Little bluestem tiller defoliation patterns under continuous and rotational grazing

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Abstract

Defoliation patterns of little bluestem [Schizachyrium scoparium (Michx.) Nash] on tallgrass prairie were compared using continuous and rotational grazing systems on six 24-ha pastures for each system over a range of stocking rates (0.28 to 0.49 AU ha⁻¹) in 1991 and 1992. We tested the generalization that rotational grazing provides greater managerial control over the frequency, intensity, and uniformity of tiller defoliation compared to continuous grazing. Rotational system pastures were subdivided into 8 paddocks with 4 grazing cycles (3-7 day graze periods) per grazing season. Tillers were sampled biweekly in continuous system pastures and at the beginning, midpoint, and end of each grazing season. Multiple regression prediction equations were developed for grazed height, number of defoliation events in a grazing season, percent of tillers defoliated per rotation system, and number of defoliation events within a grazing cycle (rotational system). Grazed height decreased as stocking rate increased, but was not influenced by grazing system. The number of cumulative defoliation events per tiller increased with increasing stocking rate over the grazing season. Under similar stocking rates, a higher percentage of tillers were defoliated during the grazing season in the continuous than in the rotational grazing system. Within both grazing systems, percentage of tillers defoliated increased with increasing stocking rates. The percentage of tillers defoliated biweekly in continuous system pastures was similar over the grazing season; the percentage of tillers defoliated per cycle increased as grazing periods lengthened in rotational system pastures. A large number of tillers were defoliated during the second half of each grazing period. Less than 10% of tillers were regrazed within a grazing cycle, even at the highest stocking rate and longest grazing period. Rotational grazing provided greater managerial control over the frequency and uniformity of tiller defoliation; intensity of tiller defoliation was similar between the 2 grazing systems. We hypothesize higher range condition will be maintained over the long-term in rotational system pastures as little bluestem will remain more competitive and productive resulting from fewer defoliation events throughout the grazing season.

Key Words: defoliation frequency, grazed height, grazing system, range condition, Schizachyrium scoparium, stocking rate, tallgrass prairie

Little bluestem [Schizachyrium scoparium (Michx.) Nash], is one of the most important grasses in the tallgrass prairie and responds to defoliation as a decreaser (Brown and Stuth 1984). Yet, with many tillers per plant arranged in a caspitoise growth form, little bluestem is often underutilized by livestock. Patch grazing results from a high frequency (number of defoliations/time period) and intensity (amount of plant material removed/defoliation) of defoliation of a small percentage of the tillers (Hinnant and Kothmann 1986). A high frequency of tiller defoliation following the initial defoliation assumed to be the predominant mechanism in producing patch grazing in continuous grazing systems. Unrestricted selective grazing of specific plant species throughout the grazing season often leads to overgrazing and an eventual reduction in population structure (Butler and Briske 1988) and productivity of the most palatable species (Kothmann 1986). Intervals between defoliations are affected by the rate of growth of defoliated tillers, the degree of selection for or against previously defoliated tillers, and seasonal changes in herbivore preference among species (Gammon and Roberts 1978c).

Grazing managers have begun to implement rotational grazing systems to increase the uniformity of species utilization and increase carrying capacity compared to continuous grazing systems. Rotational grazing provides an opportunity, through manipulation of the length of grazing period, to improve control of the frequency, intensity, and uniformity of defoliation (Denny and Barnes 1977, Hinnant and Kothmann 1986). However, Gammon and Roberts (1978a, 1978b) found heights of grazing, frequency of defoliation, and patterns of selection to be similar between rotational and continuous systems. Therefore, the proposed benefits of additional control over defoliation intensity and frequency in rotational grazing systems have not been conclusively demonstrated.

The specific objective of this study was to determine the effect of continuous and rotation grazing systems over a range of stocking rates on little bluestem tiller defoliation patterns in tallgrass prairie. Our primary emphasis was to test the generalization that rotational grazing provides greater managerial control over the frequency, intensity, and uniformity of defoliation compared to continuous grazing. Defoliation pattern studies involving rotational and continuous grazing systems on tallgrass prairie are limited (e.g., Gillen et al. 1990). Multiple regression prediction equations were developed for comparison of the tiller defoliation patterns between the 2 grazing systems. These prediction equations can be used as tools by land resource managers in assessing, developing, and implementing grazing management strategies.

Study Area

The study area is located on the Oklahoma State University Research Range about 21 km southwest of Stillwater, Okla. (36° 3'...
The climate is continental with an average frost-free growing period of 204 days extending from April to October. 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).

