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Cattle diet quality under short duration grazing on tallgrass prairie

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Abstract

Paddocks of tallgrass prairie were grazed at intervals similar to 8-paddock short duration grazing. Two replicates of a 2 × 3 factorial treatment design were evaluated to determine the influence of stocking rate and grazing schedule on crude protein and digestible organic matter content of cattle diets. Stocking rates were 1.3 or 1.8 multiples of the rates recommended by the Soil Conservation Service for the study site. Grazing schedules were 2, 3, or 4 complete cycles during a 152-day grazing season. Grazing and rest periods were lengthened as the season progressed and forage accumulation rate slowed. Masticate samples were collected from the experimental paddocks on alternate days during the grazing periods in 2 consecutive years. No stocking rate by grazing schedule interactions were observed (P>0.10). Diet crude protein was depressed (P<0.05) slightly at the higher stocking rate. Diets collected from the 4-cycle paddocks contained more (P<0.05) protein than diets from the 2- and 3-cycle paddocks. Diets from the 2- and 3-cycle paddocks were not different (P>0.20). In vitro digestibility was not influenced by stocking rate but tended (P<0.13) to be higher for the 3- and 4-cycle grazing schedules. The balance of crude protein and digestible organic matter was most favorable (P<0.05) for the 3-cycle diets. Based on diet composition, more frequent grazing periods appeared to maintain a higher, more stable plane of nutrition than the slower rotation schedules.

Key Words: cattle, diet, grazing systems, stocking rate

An objective of grazing management is to optimize the efficiency of forage harvest by grazing livestock while providing sufficient periods of time for desirable plants to recover from defoliation. Accompanying this objective is the desire to provide an environment conducive to a high and stable plane of nutrition for the livestock grazing in the system. Multipaddock, single-herd grazing systems may provide the flexibility to manipulate grazing to achieve these objectives.

Rotation schedules are generally developed based on the length of rest periods required between defoliations (Savory 1988), with the length of rest being determined by the rate of forage accumulation and severity of defoliation in the previous grazing period. The length of rest periods can impact the plane of nutrition and performance of livestock by altering (1) the amount, quality and heterogeneity of forage accumulated in the paddocks between grazing periods, and (2) grazing intensity (the product of stocking density and length of grazing period) during a grazing period (Denny and Barnes 1977; Hodgson 1977).

The information presented in this report is part of a broader effort to determine the effects of stocking rate and length of rest periods on vegetation dynamics and nutrition of cattle grazing tallgrass prairie. Standing crop dynamics and tiller defoliation aspects have been presented in previous publications (Brummer et al. 1988; Gillen et al. 1990; Gillen et al. 1991). We hypothesized that in seasonal grazing programs, shorter rest periods with more frequent grazing periods would maintain better diet quality by reducing forage accumulation between grazing periods, and by reducing grazing pressure on desirable sward components, especially in the late season when forage growth has slowed and the mixture of desirable an undesirable sward components is more heterogeneous. In contrast, longer rest periods will allow accumulation of lower quality forage between grazing periods early in the growing season (Brummer et al. 1988) and result in higher grazing pressure on the desirable sward components during lengthened grazing periods. In addition, we hypothesized that diet quality would be reduced at higher stocking rates.

Study Area

The study was conducted on the Oklahoma Agricultural Experiment Station Research Range approximately 21 km southwest of Stillwater, Okla. Climate of the area is continental with an average growing season of 204 days extending from April to October. Annual mean temperature is 15°C with average minimum and maximum temperatures ranging from -4.3°C in January to 34°C in August. Precipitation in Stillwater averages 831 mm with 65% falling as rain between May and October (Myers 1982).

The study area was established on native tallgrass prairie. Dominant range sites were loamy prairie and shallow prairie. Soils on the loamy prairie site are in the Coyle series and comprise about 60% of the area. This series has a fine sandy loam surface with a sandy clay loam subsoil and is a member of the fine-loamy, siliceous, thermic family of Udic Arguistolls. Soils on the shallow prairie site are in the Grainola series and comprise about 35% of the area. The series has a loam surface with a silty clay loam subsoil and is a member of the fine, mixed, thermic family of Vertic Haplustalfs.

