Tiller defoliation patterns under short duration grazing in tallgrass prairie

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Abstract

Simulated 8-pasture short duration grazing systems were studied in 1985–86 to determine the effect of grazing schedule and stocking rate on defoliation patterns of individual grass tillers of big bluestem (*Andropogon gerardii* Vitman) and little bluestem (*Schizachyrium scoparium* (Michx.) Nash). Treatments consisted of 3 grazing schedules (2, 3, or 4 rotation cycles per 152-day grazing season) and 2 stocking rates (1.3 and 1.8 times the recommended normal). Grazing schedule and stocking rate did not affect the percent tiller height reduction per grazing period except for the combination of 2-cycle grazing and heavy stocking which increased percent height reduction. Percent tiller height reduction per grazing period decreased over the grazing season for the 3 and 4-cycle grazing schedules. Grazing schedule and stocking rate had little effect on the height at which tillers were defoliated. Increasing the number of grazing periods reduced the percentage of tillers defoliated per grazing period but increased the cumulative defoliation frequency over the grazing season. Grazing schedule did not affect the percentage of tillers ungrazed over the entire grazing season. Big bluestem was consistently defoliated more intensely and frequently than little bluestem.

Key Words: rotation grazing, stocking rate, defoliation frequency, defoliation intensity

Defoliation regime or pattern is a major variable influencing plant response to grazing. Defoliation pattern is partially defined by the intensity (the amount of plant material removed) and frequency (the number of times a plant is defoliated in a given time period) of defoliation. Intensity and frequency of defoliation are negatively related to plant growth (Owensby et al. 1974, Dwyer et al. 1963, Jameson 1963). However, all individuals within a plant population will not experience the same defoliation regime unless grazing pressure is extreme. A plant population may slowly decline because the most heavily defoliated plants are weakened from overgrazing and die prematurely even though the average defoliation regime is moderate (Gammon 1978).

Over short measurement periods, the intensity and frequency of defoliation increases linearly as herbage allowance decreases (Hinnant and Kothmann 1986, Briske and Stuth 1982, Curll and Wilkins 1982, Hart and Balla 1982, Hodgson and Ollerenshaw 1969, Morris 1969, Hodgson 1966). This relationship becomes more variable as the period of measurement lengthens (Greenwood and Arnold 1968) and the number of species in the plant community increases (Hodgkinson 1980, Gammon and Roberts 1978a).

Only one study has compared defoliation patterns under different grazing schedules (Gammon and Roberts 1978a). Intermittent grazing reduced the number of tillers defoliated 3 or more times over a 12-month period but had little effect on the amount of herbage removed per defoliation (Gammon and Roberts 1978b, 1978c).

The objective of the current study was to determine defoliation patterns of individual grass tillers under different combinations of grazing intensity and frequency in tallgrass prairie vegetation.

Study Area

The study area was located on the Oklahoma State University Research Range approximately 21 km southwest of Stillwater, Oklahoma. The climate is continental with an average frost-free growing period of 204 days extending from April to October.

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Average precipitation at Stillwater is 831 mm with 65% falling as rain from May to October. Mean temperature is 15° C with average minimum and maximum temperatures ranging from -4.3° C in January to 34° C in August (Myers 1982).

Soils found on the area are primarily the Grainola and Coyle series, comprising approximately 60 and 35% of the area, respectively. The Grainola series has a loam surface with silty clay loam subsoil and is a member of the fine, mixed, thermic family of Vertic Haplustalfs. The Coyle series has a fine sandy loam surface with sandy clay loam subsoil and is a member of the fine-loamy, siliceous, thermic family of Udic Argiustolls. Range site classification of the Grainola soil is shallow prairie and the Coyle soil is loamy prairie.

The study area was established in 1984 on native tallgrass prairie. The area was dominated by big bluestem (*Andropogon gerardii* Vitman), little bluestem (*Schizachyrium scoparium* (Michx.) Nash), and switchgrass (*Panicum virgatum* L.), each comprising approximately 20% of the standing crop by weight in August 1984. Other important species included indiangrass (*Sorghastrum nutans* (L.) Nash), tall dropseed (*Sporobolus asper* Michx.) Kunth), and western ragweed (*Ambrosia psilostachya* DC.)