Major range sites found on the area are shallow prairie (33%), loamy prairie (25%), and eroded prairie (22%). Sandy savannah dominates the remaining area. The shallow prairie sites have Grainola series soils (fine, mixed, thermic Vertic Hapludalf), which have a loam surface with silt clay subsoil. Coyle series soils (fine-loamy, siliceous, thermic Udic Argiustoll) comprise the loamy prairie sites. These soils have fine sandy loam surfaces with sandy clay loam subsoils. The eroded prairie sites are on old fields and have Renfrow (fine, mixed, thermic Udertic Paleustoll). Mullhall (fine-loamy, siliceous, thermic Udic Paleustoll), and Coyle series soils.

The study area vegetation is currently in a high seral state. Vegetation composition on a dry weight basis, determined by the dry weight rank method in August 1991, consisted of 28% little bluestem, 30% other tallgrass [big bluestem (Andropogon gerardii Vitman), indiangrass (Sorghastrum nutans (L.) Nash), and switchgrass (Panicum virgatum L.)], 25% midgrasses, 13% forbs, and 4% shortgrasses and annual grasses.

Methods

Experimental treatments consisted of continuous and rotational grazing systems over a range of stocking rates (0.28 to 0.49 AU ha⁻¹). Stocking rate was not replicated within or between grazing systems. Each grazing system had six, 24-ha pastures. Rotational system pastures were subdivided into 8 paddocks. Within the rotational grazing system 4 grazing cycles were used. Grazing systems over a range of stocking rates (0.28 to 0.49 AU ha⁻¹). Stocking rate was not replicated within or between grazing systems. Each grazing system had six, 24-ha pastures. Rotational system pastures were subdivided into 8 paddocks. Within the rotational grazing system 4 grazing cycles were used. Grazing cycles, respectively. Data were not taken from the first grazing cycle, respectively. Data were not taken from the first 2 paddocks were averaged over the sampling period (for continuous system) and cycle (for rotational system), and number of defoliation events within a grazing cycle (for rotational system).

Between Grazing Systems

Grazed Height

Grazed height decreased as stocking rate increased (Fig. 1), but was not influenced by grazing system. Gammon and Roberts (1978a) also found grazed heights did not differ between continuous and rotational grazing on the Matopos Sandveld in Rhodesia. Although year was a significant variable in the prediction equation for grazed height, the effect of year may be biased due to the lack of data taken during the first grazing cycle from the rotational system.

Table 1. Coefficients of multiple regression equations for defoliation events in a grazing season. D.E. = defoliation events, YR = year, GRSY = grazing system, SR = stocking rate, R² = coefficient of determination. All regression coefficients significant at P<0.05.

<table>
<thead>
<tr>
<th>D.E.</th>
<th>b₀</th>
<th>YR</th>
<th>GRSY</th>
<th>SR</th>
<th>SR²</th>
<th>SR *YR</th>
<th>GRSY *YR</th>
<th>SR¹ *YR</th>
<th>GRSY *GRSY</th>
<th>SR² *YR</th>
<th>GRSY² *YR</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>41.1</td>
<td>42.3</td>
<td>10.7</td>
<td>-89.4</td>
<td>-91.1</td>
<td>-89.4</td>
<td>-91.1</td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>40.0</td>
<td>0</td>
<td>18.1</td>
<td>-66.2</td>
<td>64.1</td>
<td>64.1</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>24.0</td>
<td>-28.9</td>
<td>-18.1</td>
<td>-66.2</td>
<td>64.1</td>
<td>64.1</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-8.8</td>
<td>-28.9</td>
<td>-8.8</td>
<td>-38.9</td>
<td>64.1</td>
<td>64.1</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-1.2</td>
<td>-7.8</td>
<td>-7.8</td>
<td>41.0</td>
<td>41.0</td>
<td>0.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-1.2</td>
<td>-7.1</td>
<td>-7.1</td>
<td>34.5</td>
<td>34.5</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.3</td>
<td>-5.8</td>
<td>-5.8</td>
<td>25.3</td>
<td>-16.4</td>
<td>-16.4</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;6</td>
<td>2.5</td>
<td>-4.3</td>
<td>-4.3</td>
<td>14.3</td>
<td>-11.3</td>
<td>-11.3</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Precipitation for the water year (November–October) was 81% and 101% of average for 1991 and 1992, respectively. Growing season precipitation (May–August) was 92% of average for 1991 and 143% of average for 1992. As a result of the above average growing season precipitation in 1992, forage production levels exceeded that of the previous year. September standing crop for the continuous system pastures was 2,890 kg ha⁻¹ in 1991 and 3,961 kg ha⁻¹ in 1992. Values for the rotational system pastures were 3,437 kg ha⁻¹ in 1991 and 4,802 kg ha⁻¹ in 1992. Utilization of little bluestem tillers declined in response to the increased forage production levels in 1992.
pastures in 1991. Predicted grazed height (averaged over year) for the lightest stocking rate (0.28 AU ha\(^{-1}\)) was 23.9 cm and 11.4 cm for the heaviest stocking rate (0.49 AU ha\(^{-1}\)). Clipping studies involving little bluestem have imposed grazed heights of 3 and 5 cm (Carmen and Briske 1982), 5 cm (Carmen 1985), 6 cm (Carmen and Briske 1985), 7 cm (Welker et al. 1987), and 15 cm (Smith and Leinweber 1971, Briske and Anderson 1992). Thus, our data indicate most clipping studies on little bluestem impose grazed heights which are more severe than those found under field conditions.