Vegetation on the area was dominated by big bluestem [*Andropogon gerardii* Vitman], little bluestem [*Schiza-chyrium sco-*

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parium (Michx.) Nash], and switchgrass [*Panicum virgatum* L.]. Each species comprised approximately 20% of the standing crop in August 1984. Other important species included indiangrass [*Sorghastrum nutans* (L.) Nash], tall dropseed [*Sporobulus asper* (Michx.) Kunth], and western ragweed [*Ambrosia psilostachya* DC.]. The entire area was burned each year approximately 4 weeks before the start of the grazing season.

Methods

Grazing treatments consisted of 2 replications of a factorial arrangement of 3 rotation schedules and 2 stocking rates. Treatments were applied to 12 individual paddocks (3x2x2) representing paddock number 4 in an 8-paddock short duration grazing system. Short duration grazing was simulated by grazing the test paddocks during scheduled grazing periods.

Rotation schedules were based on the number of grazing cycles (2, 3, or 4) in an 8-paddock cell that could be completed in a 152-day spring-summer grazing season (Table 1). Graze/rest periods were gradually lengthened during the season as forage accumulation rate slowed and vegetation matured (Table 1). Each test paddock was grazed a total of 19 days each season.

Table 1. Grazing and rest periods utilized under the 3 grazing schedule treatments.

Grazing schedule	Grazing Cycle 1	2	3	4	Mean
	(Days grazing/ days rest)				
2-cycle	6/42	13/91	—	—	10/67
3-cycle	4/28	6/42	9/63	—	6/44
4-cycle	3/21	4/28	5/35	7/49	5/33

The grazing season was initiated between 15 April and 1 May based on forage availability. Grazing periods for the test paddocks were scheduled on the appropriate dates following the initiation of the grazing season. For instance, if the grazing season was initiated on 1 May, the first grazing period for paddocks in the 4-cycle treatment began 9 days (3 paddocks x 3 days grazing/paddock) later on 10 May and extended through 12 May while the first grazing period for paddocks on the 2-cycle treatment began on 19 May (3 paddocks x 6 days grazing/paddock) and extended through 24 May.

Stocking rates were intended to be 1.3 (light) and 1.8 (heavy) times recommended moderate use stocking rates for the range sites under study. Moderate stocking rates recommended by the Soil Conservation Service for continuous summer grazing on these range sites are 65 to 85 AUD ha^{-1}. Actual stocking rates were 110 and 154 AUD ha^{-1}, respectively, for the light and heavy treatments. Paddock areas were 0.40 ha (light) and 0.48 ha (heavy). Stocker steers and heifers with average seasonal weights of 315 kg were used to graze the paddocks. Three head were grazed on the light stocking rate and 5 head were grazed on the heavy stocking rate paddocks.

Crude protein and digestible organic matter content of diets grazed from the treatment paddocks were evaluated during the 2 grazing seasons. Masticate samples were collected during each grazing period using beef steers with an esophageal fistula. Surgery was conducted by a licensed staff veterinarian at the Oklahoma State University School of Veterinary Medicine. The fistulated steers were maintained on an adjacent area with similar vegetation and stocked at a density similar to the treatment areas.

Masticate samples were collected on the first and last days, and alternate days within each grazing period. This resulted in 11 sampling days for each treatment in each year. For instance, the 2-cycle paddocks were sampled on days 1, 3, 5, and 6 of cycle 1, and days 1, 3, 5, 7, 9, 11, 13 of the second cycle. Three fistulated steers were assigned to each replication each year and were used to collect samples from all paddocks in each replication. As illustrated in Figure 1, grazing periods for the 2, 3, and 4-cycle treatments did not overlap therefore, sampling occurred in 2 paddocks (heavy or light stocking rate) per replication on any given sampling day.

