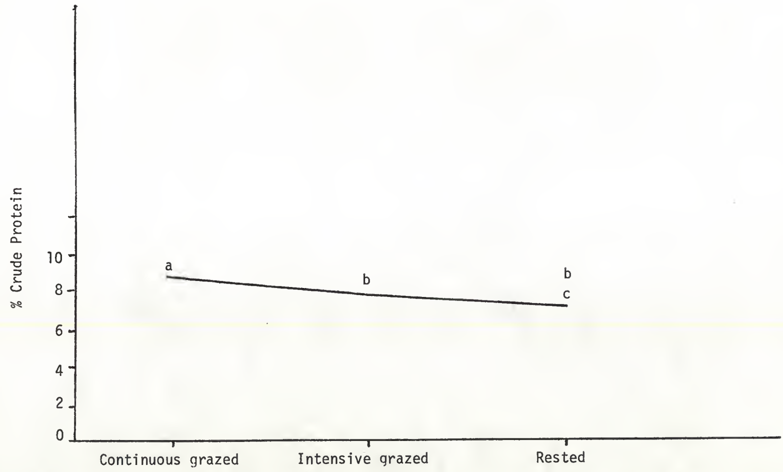

Fig. 8 Crude protein % in esophageal fistula diet samples, averaged over dates for indicated treatments (July 15 - November 1, 1977). 1/ Treatments with common letter are not significantly different ($P<.05$).

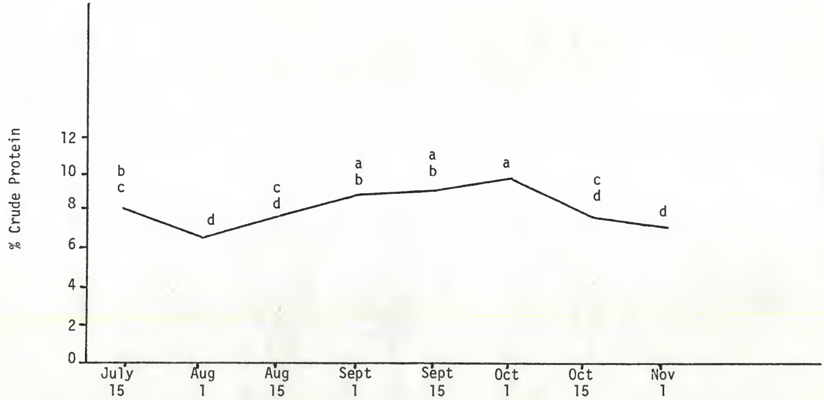

Fig. 9 Crude protein % of esophageal fistula diet samples, averaged over all treatments, July 15 - November 1, 1977. 1/ Treatments with common letter are not significantly different ($P<.05$).

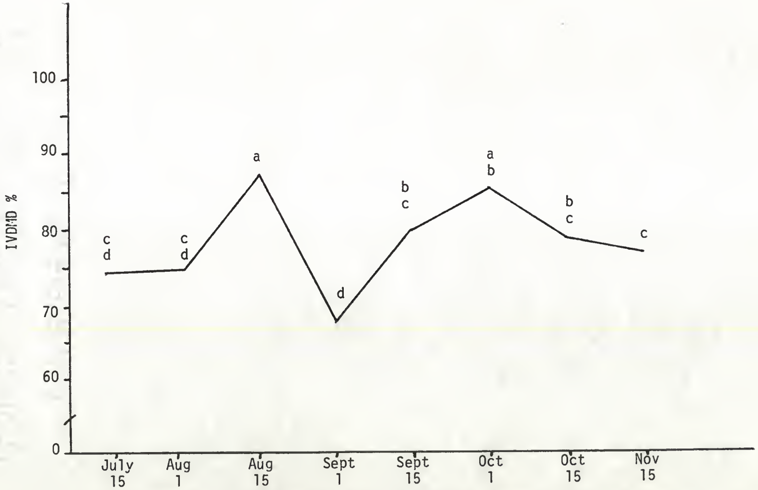

Fig. 10 IVDMD % of diet samples, as % of standard digestibility, averaged over all treatments (July 15 - November 1, 1977). 1/ Dates with common letter are not significantly different ($P<.05$).

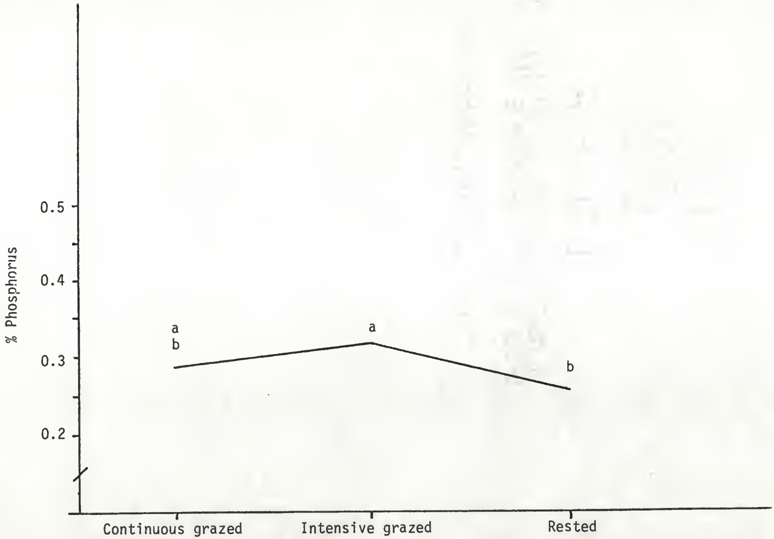

Fig. 11 Phosphorus % of esophageal diet samples, averaged over all dates, (July 15 - November 1, 1977). 1/ Treatments with common letter are not significantly different (P<.05).

that hand-clipped big bluestem P levels decreased with maturity. Diet samples contaminated by saliva elevated P levels in the fistula samples. P is present in the increased ash of esophageal samples (Hoenne et al., 1967; Bath et al., 1956; McManus, 1961; Wilson, 1963).

Diet phosphorus levels from July 15 to September 1 were not significantly different, but were lower than the levels from September 15 to November 1 ($P<.05$) (Fig. 12).

Potassium

Diet potassium (K) levels on the continuous grazed unit were higher than the rested unit, but not different from the intensely grazed units ($P<.05$) (Fig. 13). Diet percentages did not change with date ($P<.11$). K is normally found in low levels in bovine saliva (Bartley, 1975) and does elevate fistula estimates of K. Bailey and Balch (1961) found parotid saliva to contain 7.0 mEq. of K per liter. That could contribute 0.16g of K to a 600 g sample of saliva.