Methods

Experimental treatments consisted of 3 grazing schedules under 2 stocking rates. Grazing schedule treatments were based on the number of complete grazing cycles (2, 3, or 4) in an 8-pasture rotation that could be completed during a 152-day spring-summer grazing season. Within grazing schedule treatments, shorter graze/rest periods were used at the beginning of the grazing season when the vegetation was in a rapid growth stage. Graze/rest periods were gradually lengthened during the season as the vegetation matured (Table 1). Each treatment pasture received 19 total days of grazing.

Table 1. Days of grazing and rest per cycle for the 3 grazing schedule treatments.

Grazing schedule	Cycle 1		Cycle 2		Cycle 3		Cycle 4		Mean	
	DG[1]	DR[2]	DG	DR	DG	DR	DG	DR	DG	DR
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

[1]DG = Days of grazing per cycle.
[2]DR = Days of rest cycle.

Grazing began on 1 May and 19 April in 1985 and 1986, respectively. All pastures were burned approximately 4 weeks before the starting dates in both years.

Stocking rate treatments were set at 1.3 (light) and 1.8 (heavy) times the Soil Conservation Service recommended rate for the range sites under study. Three animals were grazed on 0.40-ha pastures to obtain the light stocking rate while 5 animals were grazed on 0.48-ha pastures to obtain the heavy stocking rate. Stocker steers and heifers with a starting weight of approximately 275 kg were used. Stocking rates averaged 110 AUD ha^{-1} for the light rate and 154 AUD ha^{-1} for the heavy rate.

Treatments were applied using a simulated 8-pasture short duration grazing system. Pasture number 4 in the rotation was used to determine the mean system effect. Grazing schedules and stocking rates were arranged factorially in a randomized complete block design with 3 replications.

Individual tillers of big bluestem and little bluestem were permanently marked with colored wire rings before the first grazing period in each treatment pasture. Ten tillers of each species were alternately and systematically located along 3, 20-m permanent transects for a total of 30 tillers of each species in each pasture.

Tillers were sampled before and after each grazing period. Tiller measurements included the presence/absence of defoliation, total tiller height with leaves extended, and the minimum height at which defoliation had occurred. The same tillers were sampled for the entire spring-summer grazing season. Lost tillers were replaced with the nearest tiller of the same species. Grazed edges of leaves and stems were marked with white latex paint to determine regrazing in subsequent grazing periods. Regrazing within a grazing period was not determined. Percent height reduction was calculated as the difference in tiller height before and after grazing divided by the tiller height before grazing. Means for grazing height and percent height reduction were based on defoliated tillers only.

All data were analyzed using analysis of variance techniques for a randomized complete block design with repeated measures. Grazing schedule and stocking rate were whole plot factors while species, cycles within schedules, and year were repeated factors. Pastures were experimental units. Tiller means within pastures were used as observations for the analysis. When significant treatment differences ($P = 0.05$) were indicated by the F-tests, treatment means were compared using least significant differences (LSD). Statistical procedures followed the methods of Milliken and Johnson (1984).

Regression analysis was used to determine the relationship between herbage allowance and percentage tillers grazed within a grazing period. Herbage allowance was calculated as the herbage standing crop at the start of a grazing period divided by the total animal-unit-days (AUD) during the period.

Results and Discussion

Precipitation was 51% and 24% above normal for 1985 and 1986, resulting in excellent growing conditions in both years. End-of-season standing crop in ungrazed control pastures averaged 6,060 kg ha^{-1} for the 2 study years. As a result of the above-average forage production, utilization levels were relatively low. Utilization (based on end-of-season standing crop in grazed and ungrazed pastures) averaged 31%, 27%, and 33%, for 2, 3, and 4-cycle grazing schedules, respectively, and 26% and 34% for light and heavy stocking rates (Brummer et al. 1988).

Defoliation Intensity

Percent Height Reduction

The percent height reduction per grazing period averaged 55% and was not affected by grazing schedule or stocking rate with one exception (Table 2). The longer grazing periods under the 2-cycle schedule coupled with the heavy stocking rate resulted in significantly greater percent height reduction. Big bluestem was defoliated more severely than little bluestem under all grazing schedules but the difference between species increased as the frequency of livestock movement decreased (Table 2). Percent height reduction for little bluestem was not affected by grazing schedule. Big bluestem tiller height removal only increased under the longer grazing

Table 2. Percent height reduction per grazing period for defoliated tillers averaged over years.