The fistulated steers were penned at dawn and samples were collected between 0700 and 0900 hour. During sampling, the steers were allowed to graze freely across the paddocks for 15 to 20 minutes. In general, the cattle visited all areas of the paddocks during this time period. Masticate samples were composited across steers within treatment paddock, replication, and day.

Samples were stored frozen in plastic bags then thawed at room temperature, and dried in a forced air oven at less than 30°C. During drying, the samples were mixed frequently to prevent overheating, speed the drying process and reduce the potential for artifact lignin formation. Drying was complete in 12-16 hours. We realize that this is not the optimal method for drying masticate, however, at the time of the study, this was the only alternative available. In addition, the impacts of oven-drying should have had minimal impacts on relative differences among treatments.

Samples were ground through a 2mm screen in a Wiley mill before analyses for dry matter, ash, and kjeldahl N (AOAC 1984). Crude protein was calculated as 6.25 x N. In vitro organic matter disappearance was determined with a two-stage rumen inoculum-pepsin incubation procedure (Galyean 1983). Inoculum was obtained from a steer consuming prairie grass hay ad libitum in addition to 0.9 kg/day soybean meal. All measurements were adjusted to an organic matter basis.

Diet composition data were analyzed as a split block design with repeated measures using general linear models procedures. The model included block, rotation schedule, stocking rate, and schedule x stocking rate; year was treated as a repeated measure. Schedule and stocking rate effects were tested using schedule x block and stocking rate x block, respectively, as error terms. The schedule x stocking rate effect was tested with the block x schedule x stocking rate interaction. Year and the two- and three-way interactions including year, schedule and stocking rate were tested with the residual error term. No interactions of year with grazing schedule and/or stocking rate were detected (P>0.20).

Regression lines were developed for each grazing schedule treatment to profile estimated differences in diet crude protein across the grazing season. Data for each grazing schedule were pooled across stocking rate treatments and years.

Results and Discussion

From November 1984 through October 1985, precipitation was 51% above average. However, from July through October rainfall was about average. This resulted in excellent growing conditions in the early portion of the 1985 grazing season and poor but normal growing conditions for the latter half of the season. Precipitation was 24% above average from November 1985 through October 1986. Rainfall was about average through July but was about 100% above average in August and September. This resulted in good growing conditions throughout the 1986 grazing season.

The stocking rates resulted in light forage utilization during the 2 study years (Brummer et al. 1988). Brummer et al. (1988) attributed this to the above average growing conditions encountered in both

Table 2. Herbage allowance at the initiation of each grazing period for different stocking rates and rotational grazing schedules on tallgrass prairie (Brummer 1986).

Grazing schedule	Stocking rate	Grazing cycle 1	2	3	4
		-Herbage allowance (kg herbage/AUD -			
Year 1					
2-cycle	1.3	50	57	—	—
	1.8	30	35	—	—
3-cycle	1.3	68	101	87	—
	1.8	53	68	60	—
4-cycle	1.3	69	89	121	105
	1.8	60	76	87	76
Year 2					
2-cycle	1.3	50	62	—	—
	1.8	33	37	—	—
3-cycle	1.3	61	91	87	—
	1.8	45	62	58	—
4-cycle	1.3	80	110	119	100
	1.8	65	62	81	58

years of study. It is also possible that recommendations from the Soil Conservation Service were too conservative.

Herbage allowance remained above 30 kg/animal-unit day throughout the trials (Table 2; Brummer 1986). Brummer et al. (1988) reported that herbage disappearance was similar among the treatments and concluded, based on previous studies by Ralphs et al. (1986) and Allison et al. (1982), that grazing pressures may have been too low for stocking rate to affect herbage disappearance (kg AUD^{-1}). Severity of defoliation of big bluestem and little bluestem tillers indicated moderate defoliation during the various grazing periods (Gillen et al. 1990).