Acid Detergent Fiber

Acid detergent fiber (ADF) content of fistula samples was not different due to treatments ($P<.12$). ADF was highest on August 15, reaching a minimum percentage on September 15 ($P<.05$) (Fig. 14). Allen, 1973; Watkins, 1955; Cogswell and Kamstra, 1976; and Kamstra, 1973 show lignin and fiber to increase with maturity of forage. Salivary ash could lower the ADF values by increasing the indicated cell solubles. Marshall et al. (1964) reports dry matter of bovine saliva as 1.03% while Autrey (1964) reports 1.12%. Acosta (1976) found that 3.4 g saliva was added per gram of bermudagrass when screen bottom collection bags were

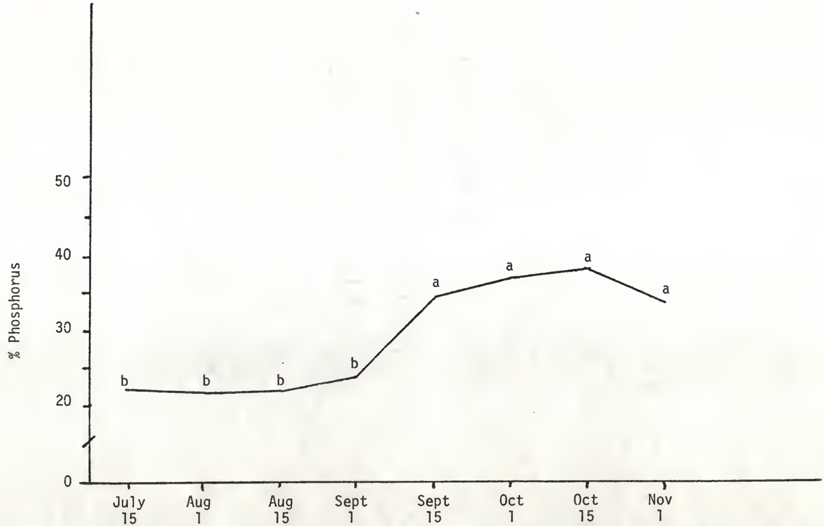

Fig 12. Phosphorus % of esophageal diet samples averaged over all treatments, (July 15 - November 1, 1977). 1/ Dates with common letter are not significantly different ($P < .05$).

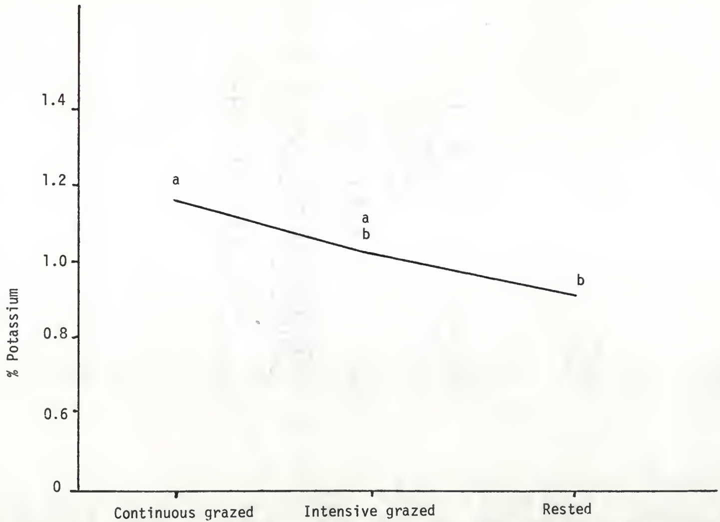

Fig. 13 Potassium % in esophageal diet samples, averaged over all dates (July 15 - November 1, 1977). 1/ Treatments with common letter are not significantly different ($P < .05$).

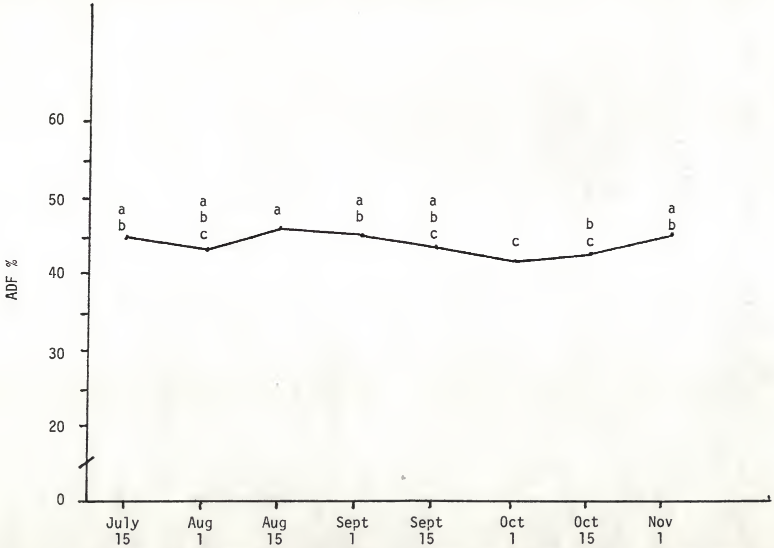

Fig. 14 Acid detergent fiber (ADF) % in esophageal diet samples, averaged over all treatments, July 15 - November 1, 1977. 1/ Dates with common letter are not significantly different (P<.05).

used. That could cause an underestimation of ADF by 4%.

Conclusion

The grazing system, using a late season rest from grazing on one unit of a three pasture rotation system, had no negative effect on cow weight ($P<.05$) or health. Calf gains under the system were significantly less than under continuous grazing; that difference was present at the start of the season prior to system implementation and would seem to be due to other than effects of the system. Heifers were significantly heavier in the unit which was rested on July 15. That would indicate that growing animals are not adversely affected by the one time move and supports the position that the difference in calf weights is due to other than the system.

Grazing patterns on the two units grazed at a higher starting rate from July 15 to November 1, 1977 showed that cattle grazed more of the total area, yet no indication of overgrazing was noted. Herbage remaining on November 1 was not different on CG, IG, or R units. Nearly 2000 lbs. of forage per acre was left to be grazed by the cattle during winter.

Crude protein and potassium of fistula samples were higher in the continuously grazed unit than on the rest unit. That could be an indication that the regrowth from grazing was elevating the dietary protein and K. The fall elevation of crude protein in samples may be due to the selection of forbs which were high in protein. Crude protein levels in November were still above the recommended 6% for dry pregnant cows. Crude protein levels were consistently higher than hand-clipped bluestem samples reported by Allen (1973), at similar dates. Schumway et al. (1963) found generally non-significant differences in protein of rumen fistula samples, due to saliva contamination, of alfalfa and cottonseed hulls, analyzed before and after feeding.

IVDMD of esophageal samples showed a significant drop in late August and early September, compared to early August. Regrowth was slow and cattle may have selected less desireable forage, which contained more structural materials than forage grazed in July and later in the fall, in October.

Phosphorus was significantly higher in the fall, perhaps due to a shift in diet composition.

Acid detergent fiber levels were not different for grazing treatments. Fiber levels were highest in August and November, averaged over all treatments. Increases in ADF are associated with decreased digestibility due to the increased amount of less digestible structural material.

The system did not adversely affect the diet selected by the steers, as compared to continuous grazing. It supplied adequate levels of crude protein and did not lower digestibility of the forage selection.

The excellent regrowth on the deferred unit allowed perennials to store carbohydrate reserves to begin growth the following year. That should manifest itself in the future as increased production of the range grasses. Smith and Owensby (1978) have shown long-term effects of early intensive stocking of steers maintained or increased yields of perennial grasses through late season rest.

