Seasonal Change in Nutritive Value of Bluestem Pastures

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Highlight: *Esophageally fistulated steers were used to determine organic matter intake and digestibility of bluestem pastures during the summer grazing season. Following a 48-hour total fecal collection period, esophageally fistulated steers were used to collect grazed samples of native pastures during June, July, August, September, and October. Esophageal samples were higher in ash and crude protein and lower in crude fiber, N-free extract, and acid detergent fiber than were hand-clipped samples. In vitro dry and organic matter digestibilities were higher in forage collected by cattle than in hand-clipped forage. Multiple regression equations were developed to predict in vitro digestibility. Only crude protein and acid-detergent fiber were highly correlated with digestibility. Average daily intakes of organic matter, digestible crude protein, and digestible energy by steers on pasture were estimated from fecal nitrogen regression established from hay trials. Protein apparently became limiting about mid-July and energy in late August. The positive effects of burning were increased forage yield and weight gain with lowered lignin content.*

A foremost problem in range and pasture nutrition is accurately assessing chemical and botanical compositions of diets of grazing livestock (Van Dyne and Torell, 1964). Inability to manually sample forages representative of that ingested by livestock has led investigators to use esophageally-fistulated animals to collect naturally grazed samples (Lesperance et al., 1960). Only after relative seasonal availabilities of nutrients are known can livestock be managed for maximum return from available forage resources (Raleigh, 1970).

Animals fitted with esophageal fistulae recently have been used to obtain grazed forage samples. However, nutritive value and digestibility of diets selected by cattle grazing Flint Hills Range have not been thus measured.

We used such samples to determine the nutritive value of grazed forage and to measure energy and crude protein of Flint Hills Range consumed during the summer grazing season.

Experimental Area and Methods

The study area is in the Flint Hills, tallgrass prairie five miles northwest of Manhattan, Kans. The summer grazing season, when the plants are highest in nutrient value, is from about May 1 to October 1. The warm season grasses begin to mature in July and have developed seed heads by August. Although the pastures used in this study were not grazed during the winter period, some pastures in the area are grazed throughout the year.

Between 50 and 60% of the vegetation is big and little Bluestem (*Andropogon gerardi* Vitman and *A. scoparius* Michx) (Herbel and Anderson, 1959). Three other warm season grasses, Indiangrass [*Sorghastrum nutans* (L.) Nash], switchgrass (*Panicum virgatum* L.), and sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.] comprise another 10 to 20%. The elevation is 400 m. Annual rainfall varies from

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The article is Contribution No. 433, Department of Animal Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan. Supported in part by contract fund AID (Nesa-146).

Manuscript received October 26, 1972.

63.5 to 92 cm with most of it during summer months.

Three major range sites of the experimental area were loamy upland, limestone breaks, and claypan (Anderson and Fly, 1955). Two 24-ha pastures and two 16-ha containing approximately the same percentages of loamy upland, limestone breaks, and claypan were used. Two of the pastures had been burned annually in late spring (May 1) since 1950; two unburned pastures served as a control (Anderson et al., 1970). All were grazed from May 1 to October 1 at approximately two hectares per animal unit.

Eight 8-month-old Holstein steers averaging 180 kg were esophageally fistulated according to the method of Van Dyne and Torell (1964). Two animals were selected at random and allotted to each of the four pastures. They were placed on pasture 3 weeks before first collections of grazed forage and remained there throughout the experimental period. Yearling Hereford steers (average weight 182 kg) were used for a simultaneous 140-day growth study on these pastures.

Individual esophageal samples were taken from each animal monthly in June, July, August, September, and October. Samples were collected using screen-bottomed canvas bags. Animals had fasted overnight. Samples were deep frozen at -10° C until they were analyzed. Total feces were collected from all fistulated steers twice daily 48 hours before esophageal collections. Subsamples were taken daily to determine dry matter, and a "bulked" subsample of 5% wet weight of feces each day was frozen and later analyzed. The amount of pasture available (dry matter/ha) on each of the four pastures was determined following esophageal collections by sampling with a 1/10,000-acre plot frame to 1 inch above ground level on the range sites. Six samples were taken from three predetermined sites in each pasture. The sample was also used as a control to compare with esophageal samples to determine animal selection.