Masticate collected from the light stocking rate treatment contained more ($P<0.05$) crude protein than masticates from the heavily stocked paddocks (Table 3). Assuming equal daily forage intake between treatments, the difference equates to approximately 12 g crude protein day^{-1} for a 250 kg beef steer, or 21 g crude protein day^{-1} for a 454 kg cow, consuming 2.25 kg forage/100 kg of body weight. Diet crude protein was also depressed at higher stocking rates in simulated short duration grazing systems on a Schizycharium/Paspalum/Quercus savannah in central Texas (Olson 1984) and a mixed-grass community in southwest Texas (Ralphs et al. 1986).

The 4-cycle schedule allowed cattle to select diets containing more ($P<0.05$) crude protein than the 2- or 3-cycle schedules (Table 3). Assuming a constant daily forage intake of 2.25 kg forage/100 kg body weight, crude protein intake would have been reduced approximately 48 and 54 g day^{-1} for a 250 kg steer or 454 kg cow, respectively, grazing the 2- and 3-cycle paddocks. In addition to the higher protein concentration, comparison of the coefficients of variation (Table 6) for the grazing schedule treatments indicated that diet protein content was relatively more stable in relation to the treatment mean with the shorter, more frequent grazing periods in the 4-cycle schedule.

Table 3. Crude protein (grams/kilogram, organic matter basis) in the esophageal masticate of cattle grazing tallgrass prairie at different stocking rates and rotational grazing schedules.

Stocking rate[f]	Grazing schedule[e] 2	3	4	Mean	SE[g]
1.3	93.8	93.8	102.7	96.8[c]	.07
1.8	91.3	92.7	100.2	94.7[d]	
Mean	92.5[a]	93.3[a]	101.5[b]		
SE[g]		1.6			

[a,b] Row means are different ($P<0.05$).
[c,d] Column means are different ($P<0.05$).
[e] Cycles through an 8-paddock cell.
[f] Multiples of recommended moderate use stocking rates.
[g] Standard error of the mean; n=132 for stocking rate; n=88 for grazing schedule.

Table 4. In vitro digestible organic matter (grams/kilogram) in the esophageal masticate of cattle grazing tallgrass prairie at different stocking rates and rotational grazing schedules.

Stocking rate[b]	Grazing schedule[a] 2	3	4	Mean	SE[c]
1.3	520.6	545.8	541.9	536.1	2.8
1.8	530.9	536.4	534.1	533.8	
mean	525.7	541.1	538.0		
SE[c]		4.5			

[a] Cycles through an 8-paddock cell.
[b] Multiples of recommended moderate use stocking rates.
[g] Standard error of the mean; n=132 for stocking rate; n=88 for grazing schedule.

In vitro organic matter digestibility was not different for masticate collected from the 2 stocking rates (Table 4). However, the masticates collected from the 3- and 4-cycle treatments tended ($P<0.13$) to be more digestible than masticate selected by cattle grazing the 2-cycle paddocks. Based on coefficients of variation, digestibility was more variable in relation to the treatment mean for diets in the 3-cycle paddocks. This observation is similar to the variation noted for diet crude protein and suggested that the 3-cycle treatment, either due to timing of grazing during the growing season and/or length of grazing periods, may cause larger swings in nutrient intake.

The ratio of digestible organic matter to crude protein is an index of the balance of nutrients available to the ruminal microbial population (Hogan 1982) and can indicate when an imbalance may lead to reduced animal performance due to reduced ruminal fermentation and forage intake (Moore 1992). A ratio of about 4:1 is considered optimal (Hogan 1982) while ratios in excess of 6-8:1 have been associated with depressions in forage intake (Moore 1992). Again, the optimal treatment was the 4-cycle schedule with the lowest ($P<0.05$; Table 5) and least variable (Table 6) ratio of digestible organic matter and crude protein. The 2-cycle schedule provided diets with ratios intermediate ($P<0.05$) to the 3- and 4-cycle treatments while diets from the 3-cycle treatment had the poorest and most variable balance of digestible organic matter and crude protein.

The estimated seasonal decay curves for masticate crude protein on each grazing schedule treatment are shown in Figure 1. It appears

Table 5. The ratio of digestible organic matter:crude protein in the esophageal masticate of cattle grazing tallgrass prairie at different stocking rates and rotational grazing schedules.