II. Cattle Diet Constituents of Big Bluestem (*Andropogon gerardi* Vitman)

Methods

Study Area

The study area was in native tallgrass prairie 7 miles northwest of Manhattan, Kansas. The sample area (1260 acres) was burned in late April, 1977. Botanical composition was typical True Prairie with big bluestem (*Andropogon gerardi* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash), and little bluestem (*Andropogon scoparius* Michx.) composing more than 50% of the stand. The remainder was composed of forbs, woody plants and grasses. Grazing was with cows and calves at 8 acres per animal unit, yearlong. Three treatments were applied to the four units in the study area. Unit 1 was grazed yearlong at a constant rate of 8 acres per animal unit. Unit 3 was rested from grazing beginning July 15, 1977 and ending November 1, 1977. Units 2 and 3 each received half of the herd from unit 3 during the rest period. Prior to July 15, 1977, and after November 1, 1977 all units were grazed at 8 acres per animal unit.

Big Bluestem Sampling

Big bluestem were hand clipped the first and third week of each month, June 1, to November 1, 1977. Samples were collected by hand-clipping all big bluestem growing in four 1/10,000 acre plots which were laid at one meter intervals along five, 5 meter lines randomly located on loamy upland in different areas of each pasture unit. Big bluestem clipped from the four plots was placed in one bag, giving five samples per pasture per date.

The line in each was moved after each sampling date to prevent clipping the same plot twice.

The samples were dried at 55°C for five days, weighed, ground in a wiley mill (1 mm screen), and stored in glass bottles.

Two stage *in vitro* dry matter digestability determinations (Tilley and Terry, 1963) were performed on each sample. The digestibilities are reported as percentages of a standard sample of big bluestem to correct for variations over time due to rumen inoculum changes which altered indicated digestibility. The standard sample was collected May 15, 1977 and prepared in the same manner as the big bluestem clipped samples. Digestibilities were calculated as follows:

$$\frac{\text{Sample Digestibility}}{\text{Standard Digestibility}} \times 100 = \begin{matrix}\text{Corrected}\\ \text{Percentage}\\ \text{Digestibility}\end{matrix}$$

Acid detergent fiber (ADF) of clipped samples was analyzed by the method of Goering and Van Soest (1970).

Total nitrogen, potassium and phosphorus were determined using aliquots from a sulfuric acid digest of the samples (Isaac and Johnson, 1976). Calculations were on a dry matter basis. Total nitrogen was determined by reading the ammonia-salycilate complex on a colorimeter (Technicon Autoanalyzer) (Anonymous, 1976). Phosphorus was determined colorimetrically using ammonium molybdate-ammonium vanadate reagent (Jackson, 1958). Potassium was determined by diluting the acid digest solution 1:10 and reading on a flame-emission spectrometer.

Statistical analyses were by least squares (Barr and Goodnight, 1972). Means were separated using Duncan's new multiple range test (Duncan, 1955).

Results and Discussion

Crude Protein

Big bluestem samples from intensively grazed units yielded more crude protein than the rested unit, while not greater than the continuous stocked unit (Table 3). Crude protein on all treatments was highest June 1 and lowest in November. August 1 levels were lower than all dates except those from September 15 to November 1 (Fig. 15). That low point coincides with flowering of the bluestem, which was quite extensive in 1977. Increases in crude protein after September 15 were likely due to improved moisture conditions and fall regrowth of the big bluestem.

In Vitro Dry Matter Digestibility (IVDMD)

IVDMD as a percentage of standard was different among treatments ($P<.05$). The IVDMD of intensively grazed units was significantly greater than that of the rested unit, but not different from that of the continuous grazed unit ($P<.05$). Date effect was significant with IVDMD values on June 1 being most digestible and November least for hand-clipped bluestem samples ($P<.05$). On the first three clipping dates IVDMD decreased significantly ($P<.05$) (Fig. 16), but did not decrease again until October 1.

Phosphorus

Phosphorus % in hand-clipped big bluestem samples from the IG unit and the rested unit was not different ($P<.05$), but both IG and R units were greater than CG unit ($P<.05$) (Table 3). Phosphorus levels of hand-clipped big bluestem, averaged over all treatments, declined from June 1 to August 15 (Fig. 17). The general trend was a steady decline throughout the season. Phosphorus levels of big bluestem were consistently below

Table 3 Crude protein, *in vitro* digestibility, phosphorus , potassium and acid detergent fiber averaged over dates for hand clipped big bluestem plants, June - Nov. 1977, 1/ means with the same letter in a column are not different ($P < .05$).

Treatments	C. P.	IVDMD	P	K	ADF
	%	% of Std	%	%	%
Continuous grazed	5.4^{ab}	74.9^{ab}	0.102^{b}	1.10^{a}	40.5^{b}
Intensively grazed	5.6^{a}	75.2^{a}	0.127^{a}	1.16^{a}	41.0^{b}
Rested	5.1^{b}	73.2^{b}	0.119^{a}	1.11^{a}	41.4^{a}

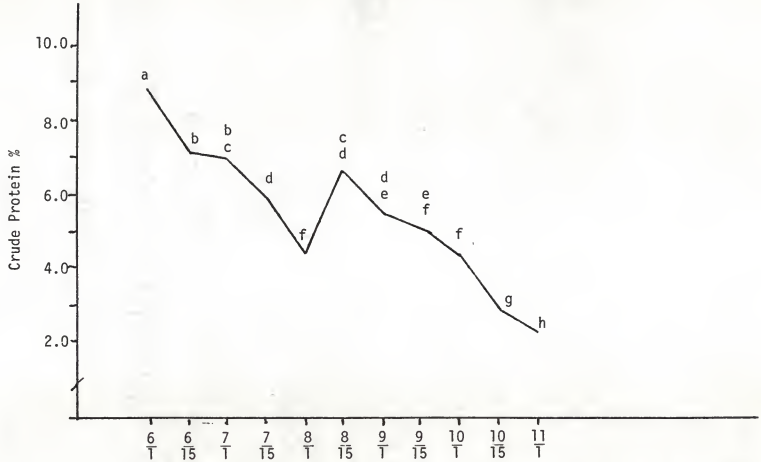

Fig. 15 Crude protein % in hand clipped big bluestem, averaged over all treatments, at different dates (June 1 - November 1, 1977). 1/ Dates with same letter are not significantly different (P<.05).

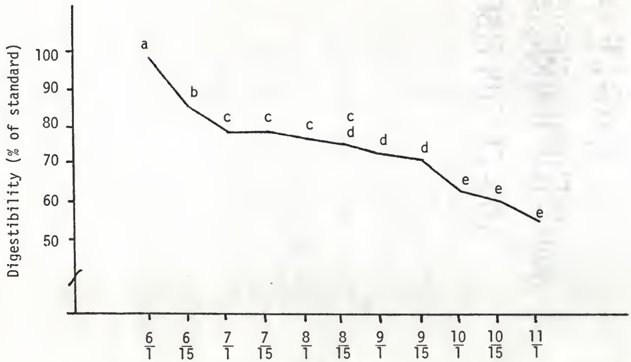

Fig. 16 IVDMD % of hand-clipped big bluestem as % of standard digestibility, averaged over all treatments, (June 1 - November 1, 1977). 1/ Dates with common letter are not significantly different ($P<.05$).