Forage and fecal samples taken for proximate analysis were dried in a forced-air oven at 50° C for 72 hours, allowed to equilibrate with air at room temperature 24 hours, and ground in a Wiley mill through a 1-mm screen. Proximate analyses were determined by A.O.A.C. (1970) methods and cell-wall constituents according to the procedure by Goering and Van Soest (1970). Lignin was determined by the permanganate method of Van Soest and Wine (1968). In vitro digestibilities were estimated by the method of Tilley and Terry (1963).

Statistical analyses followed the least-squares procedure of Harvey (1960) and regression analyses the stepwise deletion procedure of Draper and Smith (1966). Duncan's new multiple range test was used to separate significant differences among means (Steel and Torrie, 1960). Data differing at the 5% level of probability were considered significant.

Results and Discussion

The amount of forage available for grazing and the average daily gain of experimental steers are shown in Table 1. The burned pasture generally produced more forage during the collection period than the unburned pasture. A similar pattern was noted in average daily gain.

Chemical Composition

Ash content of esophageal samples (Table 2) was consistently higher than that of the hand clipped samples, possibly because of salivary contamination. The amount and composition of salivary contamination usually varies with types and amounts of feed consumed. Bath et al. (1956) showed that ash content of chopped alfalfa increased while passing through esophageal fistulae.

Crude protein was higher in esophageal samples than in hand-clipped samples, but there was no difference between protein content due to burning. Forage selected by ruminants was generally higher in protein than were hand-clipped samples. Bredon et al. (1967) posited that selective grazing explained a 66% increase in crude protein of fistula forage collected from cattle grazing tropical forage pastures over that of clipped pasture forage. Average compositions of all grasses we analyzed showed crude protein of leaves was 55% higher than crude protein of whole plants. Animals seem to have the ability to select a diet high in protein within limits, however, because protein content of diets selected declined as the season advanced (8.84% to 5.12%). A similar trend in grazing habits has been reported on Sand Hills ranges (Scales et al., 1971).

Crude fiber and nitrogen-free extract were lower in esophageal samples than in hand-clipped samples. Sample by months interaction was significant for both sampling techniques demonstrating selective grazing of forage low in crude fiber. Results were similar when hand-clipped samples were compared with samples from esophageal fistulae of sheep grazing Utah ranges (Edlefsen et al., 1960), from steers on New Mexico ranges (Keisling et al., 1968), and from steers on Orchardgrass-Ladino clover pastures (Coleman and Bath, 1972). Burning lowered lignin content 10.06 vs. 8.86%. Significant interactions were also observed between sample by months and treatment by months. Acid detergent fiber was lower in esophageal samples than in hand-clipped samples. One interaction between sample by months was significant due to animal selection as the grass matured. Our results agree with those of Coleman and Barth (1972), but not those of Keisling et al. (1968), who reported more detergent fiber in esophageal

Table 1. Steer growth and forage availability on native bluestem pastures.

Treatment and measurement	June	July	August	September
Nonburned pasture				
Dry matter available (kg/ha)	1912	2964	2968	2387
Intact steers' avg daily gain (g)	309	369	423	119
Esophageal steers' avg daily gain (g)	–	139	490	–90
Burned pasture				
Dry matter available (kg/ha)	2151	2639	3815	2690
Intact steers' avg daily gain (g)	695	545	636	100
Esophageal steers' avg daily gain (g)	–	130	252	22

Table 2. Means and standard errors of chemical constituents (% of total dry matter) of pasture samples.