Stocking rate[e]	Grazing schedule[d] 2	3	4	Mean	SE[f]
1.3	5.8	6.4	5.6	5.9	.11
1.8	6.1	6.3	5.6	6.0	
Mean	6.0[a]	6.3[b]	5.6[c]		
SE[f]		.08			

[a,b,c] Means are different ($P<0.05$).
[d] Cycles through an 8-paddock cell.
[e] Multiples of recommended moderate use stocking rates.
[f] Standard error of the mean ; n=132 for stocking rate; n=88 for grazing schedule.

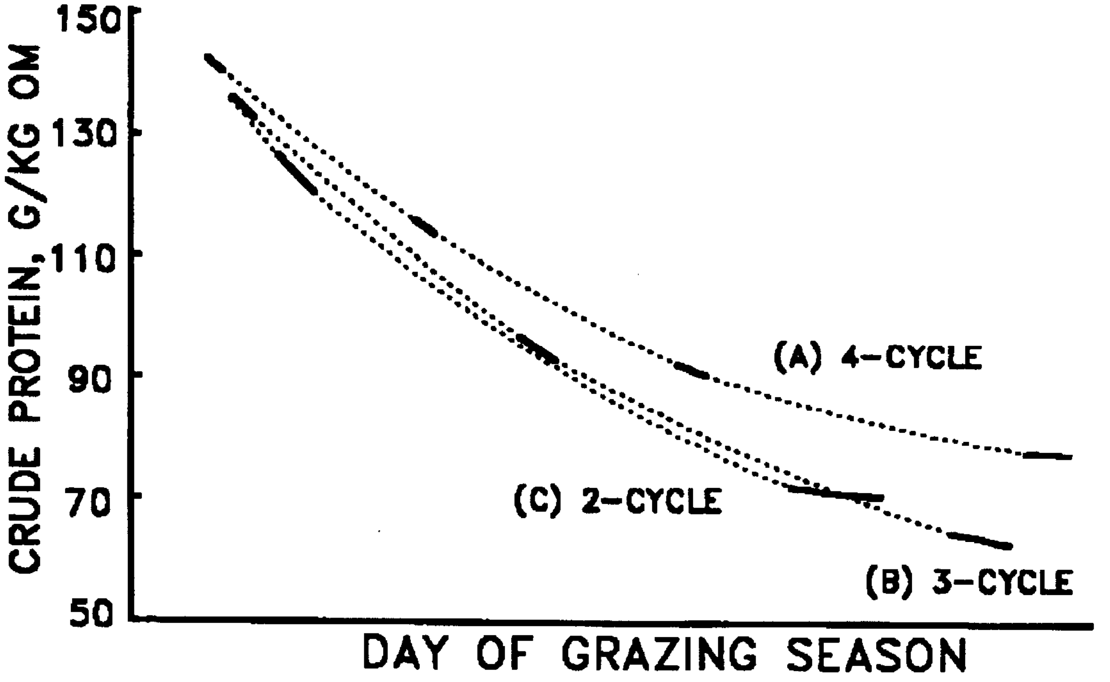

Fig. 1. Estimated seasonal decay curves for crude protein concentration (g/kg organic matter) in the esophageal masticate of cattle grazing tallgrass prairie at different stocking rates and rotational grazing schedules. Solid segments of each line represent the sampling periods during the grazing season; dotted segments are estimated by regression.

that the second grazing period in the 4-cycle treatment may have staged the paddocks in a manner that resulted in higher diet protein in the remainder of the grazing season. Brummer et al. (1988) observed that standing crop within each treatment paddock reached similar peak levels. But in 1985, standing crop peaked in the 2- and 3-cycle paddocks in mid-July while peak standing crop in the 4-cycle paddocks was observed in August. A similar tendency was observed in 1986 (Brummer et al. 1988). It is logical to assume that forage quality was lower on the paddocks that reached peak standing crop at an earlier date.