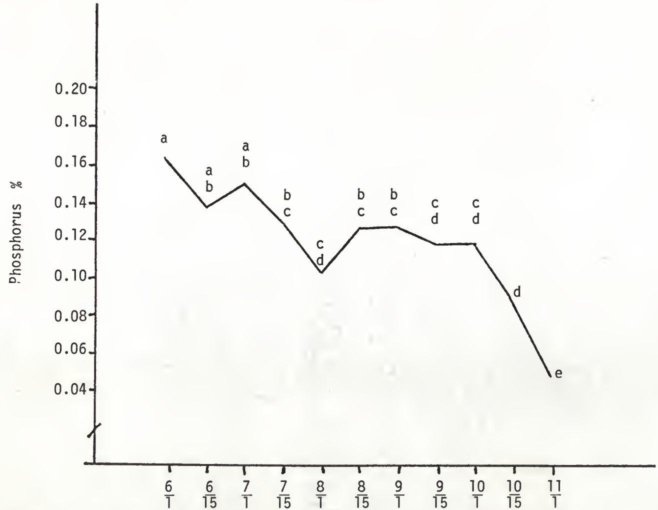

Fig. 17 Phosphorus % in hand-clipped big bluestem vegetation, averaged over all treatments (June 1 - November 1, 1977). 1/ Dates with common letter are not significantly different ($P \leq .05$).

the 0.3% dry matter level required for cattle. That suggests that other plants are required to maintain the level of phosphorus needed in the diet of cattle, or that cattle can select higher quality specimens of big bluestem and other range grasses (i.e. higher quality regrowth from previous grazing periods).

Potassium

Potassium (K) of hand-clipped big bluestem on all treatments decreased significantly through the season (P .05) (Fig. 18). Big bluestem K levels did not decline P .05 during mid August, which was coincident with culm elongation and flowering of big bluestem in 1977, which could indicate K uptake from storage organs to supply K for growth of the culm.

Potassium was not different in big bluestem of any of the treatments, averaged over all dates (P .07).

Acid Detergent Fiber (ADF)

ADF of handclipped big bluestem, averaged over all dates was not different in the IG and R units of the grazing system ($P<.05$). ADF of big bluestem samples from CG were lower than from the R unit ($R<.05$) (Table 3). The decrease in big bluestem ADF of the continuous grazed unit compared with the rested unit could be due to lack of big bluestem regrowth on the rested unit. Kamstra et al. (1966) have shown that regrowth materials lignin and cellulouse increase with time after last clipping.

Big bluestem ADF levels averaged over all treatments, increased 3.7% in the first two weeks of June 1977 ($P<.05$). ADF of samples did not increase again until August 15 when it increased each date to October 1. November samples were highest in ADF ($P<.05$) (Fig. 19).

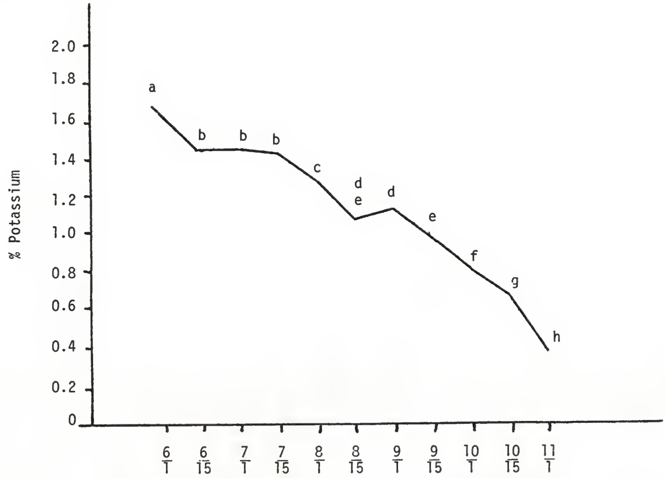

Fig. 18 Potassium % in hand-clipped big bluestem vegetation, averaged over all treatments (June 1 - November 1, 1977). 1/ Dates with common letter are not significantly different (P<.05).

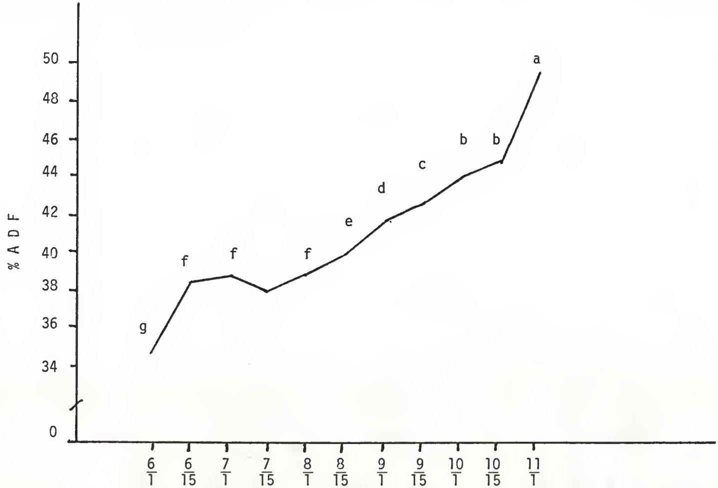

Fig. 19 Acid detergent fiber of hand clipped big bluestem vegetation averaged over all treatments (June 1 - November 1, 1977). 1/ Dates with common letter are not significantly different ($P<.05$).

Conclusions

Diet constituents of big bluestem from hand-clipped samples were adversely affected by increased maturity. Crude protein levels dropped significantly each month, June 1 to August 1, from 8.7 to 4.4%, respectively. IVDMD dropped less markedly through the season, with the greatest drop from June 1 to July 1. Cogswell and Kamstra (1976) have shown an early decrease in crude protein, with a steady decline to the end of the growing season. Kamstra et al. (1958) have shown the digestibility of range forage to decrease with maturity.

Big bluestem phosphorus and potassium of hand clipped samples were highest during active growth phases (June 1 - July 15), decreasing with maturity. Probable causes for this decline are the seasonal effects of translocation, and dilution of the P and K with increased top-growth. Weinman (1942) demonstrated the translocation of nitrogen and phosphorus from vegetation to storage organs during the fall in *Trachypogon plusosus*. McKendrick (1971) discussed the seasonal changes in big bluestem rhizome nitrogen %, with conclusions similar to Weinman (1942).

Big bluestem ADF increased significantly for the first two weeks in June, when crude protein and digestibility made their largest drops. That points to the early formation of structural material which increases ADF and can decrease IVDMD. ADF increased after October 15, after a killing frost occured, stopping growth of big bluestem except where protected.

The grazing treatments applied to the area showed that crude protein and IVDMD of the grazed area's big bluestem increased while ADF levels of big bluestem decreased with grazing compared to resting. That is evidenced in the hand-clipped big bluestem samples collected in this study. That points to the need to graze rangeland from the start of the season to obtain forage at its highest quality. Rest, beginning in mid-season, continuing to the end of the season, allows the forage to store large amounts of reserves. Owensby et al. (1977) have shown that early-season intensive grazing of bluestem range with rest from July 15 to the end of the season allows the big bluestem present to fully replenish its reserves, with vigorous production the following year. They have concluded that late season rest promotes the growth of the desired tallgrass species. It is desireable to graze the range before placing new animals on it in mid-season, rather than deferring the range from the start of the season, without the benefit of grazing during the early season. The negative effect of maturity on range grasses lowers forage quality. If cattle can select regrowth from recently grazed forage, they can select a higher quality diet than on ungrazed range, as evidenced in the big bluestem's response to grazing in this study. Kamstra et al. (1966) have shown that nutritive components of grasses decrease with growth stage and maturity, and that the lignin and cellulose content of the grasses increased with length of time since last clipping.