Sample	Ash	Crude protein	Crude fiber	N-free extract
Collection method				
Esophageal	10.13^{a}[1]	6.94^{a}	28.26^{a}	42.96^{a}
Hand clipped	8.23^{b}	4.30^{b}	30.69^{b}	44.96^{b}
S. E.	0.21	0.17	0.36	0.26
Collection month				
June	7.97^{a}	7.35^{a}	28.76^{a}	44.85^{a}
July	8.82^{a}	6.96^{a}	30.16^{a}	41.79^{b}
August	9.44^{b}	5.12^{b}	30.94^{a}	43.89^{a}
September	10.21^{b}	5.04^{b}	27.31^{b}	44.37^{a}
October	9.44^{b}	3.75^{c}	30.20^{a}	44.92^{a}
S. E.	0.33	0.27	0.57	0.41

[1]Unlike superscripts in columns indicate significant differences ($P<0.05$).

Table 3. Means and standard errors of cell-wall constituents (% of total dry matter) of pasture samples.

Collection method and month	Neutral detergent fiber	Ash free neutral detergent fiber	Acid detergent fiber	Hemi-cellulose	Cellulose	Lignin
Esophageal method						
June	83.23a[1]	80.38a	46.69a	39.58a	46.88a	8.12a
July	87.82b	84.40b	47.75a	39.33a	54.63b	7.76a
August	84.69a	81.21a	51.17b	32.33b	49.01a	9.80c
September	75.75c	72.36c	45.65a	31.04b	49.18a	12.46b
October	81.57a	77.64a	51.23b	28.33c	48.68a	9.07c
Hand clipped method						
June	76.46a	73.78a	51.15a	33.20b	50.62a	9.16a
July	80.48b	77.71b	52.88a	34.30c	48.94a	8.77a
August	78.81b	76.16b	53.06a	32.64b	48.96a	9.26a
September	80.94b	77.16b	56.54b	29.71a	49.44a	10.10a
October	85.76c	82.35c	59.71c	30.35a	49.71a	10.12a
S. E.	1.69	1.67	0.99	1.34	0.82	0.51

[1] Unlike superscripts in columns indicate significant differences ($P<0.05$).

samples than in hand-clipped samples. Other cell-wall constituents were significantly influenced by stage of growth (months) and the sample by months interaction.

Digestibility

In vitro dry matter and organic matter digestibilities were higher in esophageal samples than in hand-clipped samples (Fig. 1), with differences between months also significant. July samples were the most digestible. Digestibility decreased 8 to 9 units between June and October. The sudden decrease in digestibility during August was primarily from an increase in lignin content in both esophageal and hand-clipped samples (Table 3).

Prediction Equations

Multiple regression analyses of the data were made using a stepwise deletion procedure to obtain the best fit to accurately predict in vitro dry matter digestibilities. Crude protein, organic matter, ash free neutral detergent fiber, acid detergent fiber, and lignin data obtained from pasture samples were used as independent variables. The best regression equation was obtained with crude protein and acid detergent fiber as shown below. The two regressions were significant with r values of 0.87 and 0.81, respectively.

$$\hat{Y}(DMD) = -77.56 + 1.711(CP) + 4.7(ADF) - 0.05(ADF)^2$$

$$\hat{Y}(OMD) = -110.64 + 1.78(CP) + 5.84(ADF) - 0.06(ADF)^2$$

DMD and *OMD* = In vitro dry matter and organic matter digestibilities (%)

CP = Crude protein (%)

ADF = Acid detergent fiber (%)