Grazing Schedule	Stocking Rate		Species	
	Light	Heavy	LB[1]	BB
2-Cycle	54	62	53	63
3-Cycle	54	55	50	59
4-Cycle	54	56	52	58
$LSD_{0.05}$	3		5	

[1]LB = little bluestem, BB = big bluestem

periods associated with 2-cycle grazing. There was a small, but significant, difference in height reduction between years, averaging 54 and 58% for 1985 and 1986, respectively ($P = 0.01$). Peak standing crop in ungrazed pastures was similar between years and the cause of the difference in percent height reduction between years was not clear. No other treatment factors or interactions significantly affected percent height reduction.

Within grazing schedules, percent height reduction tended to be highest in the early grazing periods and decreased as the season progressed (Table 3). Pierson and Scarnecchia (1987) also reported

Table 3. Percent height reduction and grazing height (cm) of defoliated tillers for individual cycles within grazing schedules averaged over species and years.

	Percent Height Reduction			Grazing Height		
	Grazing Schedule			Grazing Schedule		
Grazing Cycle	2-Cycle	3-Cycle	4-Cycle	2-Cycle	3-Cycle	4-Cycle
1	62	60	60	8	8	7
2	56	53	59	19	16	11
3	--	53	51	--	17	17
4	--	--	53	--	--	16
$LSD_{0.05}$	10	4	5	5	1	3

a decrease in defoliation intensity from early to late summer grazing periods. Less precise treatment comparisons under the 2-cycle schedule were attributed to fewer degrees of freedom in the analysis-of-variance as a result of fewer grazing periods (Total df = 47, 71, and 95 for the 2, 3, and 4-cycle treatments, respectively).

Grazing Height

Grazing schedule did not affect the height at which tillers were grazed (13, 14, and 13 cm for the 2, 3, and 4-cycle treatments, respectively; $P>0.05$). Stocking rate did not significantly affect the grazing height for little bluestem tillers (14 vs. 13 cm for light and heavy stocking; $P>0.05$) but big bluestem tillers were grazed to a lower height under heavy stocking (14 vs. 12 cm for light and heavy stocking; $P<0.05$). Grazing heights were slightly lower in 1986 than in 1985, 12 vs. 14 cm ($P<0.01$). No other treatment factors or interactions significantly affected grazing height.

Within grazing schedules, grazed height increased from early to late grazing periods (Table 3). Herbage was growing more rapidly than it was being consumed and was accumulating in the pastures. Tillers were not being grazed down to the same stubble height in each grazing cycle. Growth rates decline as the summer progresses (Gillen and McNew 1987) and this effect is reflected in smaller height differences between the later cycles in the 3 and 4-cycle grazing schedules. Similar accumulation patterns have been reported from Texas (Hinnant and Kothmann 1986).

Defoliation Frequency

The average percentage of grass tillers defoliated per grazing period decreased as the number of grazing cycles increased and the length of grazing periods decreased (Fig. 1). This effect was again more pronounced for big bluestem than little bluestem. Big bluestem is more palatable than little bluestem in the tallgrass prairie (Dwyer 1961). Heavy stocking increased the percentage of tillers defoliated per grazing period compared to light stocking (67 vs. 53%, $P<0.01$).

One guideline suggested for managing grazing periods under short duration grazing is to defoliate all tillers once before moving to the next pasture (Kothmann 1980). Under the current study conditions, this theoretical guideline could only be approached for the most palatable species under the longest grazing periods. Selectivity between species was present under all grazing schedules. The percentage of tillers defoliated during a grazing period was constant over cycles within grazing schedules (Table 4).