III. Comparison of Two Methods for Preparation of Esophageal Diet Samples for Analysis

Methods

Study Area

The study was in the True Prairie, 7 miles northwest of Manhattan, Kansas. The entire area was late spring burned in late April, 1977. Grazing treatment, 1970 to 1975, was 10 acres per animal unit, yearlong. In 1976 the stocking rate was increased to 8 acres per animal unit. The vegetation was typical of the True Prairie. Dominant perennial grasses were big bluestem (*Andropogon gerardi* Vitman), indiangrass (*Sorghastrum nutans* (L.) Nash) and little bluestem (*Andropogon scoparius* Michx.), comprising more than 50% of the botanical composition on loamy upland and limestone breaks range sites (Anderson and Fly, 1955). Forbs, woody plants and other grasses composed the remainder of the species.

Diet Sampling

Cattle diets were sampled using four steers with well-established esophageal fistulas, described by Van Dyne and Torell (1964). The animals were fasted overnight prior to use for diet sampling, thus avoiding sample contamination by rumen contents. The animals were trailered to an area where the cow herd had recently grazed, to obtain a sample representative of what the cow herd was selecting. Bags with wire screen bottoms (1 mm mesh) were fitted to the animals after removal of the fistula plug, and the animals were released to graze the area free choice. After 30 minutes the steers were returned to the trailer and the collected samples were put in plastic bags with the steer number and date recorded for each sample. In the laboratory the samples were randomly divided in half. One half was immediately placed in a plastic bag along with saliva from collection and frozen at -23°C. The other half was washed in distilled water to eliminate saliva from the forage by placing them in a slotted bottom pan (0.5 x 2.0 mm) and rinsing until no trace of saliva remained. They were then lightly pressed by hand to expell excess water and immediately dried at 55°C in a forced draft oven for 5 days. The frozen samples were later dried as a group after all samples were collected, by emptying the sample into a pan and drying in a forced-draft oven, at 55°C for 5 days. All samples were ground in a Wiley mill (1 mm screen) and stored in brown glass bottles.

Analysis

Two stage Tilley and Terry (1963) *in vitro* dry matter digestibilities (IVDMD) of frozen and washed samples were carried out. Acid detergent fiber (ADF) was determined using the Goering and Van Soest (1970) method on all samples. Aliquots of sulfuric acid digests were used to determine total nitrogen, phosphorus and potassium percentages on a dry matter basis (Isaac and Johnson, 1976) of all samples. Nitrogen was determined by colorimetric analysis on a Technicon Autoanalyzer using an ammonia-salicylate complex (Anonymous, 1976). Crude protein was estimated from total nitrogen (%N x 6.25). Phosphorus was read on a colorimeter using a vanadomolybdate solution for color development (Jackson, 1958). Potassium was determined on a flame emission spectrometer after diluting the sample digest 1:10.

Washed and frozen samples were compared statistically using the paired T-test to determine the differences introduced by sample preparation (Steele and Torrie, 1960).

Results and Discussion

Method of sample preparation caused significant differences in all laboratory analyses ($P<.001$). Standard errors of the means were slight (Table 4).

Crude protein of the esophageal samples was 15.6% higher when frozen than when washed. The average actual difference between pairs was 1.25%. The loss of soluble nitrogen when the sample was washed, both cellular and salivary in origin, could be significant. Saliva would not be expected to affect total nitrogen greatly, since saliva is low in total nitrogen. Bailey and Balch, (1961), Cundy and Rice, (1968), and Lesperance et al., (1960), have found total saliva protein to be 3 to 14 mg/100 ml.

Digestibility *in vitro* of the frozen samples was 18.6% higher ($P<.001$), than the washed samples, an actual difference of 9.1%. Mastication is a distruptive process which would release cell constituents into the saliva, with losses occuring during the washing process. Freezing is also disruptive of cell walls and could cause elevated dry matter disappearance of *in vitro* samples due to escape of soluble constituents. The effectiveness of microbial digestion would be aided by breaking apart cell walls on mastication (Bailey, 1962).

Phosphorus and potassium of esophageal samples both decreased with washing ($P<.001$) compared to those frozen. Sample P decreased 47.6% in washed samples compared to frozen ones, an actual difference of .014%. That would be due to loss of salivary ash and leaching of plant P during washing. Sample K decreased 52.2% in washed samples, compared to frozen ones, actual difference was 0.54%. Two sources of loss, saliva and leaching of the plant solubles would both occur during washing. Bailey

Table 4 Washed versus frozen esophageal fistula diet samples, analysis by paired T-test, samples collected July - November, 1977. Values are % dry matter.

Treatment	Number of Samples	Sample Mean	Std. Error of Mean	Mean Difference	D.F.	T Value	Prob.
Washed Crude Protein	60	6.7510	0.20239	-1.2478	59	-9.883	0.000
Frozen Crude Protein	60	7.9988	0.20028				
Washed Phosphorus	60	0.1570	0.00830	-0.1425	59	-14.095	0.000
Frozen Phosphorus	60	0.2995	0.01438				
Washed Potassium	60	0.4967	0.02637	-0.5415	59	-14.416	0.000
Frozen Potassium	60	1.0382	0.03942				
Washed Digestibility	60	39.6383	0.80746	-9.0650	59	-10.114	0.000
Frozen Digestibility	60	48.7033	0.71540				
Washed ADF	60	49.2650	0.37591	5.1467	59	13.270	0.000
Frozen ADF	60	44.1183	0.45088				

and Balch (1961) found bovine saliva to contain 13.2 mEq/liter potassium and 49 mEq/liter phosphorus (K^+ and HPO^{--}), indicating that more of the change in P could be due to salivary sources.

Acid detergent fiber (ADF) of frozen samples was lower than washed samples by 10.4%. Average differences between paired samples was 5.15%. Saliva is 1.03% dry matter (Marshall et al. 1967) and could lower the indicated ADF of a frozen sample by increasing the soluble dry matter fraction of the sample. Washing would remove any cell solubles released by mastication, raising the indicated ADF values in relation to frozen samples.

Conclusions

Method of preparation significantly altered the indicated crude protein, acid detergent fiber, *in vitro* dry matter digestibility, phosphorus and potassium levels in esophageal samples from bluestem range.

Crude protein % in washed samples was lower than in frozen samples, probably due to salivary leaching. Frozen samples contained the soluble plant proteins which were lost by washing the saliva from the sample.

In vitro digestibilities were lower for washed samples than frozen due to the losses of soluble carbohydrates and proteins during the washing process.

Phosphorus and potassium levels were decreased by washing compared to freezing. Phosphorus and potassium can be leached out of masticated forage. Acid detergent fiber of the washed samples was higher than that of frozen ones. That is a further reflection that mastication has a releasing effect on internal cell solubles. The loss of these on washing raised the indicated percentage of acid detergent fiber compared to frozen samples.