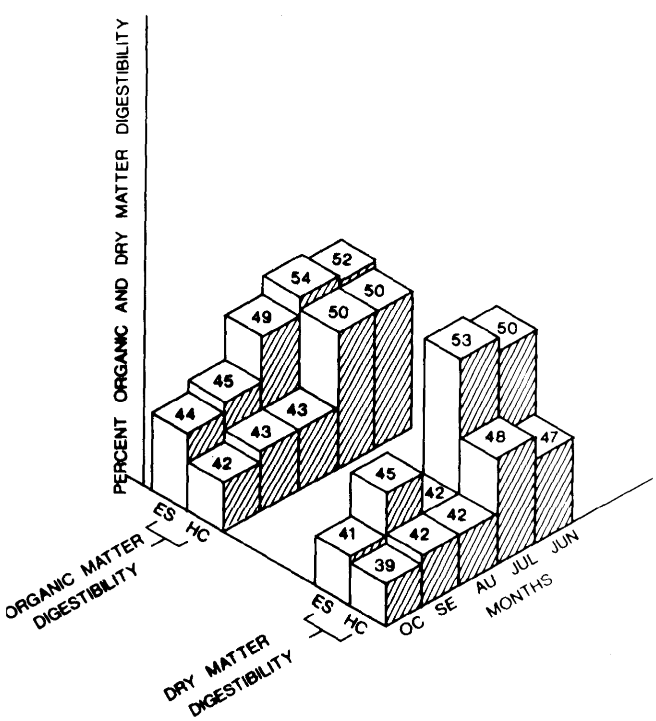

Fig. 1. *Percentages of in vitro organic and dry matter digestion of pasture samples compared.*

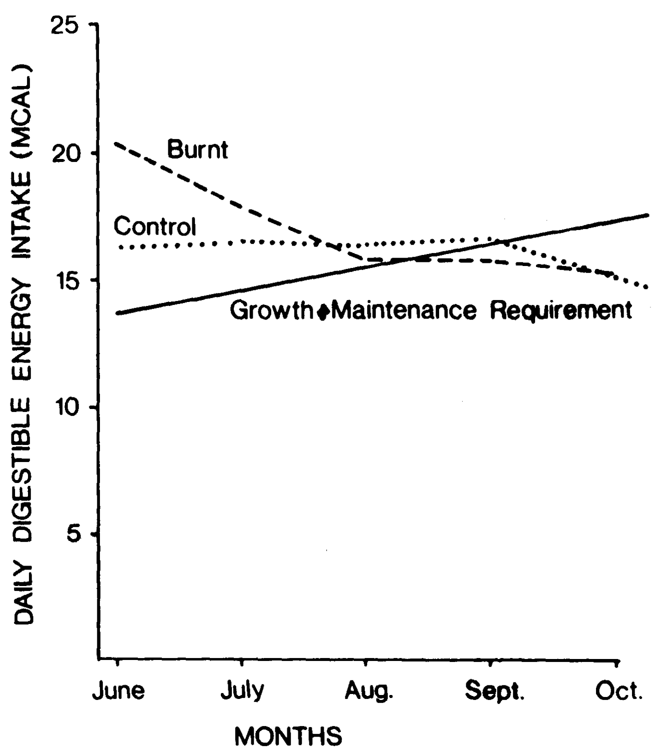

Fig. 2. *Amount of digestible energy required for maintenance plus 0.5 kg daily gain by 200-kg yearling steers and the amount available from range forage.*

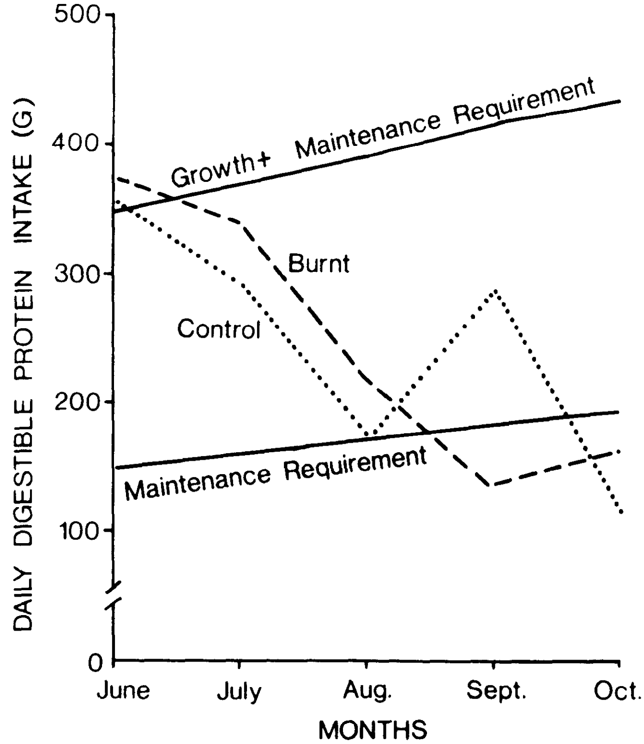

Fig. 3. *Amount of digestible protein required for maintenance plus 0.5 kg daily gain by 200-kg steers and the amount available from range forage.*

Figures 2 and 3 illustrate the probable digestible energy and digestible crude protein that animals will receive from Flint Hills range. The data were calculated using a regression equation developed by metabolism trials with bluestem hays.