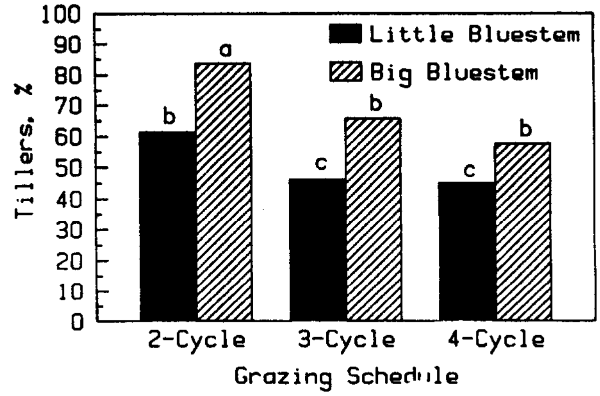

Fig. 1. Percent of grass tillers defoliated per grazing period. Bars with the same letters are not significantly different, $LSD_{0.05} = 9$.

There was a significant negative linear correlation between herbage allowance and percentage tillers defoliated within a period for both species ($P<0.01$). A relatively small amount of the variation in percentage tillers defoliated could be explained by the relationship ($r^2 = 0.29$ and 0.46 for little and big bluestem, respectively; N = 108). Herbage allowances ranged from 30 to 140 kg AUD^{-1} and perentage tillers defoliated per period ranged from 20 to 80% for little bluestem and from 35 to 100% for big bluestem.

Table 4. Percentage of tillers defoliated for individual cycles within grazing schedules averaged over species and years.

	Grazing Schedule		
Grazing Cycle	2-Cycle	3-Cycle	4-Cycle
1	74	57	53
2	71	54	55
3	--	57	51
4	--	--	47
$LSD_{0.05}$	NS	NS	NS

The percentage of tillers in different defoliation frequency classes (totaled over the grazing season) differed significantly among grazing schedules and species (Table 5). These defoliation frequencies should be considered minimums because tillers could have been defoliated more than once within a grazing period. It is most accurate to consider the defoliation frequencies as the number of discrete periods within the grazing season that the tillers were defoliated. About one-fifth of all little bluestem tillers were

Table 5. Tillers in 5 cumulative defoliation frequency classes (%, totaled over season) as affected by the interaction of grazing schedule and species.

	Frequency of Defoliation									
	0		1		2		3[1]		4[2]	
	Species		Species		Species		Species		Species	
Grazing Schedule	LB[3]	BB	LB	BB	LB	BB	LB	BB	LB	BB
2-Cycle	18	4	40	25	42	71	--	--	--	--
3-Cycle	20	9	33	22	32	30	14	39	--	--
4-Cycle	17	7	24	21	29	25	22	26	8	21
$LSD_{0.05}$	NS[4]		8		8		11		5[5]	

[1]3 and 4-Cycle treatments only
[2]4-Cycle treatments only
[3]LB = little bluestem, BB = big bluestem
[4]interaction nonsignificant; main effect of grazing schedule nonsignificant; main effect of species, LB = 19, BB = 7, $LSD_{0.05} = 5$
[5]LSD applies to main effect of species

not defoliated regardless of grazing schedule. More tillers were defoliated once or twice as the number of grazing cycles decreased. Defoliation was more variable as the frequency of livestock movement increased because tillers were spread over more frequency classes. Under 4-cycle grazing, 8% of the little bluestem tillers were defoliated during every period. Clipping little bluestem to a 5 cm height 4 times from July to September did not reduce stand density after 6 years but did reduce shoot and root production in an earlier study (Dwyer et al. 1963). However, a 5-cm defoliation height is much lower than observed in the current study.

Big bluestem tillers were consistently defoliated more frequently than little bluestem tillers (Table 5), reinforcing the basis for the preference rankings for these 2 species. Less than 10% of the big bluestem tillers were ungrazed under all grazing schedules. The longer grazing periods under 2-cycle grazing allowed 71% of the tillers to be defoliated at least twice, the highest proportion in any frequency class-treatment combination. As with little bluestem, increasing the number of grazing periods increased the spread of tillers across grazing frequency classes. Over one-fifth of all big bluestem tillers were defoliated during every grazing period under 4-cycle grazing. Other studies have suggested that such a defoliation frequency would have negative effects on big bluestem plant vigor and long-term population levels (Owensby et al. 1974, Dwyer et al. 1963).