Much of the work done with esophageally fistulated steers has used screen bottomed collection bags. These data indicate that the loss of saliva induces lowered estimates of plant dietary constituents. Further study is needed to ascertain methods of correcting sample values for these losses.

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APPENDIX

REVIEW OF LITERATURE

Native rangeland has evolved under grazing pressure from many species of herbivores. The advent of commercial ranching enterprises altered the natural system of grazing which existed previously, to one dominated by one species, cattle. The low value of range led to abuse by overstocking, in an attempt to increase returns from the land. That abuse led early researchers to point out the deleterious effects of heavy grazing on plant survival, vigor and seed fertility (Sampson, 1913; Smith, 1895; Sarvis, 1923). They proposed grazing systems to improve the quality and vigor of forage. Sims (1970) defined grazing management systems to be the control of animals in time and space by varying stocking rate, season of use, kind of animal, distribution, and frequency of grazing use.

Grazing Systems

Grazing systems use rotations of several pastures, deferrment of a pasture for a time period, complete rest for one year, or one of several combinations of these.

Rotation grazing is an orderly sequence of use when each subdivision is both grazed and deferred during the same grazing season or calendar year (ASRM, 1964).

Rotational systems have been developed and used by many authors (Johnson, 1965; Lenaghan, 1969; Rogler, 1951; Smith et al., 1967). Hickey (Undated) reviewed 33 papers on rotational systems.

Animal performance on rotational systems has varied with different studies. Lenaghan (1969) determined that extensive subdivision was costly and not likely to give large improvements in animal productivity. He felt that if the range was overstocked, a rotational system would compare favorably to continuous grazing. Rotational systems are commonly used with dairy cattle. Hodgson et al. (1934) used dairy cattle on a six pasture rotation and found gains to be 0.2 pounds greater per day on the rotation system, with 3.6 pounds more milk per day. Rogler (1951) found that over a seven-year period steers under continuous grazing at both moderate and heavy rates gained more per head than steers under rotation.

Deferred grazing systems discontinue grazing on a unit for a specified period of time during the season (ASRM, 1964). Deferral starts at the beginning of the growing season. Aldous (1935) and Anderson (1940) have used deferred grazing in the Flint Hills, showing greater livestock gains per acre with deferral but, in the case of Anderson (1940) the deferred unit gave slightly lower animal gains over the season.

Many grazing systems use the deferred-rotation (D-R) system which discontinues grazing on various parts of a range in succeeding years, allowing each part to rest successively during the growing season to permit increased plant vigor (ASRM, 1964). Merrill (1954) demonstrated increased livestock performance and range condition on D-R using three herds and four pastures. The system allows 4 months of rest after one year of continuous grazing. McElvain (1955) reported on a 2-pasture rotation, yearlong system for cows and calves. He found that animals performed equally with the animals on a continuous system.

Owensby et al. (1973) used a 3-pasture D-R system with yearling steers and found that animal performance was lower on the D-R system than pastures stocked season long. They noted that differences in gain occurred after movement to the deferred pasture. Hyder and Sawyer (1951) also reported lower animal gains over the season with D-R grazing.

Grazing systems generally improve the range condition over that of continuous stocking (Merrill and Young, 1952; Hanson and Love, 1931; Merril, 1954; and Smoliak, 1960). The expense of the system may not justify the gains in forage quality, if animal gains do not also benefit (Smoliak, 1960). Costs may exceed returns on some systems (Hubbard, 1951).

Herbel (1971) reviewed grazing systems and concluded that continuous grazing gave the most consistent results. He felt that any system of management should use an ecosystem approach to management decisions. Heady (1961) reached similar conclusions with a review of systems for the California annual-type range, noting that continuous grazing had greater gains per head in most studies.

One of the reasons that continuous stocking achieves greater gains is the negative influence on animal gains of length of time since the plant was last grazed.

Forage Clipping and Grazing

One of the prime considerations in grazing management is the maintenance of a vigorous stand of grass. In order for the perennial grasses to maintain vigor and initiate active spring growth, satisfactory carbohydrate reserves must be maintained in the storage organs. Carbohydrate storage is in stem bases, crowns, stolons, rhizomes and roots of perennial grasses.

Owensby et al. (1974) noted a reduction in tiller density, herbage production, and total nonstructural carbohydrate content of big bluestem with increased clipping frequency. Perry and Chapman (1976) noted a decrease in survival of basin wildrye (*Elymus cinerus* Scribn. and Merr.) with decreased clipping height and increased frequency. Trlica et al. (1977) found that repeated severe defoliation of range grasses and forbs resulted in long-term reduction of herbage yields, even though reserve CHO levels of the grasses returned to near normal in 26 months. They felt that this was due to a reduction in underground biomass which resulted from the repeated defoliations. Clipping does not duplicate the effects of grazing on the plant. It does however show similar trends in plant responses to removal of topgrowth.

When cattle graze an area they reduce the photosynthetic area of the forage. Grazing lowers the total nonstructural carbohydrate reserve levels of big bluestem during the growing season (Rains et al. 1975), lowered reserves can have detrimental effects on later plant growth (Jameson 1964).

Animals will select palatable forages to the exclusion of undesirable plants. Rosiere et al. (1975) studied cattle diet composition on semi-deferred range and found that the composition of diets shifted with season as different species gained favor. Hubbard and Hanson (1976) and Hanson et al. (1977) have shown the food preferences of different grazing species by microscopic analysis of fecal samples. As animals continue to select the same plants, they place additional stress on those species.

Maturity Effects on Grasses

Range grasses invariably increase in lignin, fiber, and cuticular materials with increased maturity (Rao et al., 1974: Kamstra et al., 1958; Kamstra, 1973; Quicke, and Bentley, 1959; Cogswell and Kamstra, 1976). Protein percentages decline early in the season for most warm-season perennials. Kamstra (1973) found a significant decline in crude protein content of some important South Dakota range species. Allen (1973), working in the Flint Hills, found that crude protein decreased from 17.89% in May to 6.0% by July 1, on combined samples of big and little bluestem.

In vitro dry matter digestibility (IVDMD) of forage declines with an increase in fiber and lignin. Tomlin et al. (1965), Forbes and Garrigus (1948), Quicke and Bentley (1959), Kamstra et al. (1968), and Rao et al. (1974), have noted that IVDMD decreased with maturity or length of regrowth after grazing.

Heavy grazing has been found to increase digestibility of range forage (Kamstra et al. 1968). They also found that late in the season the upper portion of western wheatgrass (*Agropyron smithii* Rybd.) (containing the most recent growth) was more digestible, and that cattle grazed these upper plant parts in the late season. Hopper and Nesbitt (1930) found that the general nutrient content of North Dakota grasses increased with grazing. That increase in digestibility and nutrient content of grasses under grazing has been attributed to the continual regrowth which occurs after grazing.

Minerals in Plants

Mineral content of forage has been shown to change seasonally in perennial ryegrass (*Lolium perenne* Glasnevin) by Fleming and Murphy (1968). Reith et al. (1964) did not find marked seasonal variation in a mixed stand of perennial ryegrass and cockspot (*Dactylis glomerata* S37).