Based on the seasonal profiles, estimated diet crude protein was similar among the 3 treatments early in the grazing season. On day 10, estimated crude protein ranged from 141 to 142 g/kg organic matter for the 3 treatments. But as the season progressed differences between the 4-cycle treatment and the 2- and 3-cycle treatments increased. On day 50, the 4-cycle diets were estimated to contain 8 and 16 g/kg organic matter more crude protein than the 3- and 2-cycle diets, respectively. On days 90 and 130, the estimated differences between the 4-cycle and 3-cycle diets had increased to 12 and 16 g/kg organic matter, respectively. Estimated differences between the 4-cycle and 2-cycle diets were 11 and 16 g/kg on days 90 and 130, respectively.

Tallgrass prairie accumulates forage at relatively rapid rates during late spring and early summer with peak standing crop occurring in July) Brummer et al. 1988). During this same period, the quality of available forage and grazed diets decreases severely (Waller et al. 1972; Campbell and McCollum 1989). Accompanying the changes in standing crop and quality is an increase in the heterogeneity of plant material available to grazing livestock. The shorter, more frequent grazing periods in the 4-cycle treatment resulted in cattle selecting diets of higher quality with a better balance of crude protein and digestible energy than the other slower rotation schedules. The shorter rest periods on the 4-cycle treatment resulted in paddocks being regrazed more frequently when the forage was at more immature stages of growth. The shorter grazing periods reduced grazing pressure (Table 2) on the desirable sward components during any single grazing period which probably contributed to better diet quality. In contrast, the longer rest periods for the 2- and 3-cycle treatments accumulated lower quality forage and the longer grazing periods increased grazing pressure on the more desirable components leading to consumption of plants and plant parts of lower quality. Coefficients of variation were higher for the 3-cycle treatment suggesting that cattle grazing under this program may have been subjected to wider swings in nutrient intake than cattle grazing under the other 2 grazing schedules. The 2-cycle treatment resulted in diets of lower quality but with less variability (as indicated by the CVs). The lower variability compared to the 3-cycle treatment may be associated with less frequent moves which resulted in longer grazing periods and hence less opportunities for swings in diet quality.

The frequency of defoliation of big bluestem and little bluestem tillers increased with frequency of grazing (faster rotation) with more than 20% of big bluestem tillers being defoliated during every grazing period on the 4-cycle schedule (Gillen et al. 1990). Citing previous clipping studies, Gillen et al. (1990) expressed some concern that

Table 6. Coefficients of variation for crude protein (CP), digestible organic matter (DOM), and the ratio of digestible organic matter:crude protein (DOM:D)) in the esophageal masticate of cattle grazing tallgrass prairie on different rotational grazing schedules.

	Grazing schedule[a]			Stocking rate[b]	
Item	2	3	4	1.3	1.8
CP	27.5	30.9	24.4	27.8	27.4
DOM	9.2	10.7	9.2	9.7	9.6
DOM:CP	21.0	25.7	19.0	21.7	22.1

[a] Cycles through an 8-paddock cell; 88 observation per CV.
[b] Multiples of recommended moderate use stocking rates; 132 observations per CV.

this frequency of defoliation would have negative impacts on the vigor of big bluestem. However, over a 5-year period, no major differences in species composition of the study paddocks was observed (Gillen et al. 1991).

Conclusions

Our results indicate that intensive rotational grazing on tallgrass prairie should incorporate grazing and rest periods similar to, and possibly shorter than, the 4-cycle treatment in our study. This will aid in maintaining a higher and more stable plane of nutrition for the cattle by allocating more grazing days per paddock to the early part of the growing season when forage quality is highest. Shorter grazing periods in the late growing season should theoretically maintain a better plane of nutrition by reducing grazing pressure, during any single grazing period, on the desirable forage in the paddocks.

It was not possible to measure forage intake on the various treatments. The datas from this study give some indication of the ability of cattle to select diets under the various grazing regimens. However, it is possible that any differences in diet quality could be negated if selective grazing resulted in altered bite size, grazing time and forage intake.

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