$\hat{Y}_{(OMI)} = 1.128 + 1.7524\ (F \times N)$ where

$\hat{Y}_{(OMI)}$ = Estimated organic matter intake (kg/day)

F = Fecal organic matter output (kg/day)

N = Fecal nitrogen (g/100 g dry matter)

Theoretical needs of a 200-kg steer gaining 0.5 kg/day are also presented.

Our data indicate that protein becomes limiting about mid-July and energy, in late August. Steers on our control pasture gained an average 350 g/day during June, July, and August, while the corresponding steer gain on burned pasture averaged 600 g/day. Growth rate usually drops during September (Anderson et al., 1970), suggesting that protein may be limiting by late July. Oregon pastures gave similar responses earlier in the grazing season (Raleigh, 1970).

Literature Cited

Anderson, K. L., and C. F. Fly. 1955. Vegetation-soil relationships in Flint Hills bluestem pastures. J. Range Manage. 8:163-169.

Anderson, K. L., E. F. Smith, and C. E. Owensby. 1970. Burning bluestem range. J. Range Manage. 23:81-92.

Association of Official Agricultural Chemists. 1970. Official methods of analysis of the A.O.A.C. (Washington, D. C.). 1015p.

Bath, D. L., W. C. Weir, and D. T. Torell. 1956. The use of the esophageal fistula for the determination of consumption and digestibility of pasture forage by sheep. J. Animal Sci. 15:1166-1171.

Bredon, R. M., D. T. Torell, and B. Marshall. 1967. Measurement of selective grazing of tropical pastures using esophageal fistulated steers. J. Range Manage. 20:317-320.

Coleman, S. W. and K. M. Barth. 1972. Factors affecting grazing selectivity. J. Animal Sci. 34:357.

Draper, N. R., and H. Smith. 1966. Applied Regression Analysis. John Wiley and Sons (New York). 407p.

Edlefsen, J. L., C. W. Cook, and J. T. Blake. 1960. Nutrient content of the diet as determined by hand-plucked and esophageal fistula samples. J. Anim. Sci. 19:560-567.

Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analysis. U. S. Dep. Agr. Agr. Sci. Handbook No. 379. (Washington, D. C.). 20p.

Harvey, W. R. 1960. Least-squares analysis of data with unequal subclass numbers. U. S. Dep. Agr., Agr. Res. Serv. Bull. No. 20-8. 157p.

Herbel, C. H., and K. L. Anderson. 1959. Response of True Prairie vegetation on major Flint Hills range sites to grazing treatment. Ecol. Monogr. 29:171-186.

Keisling, H. E., A. B. Nelson, and C. H. Herbel. 1968. Effect of the esophageal fistula on chemical composition of feeds. J. Anim. Sci. 27:1183.

Lesperance, A. L., V. R. Bohman, and D. W. Marble. 1960. Development of techniques for evaluating grazed forage. J. Dairy Sci. 43:682-689.

Raleigh, R. J. 1970. Symposium on pasture methods for maximum production in beef cattle: Manipulation of both livestock and forage management to give optimum production. J. Anim. Sci. 30:108-114.

Scales, G. H., C. L. Streeter, and A. H. Denham. 1971. Nutritive value and consumption of range forage. J. Anim. Sci. 33:310.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481p.

Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. British Grasslands Soc. 18:104-111.

Van Dyne, G. M., and D. T. Torell. 1964. Development and use of the esophageal fistula: A review. J. Range Manage. 17:7-19.

Van Soest, P. J., and R. H. Wine. 1968. Determination of lignin and cellulose in acid-detergent fiber with permanganate. J. Assoc. Off. Agr. Chem. 55:780-785.