Maturity effects on mineral composition of perennial grasses often manifest themselves as deficiencies of several of the inorganic elements (Whitehead, 1966; Fleming et al., 1968). These authors noted that mineral absorption and photosynthesis do not occur at the same rate, resulting in a net decrease in mineral percentage.

Phosphorus declined with increased growth stage in a study by Thomas et al. (1952). They found young leaves of perennial ryegrass to contain 0.30% P; late leaf 0.31%; mid flowering 0.25%; fully mature 0.25%; and senescent 0.18%.

Umoh (1977) found the mean P content of hand-clipped forages to be 0.082%. Glendening et al. (1952) found P content of bluestem vegetation to vary from 0.06 to 0.34%.

Potassium content of meadow fescue (*Festuca elatior* K31) perennial ryegrass and timothy (*Pleum pratense* S48) declined with advancing maturity of the vegetation (4% in April to 2% in July) by Fleming and Murphy (1968). Potassium percentages (Umoh 1977) varied from 0.087 to 1.79% in handclipped bluestem samples. K contents of forages were highest in May and decreased to a minimum in the winter months. Glendening et al. (1952) reported levels to range from a low of 0.09% to 0.30% in winter grass, while April growth was highest at 1.51%.

Esophageal Fistula Collection

The esophageal-fistula, developed by Torell (1954), and reviewed for its development and use (Van Dyne and Torell, 1964) is commonly accepted as one of the better ways of obtaining representative samples of forage selected by cattle and other livestock.

Animals select forage which is markedly different from the general chemical composition of range species (Theirer, 1969). Esophageal-fistula samples usually contain higher ash and crude protein than hand collected samples from the same area (Bredon et al., 1967; Van Dyne and Heady, 1965; Weir and Torell, 1959).

Salivary contamination is generally associated with the increased ash in fistual samples. Changes due to saliva have been reported for cattle by Bailey and Balch (1961), Kay (1960), Lesperance et al., (1960), and Marshal et al. (1967). Ions which have been identified in saliva include the cations Na^{+}, K^{+}, CA^{++}, Mg^{++} and P and anions Cl^{-}, HCO_3^{-} and $HPO_4^{=}$. Ash increase of the fistula samples due to these ions is well accepted. Bailey and Balch (1961), and Lesperance et al. (1960) reported ash content at 860 mg/100 ml. Autrey (1964) reported dry matter content at 1.12%.

Saliva secreted by cattle during eating and rumination was twice the level secreted when resting (Bailey, 1961). Saliva produced per kilogram of organic matter intake increased from fall through winter, spring and summer (Wilson, 1963). A trend of increased saliva flow with increased dry matter percentage has been shown by Bartley (1976). Total nitrogen in saliva has been variable between studies. Bailey and Balch (1961), and Cundy and Rice (1968) found saliva to have 3 to 14 mg/100 ml total nitrogen. Higher values were recorded by Little (1972), and Philipson and Mangan (1959), of 32 to 45 mg/100 ml. This range of values could be the result of diet, collection method, or collection time. Wilson (1963) indicated that protein in saliva increases with increases in dietary protein.

Salivary contamination of samples can depend on the ratio of saliva to forage. Marshall et al. (1967) converted and summarized nitrogen values of saliva reported in the literature to crude protein, reporting values from 4.5 to 17% crude protein. Saliva in their experiment contained 8.7% crude protein. They concluded that if forage protein was below 8.7% the saliva would raise the indicated crude protein level of the forage, above 8.7% the saliva would in effect add more dry matter than nitrogen.

That contaminating effect has led to efforts to remove the saliva from the forage. Screen-bottomed collection bags have been suggested and often used (Arnold et al., 1966; Darth et al., 1970; Cook, 1964; Rama et al. 1973; and Van Dyne and Torell, 1964), which allows saliva to drain from the collected forage sample. Removal of saliva from the collection bags results in salivary leaching. Radde (1967) found nitrogen and water soluble carbohydrates in saliva that passed through screen-bottomed bags.

Mastication of the ingesta releases the soluble constituents of plant cells, due to cell disruption. Doyle (1967) found that 33% of the soluble nitrogen and 51% of soluble carbohydrates in the forage were in the free liquid of the samples. Several studies show that crude protein content of forage increases upon feeding, however others have shown a negative effect or no effect at all.

Salivary ash contamination is unavoidable by any collection method, and corrections, expressing results on an organic matter basis have been used (Arnold et al., 1966; Cook, 1964, Little, 1972; Marshall et al., 1967; and McManus, 1961).

Barth et al. (1970) investigated the effects of mastication and saliva on forage acid detergent fiber (ADF). They found that ADF values of legume forage compared to offered forage increased by 13% due to salivary leaching of the carbohydrates in the sample.

Sample collection is usually in two ways. The common method involves collection with a screen-bottomed collection bag to eliminate some of the saliva, as discussed earlier. Some authors have investigated the use of closed-bottom bags to retain the saliva with the masticated forage (Basson, 1971; Bredon et al., 1970; McManus, 1961; Langlands, 1966; Little, 1972). Marshal et al. (1967) collected the forage and then squeezed the samples to separate the saliva from the forage. They found that saliva removal had a negative effect on protein and raised crude fiber.

Squeezing of excess saliva from esophageal samples gave a lower estimate of protein in blue grama grass clipped during July and August (Hoehne, 1966). Lambourne et al, (1963) found that digestibiliby of samples which had not been squeezed was significantly higher. Rinsing saliva from the sample has been tried on alfalfa, resulting in an increased fiber content and loss of some soluble compounds (Cundy and Rice, 1968). Leigh and Mulham (1967) rinsed esophageal fistula samples from sheep and found that nitrogen level of the sample reduced 18 to 31% due to washing.

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Table A.1 Analysis of variance on washed and frozen esophageal fistula diet samples from bluestem range for % crude protein (July - November 1977).

Washed Source of Variation	D.F.	Sums of Squares	F-Value	Probability of greater F
Treatment	2	12.61952114	7.46	0.0018
Date	8	70.11888736	10.37	0.0001
Steer	3	0.54692337	0.22	0.8850
Treatment Date	16	31.77737394	2.35	0.0150

Frozen Source of Variation	D.F.	Sums of Squares	F-Value	Probability of greater F
Treatment	2	19.26646089	8.45	0.0010
Date	7	55.75715966	6.99	0.0001
Steer	3	0.17117801	0.05	0.9849
Treatment Date	14	21.07764302	1.32	0.2460

Table A.2 Analysis of variance on washed and frozen esophageal fistula samples from bluestem range for in vitro dry matter digestibility values (July - November, 1977).

Washed

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	164.63601693	1.24	0.3019
Date	8	1954.76275697	3.67	0.0028
Steer	3	217.38132730	1.09	0.3659
Treatment Date	16	1045.10731851	0.98	0.4954

Frozen

Source of Variation	D.F.	Sum of Squares	V-Value	Probability of greater F
Treatment	2	39.13997970	0.37	0.6931
Date	7	2277.49905080	6.16	0.0001
Steer	3	136.83910945	0.86	0.4693
Treatment Date	14	871.17798831	1.18	0.3344

Table A.3 Analysis of variance on washed and frozen esophageal fistula diet samples from bluestem range for phosphorus (July - November, 1977).