Tiller defoliation was more frequent under heavy stocking rates than light stocking rates (Fig. 2). Briske and Stuth (1982) reported

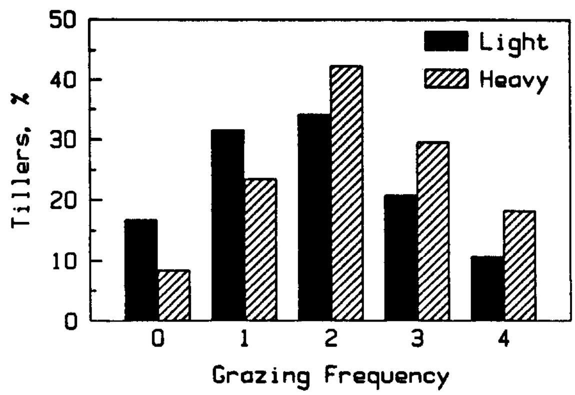

Fig. 2. Percent of grass tillers in cumulative defoliation frequency classes for light and heavy stocking. Percentages are significantly different between stocking rates for all frequency classes ($P = 0.05$).

a similar defoliation pattern as stocking rate increased. The only interaction between grazing schedule and stocking rate occurred in the twice-defoliated frequency class (Fig. 3). Stocking rate did not affect the number of tillers defoliated twice except under the 2-cycle grazing schedule. The longer grazing periods under 2-cycle grazing resulted in a significantly greater treatment effect on the heavy stocking rate.

Conclusions

When differences in tiller defoliation patterns occurred between grazing schedules, the 2-cycle treatment was usually different from the 3 and 4-cycle treatments which, in turn, were not different from each other. This pattern closely follows the initial differences between grazing schedules in terms of average days of grazing and rest within cycles (Table 1). There is less difference between the 3 and 4-cycle schedules than between these 2 schedules and the 2-cycle schedule.

Intensity of tiller defoliation was only affected by grazing schedule at the extremes of the other treatment factors, the heavy stocking rate or the most palatable species (big bluestem). Heavier

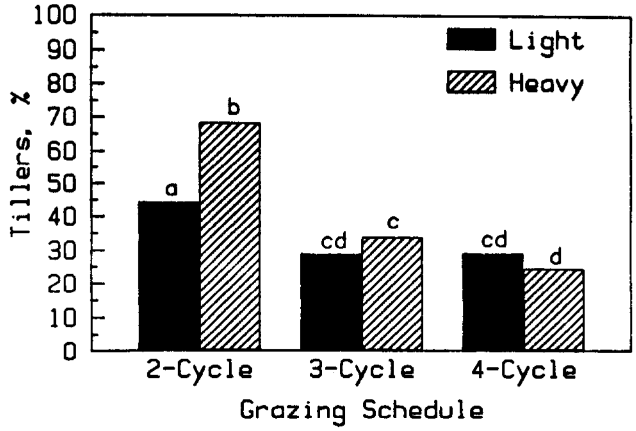

Fig. 3. Percent of tillers defoliated twice during the grazing season as affected by the interaction of grazing schedule and stocking rate. Bars with the same letters are not significantly different, $LSD_{0.05} = 9$.

stocking rates could be supported under the 3 and 4-cycle schedules without increasing percent tiller height removal or decreasing grazed height on individual tillers. This was accomplished by increasing the percent of tillers being defoliated during a grazing period. The 3 and 4-cycle schedules also tended to decrease differences in defoliation patterns between the 2 grass species. Percent tiller height removal within grazing periods was never more than 65%. This would indicate moderate defoliation since 50% of the weight of these grass tillers is contained in the lower 33% of the tiller height.

Grazing schedule did not affect the percent of tillers that were ungrazed over the entire season. The major effect of grazing schedule was to alter the frequency distributions of defoliated tillers. As the number of grazing periods increased, the opportunity for multiple defoliations increased. Comparing the 4-cycle schedule with the 2-cycle schedule, fewer tillers were defoliated 1 or 2 times but these tillers merely shifted into the higher defoliation frequency classes. Information is not available at this time to determine whether or not population stability can be maintained under these higher defoliation frequencies. The percent of big bluestem tillers defoliated 4 times under the 4-cycle grazing schedule (21%) underlines the importance of this point. The grazing treatments in this study will continue to be imposed for several more years to determine the impact of the observed defoliation patterns on long-term plant community response.

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