Washed

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	0.02209884	5.55	0.0076
Date	8	0.06689328	4.20	0.0011
Steer	3	0.00330649	0.55	0.6487
Treatment Date	16	0.07695801	2.42	0.0125

Frozen

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	0.03249537	2.57	0.0916
Date	7	0.25295342	5.71	0.0002
Steer	3	0.00890885	0.47	0.7058
Treatment Date	14	0.12279854	1.39	0.2130

Table A.4 Analysis of variance on washed and frozen esophageal fistula diet samples from bluestem range for potassium (July - November, 1977).

Washed

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	0.40117122	1.08	0.3511
Date	8	0.97822075	0.66	0.7264
Steer	3	0.91533002	1.64	0.1968
Treatment Date	16	1.59747645	0.54	0.9108

Frozen

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	0.58993374	3.47	0.0425
Date	7	1.11210542	1.87	0.1058
Steer	3	0.14327611	0.56	0.6438
Treatment Date	14	0.53274521	0.45	0.9450

Table A.5 Analysis of variance on washed and frozen esophageal fistula diet samples from bluestem range for acid detergent fiber (July - November, 1977).

Washed

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	12.38113240	1.24	0.3001
Date	8	204.06481332	5.12	0.0002
Steer	3	9.45387538	0.63	0.5988
Treatment Date	16	92.92498863	1.16	0.3365

Frozen

Source of Variation	D.F.	Sum of Squares	F-Value	Probability of greater F
Treatment	2	39.08898282	2.29	0.1170
Date	7	132.10432511	2.21	0.0582
Steer	3	11.51726682	0.45	0.7195
Treatment Date	14	217.92617025	1.82	0.0763

Table A.6 Analysis of variance on big bluestem hand clippings for crude protein, IVDMD, phosphorus, potassium and acid detergent fiber, by treatment and date (June - November, 1977).

Source of Treatment	D.F.	Sum of Squares	F-Value	Probability of greater F
Crude Protein				
Day	10	567.71726582	36.95	0.0001
Treatment	2	8.12265591	2.64	0.0738
T x D	20	32.29153909	1.05	0.4055
In Vitro Digestions				
Day	10	25962.88370909	92.44	0.0001
Treatment	2	156.59168182	2.79	0.0641
T x D	20	632.37881818	1.13	0.3263
Phosphorus				
Day	10	0.15299130	8.20	0.0001
Treatment	2	0.02350260	6.30	0.0022
T x D	20	0.01195460	0.32	0.9978
Potassium				
Day	10	25.52326145	66.74	0.0001
Treatment	2	0.21032864	2.75	0.0665
T x D	20	0.51886636	0.68	0.8444
Acid Detergent Fiber				
Day	10	2935.33432727	130.69	0.0001
Treatment	2	22.64195445	5.04	0.0074
T x D	20	48.18054545	1.07	0.3816

Table A.7 Analysis of Variance on Weights of Mature Cows, Bred heifers, and calves by treatment and date (June 1 - Nov. 1).

Source	D.F.	Sum of Squares	F Value	Probability
Mature Cows				
Treatment	2	352387.50027790	1.73	0.1783
Date	4	82349.75361699	0.20	0.9372
Treatment x Date	8	970844.57258784	1.19	0.3018
Heifers				
Treatment	2	43758.19163293	5.62	0.0043
Date	4	639712.38267544	41.10	0.0001
Treatment x Date	8	8560.63427800	0.28	0.9734
Calves				
Treatment	2	19991.30846217	2.85	0.0588
Date	4	2976137.81472659	211.95	0.0001
Treatment x Date	8	10770.05572798	0.38	0.9295

Table A.8 Analysis of variance on herbage remaining for treatment and date effects of loamy upland and breaks bluestem range (July 15, and November 1, 1977).

Source	DF	Sum of Squares	F Value	Probability
Loamy Upland - Grass				
Treatment	2	3850227.05489281	1.77	0.1750
Date	1	441590.37190180	0.41	0.5253
Treatment x Date	2	2276042.54042250	1.05	0.3546
Loamy Upland - Forbs				
Treatment	2	245676.36119149	0.96	0.3848
Date	1	1338457.69524324	10.50	0.0016
Treatment X Date	2	42430.92293276	0.17	0.8469
Breaks - Grass				
Treatment	2	4461655.97086370	2.76	0.0673
Date	1	345180.14385715	0.43	0.5144
Treatment x Date	2	2405867.28793321	1.49	0.2296
Breaks - Forbs				
Treatment	2	240981.68631026	1.39	0.2526
Date	1	93472.64111739	1.08	0.3008
Treatment x Date	2	119690.76275266	0.69	0.5028

I. EFFECT OF ROTATION OF LATE SEASON REST OF BLUESTEM RANGE ON CATTLE DIET AND ANIMAL PERFORMANCE,

II. CATTLE DIET CONSTITUENTS OF BIG BLUESTEM (*Andropogon gerardi* Vitman),

III. COMPARISON OF TWO METHODS FOR PREPARATION OF ESOPHAGEAL FISTULA DIET SAMPLES FOR ANALYSIS

by

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ABSTRACT

In part I the effect of a late-season rotation of rest from grazing on cow and calf performance and cattle diet was studied. The rest system had two treatments on 3 units: intensively grazed (IG) on 2 units from July 15 to Nov. 1, 1977, and rested (R) on 1 unit from July 15 to Nov. 1. Grazing rate was 8 acres/A.U. (November 1 to July 15) on IG and R. The system was compared to a continuous grazed unit (CG) which was grazed at 8 acres per animal unit. Crude protein, in vitro dry matter digestibility (IVDMD), phosphorus (P), potassium (K) and acid detergent fiber (ADF) was analyzed on each sample.

In part II the cattle diet constituents of hand-clipped samples of big bluestem was analyzed on CG, IG, and R pastures for the diet constituents, crude protein, IVDMD, P, K, and ADF from June to November, 1977.

In part III, esophageal fistula forage samples from bluestem range were compared for changes in content due to washing the sample in distilled water to remove saliva rather than freezing without rinsing, with drying at a later date. Samples were analyzed for crude protein, IVDMD, P, K, and ADF.

Cows weights were not different in the pastures of the grazing system, compared to the CG unit. Calves gained more weight on the CG unit while heifers gained most on the R unit. The system did not adversely affect cattle performance, or health.

Crude protein and K levels of the continuously grazed unit were higher than on the rested unit. IVDMD, P, and ADF of fistula sam-

ples was not different between treatments.

Diet constituents of big bluestem from clipped samples changed with maturity and grazing treatment. Crude protein, IVDMD, phosphorus and potassium decreased with maturity, while ADF increased with maturity of hand-clipped big bluestem.

Crude protein and IVDMD of the grazed units big bluestem clippings increased while ADF percentages decreased on grazed units. P and K of big bluestem clippings were not different due to grazing.

Method of preparation significantly altered the indicated crude protein, acid detergent fiber, in vitro digestibility, phosphorus, and potassium levels in esophageal samples. Crude protein, IVDMD, P, and K were lower in the washed samples compared to the frozen, while ADF increased in the washed samples, indicating that washing or other removal of saliva from forage after mastication may alter the levels of diet constituents.