**Number of Defoliations in a Grazing Season**

Individual multiple regression prediction equations were developed for the 8 categories describing defoliation frequency (Table 1). The amount of variation explained by the regression equations was greatest when tillers remained undefoliated or were defoliated only once. As stocking rate increased for both grazing systems, the frequency of defoliation increased (Fig. 2). The percentage of tillers undefoliated during the grazing season declined from 32 to 5% in rotational system pastures and from 22 to 0% in the continuous system pastures, as stocking rate increased from 0.3 to 0.5 AU ha\(^{-1}\). Hart et al. (1993) found 19% and 36% of western wheatgrass (Agropyron smithii Rydb.) tillers and 42% and 54% of blue grama [Bouteloua gracilis (H.B.K.) Lag. ex Steud.] tillers were undefoliated throughout the grazing season under heavy (1 steer 2.25 ha\(^{-1}\)) and moderate (1 steer 3.0 ha\(^{-1}\)) stocking, respectively.

At the same stocking rate, continuous grazing systems had fewer tillers undefoliated during the grazing season (Fig. 2). Clark et al. (1984), using a forage mix of perennial ryegrass (Lolium perenne L.), browntop (Agrostis spp.), and white clover (Trifolium repens L.), observed all species were defoliated more frequently under continuous grazing than rotational grazing when rest periods exceeded 21 days. Hart et al. (1993), however, determined frequency of defoliation was similar between continuous and rotational grazing systems. Gammon and Roberts (1978a) also found small differences in frequencies of defoliation between continuous and rotational grazing systems; a small proportion of the tillers received more than 4 defoliations under continuous grazing, while no tillers were defoliated more than 3 times under rotational grazing (Gammon 1978). Hart et al. (1993) utilized lower sampling intensity, fewer defoliation event categories, and a less diverse and
productive plant community than our study, while Gammon and Roberts (1978a) had longer grazing periods and a longer grazing season.

Within Grazing Systems

Continuous Grazing

Stocking rate, sample date, and their interaction influenced grazed heights in the continuous grazing system (Table 2). Increasing the stocking rate resulted in a decrease in grazed height. According to the prediction model, grazed height at a light stocking rate (0.28 AU ha\(^{-1}\)) would be 17 cm at the beginning and 26 cm at the end of the grazing season; corresponding values at a heavy stocking rate (0.48 AU ha\(^{-1}\)) would be 10 and 11 cm. Grazed height increased as sample date progressed during the grazing season. The interaction variable modified this increase, however, as grazed height increased 0.9 cm per sample date at the light stocking rate and 0.1 cm per sample date at the heavy stocking rate.

There were 8.5% fewer tillers defoliated in 1992 than in 1991, reflective of the increased forage production. Sample date did not influence the percentage of tillers defoliated in 1991 and resulted in a slight decrease of 0.3% tillers defoliated per sample date in 1992 (Table 2). At a given stocking rate the percentage of tillers defoliated biweekly was generally similar over the grazing season.

Rotational Grazing

Increasing stocking rates decreased both the middle and exit grazed heights of little bluestem across the grazing cycles. Gillen et al. (1990), however, reported stocking rate in rotational grazing had little effect on grazed height. Grazed heights were reduced by 1 cm with each advance in the grazing cycle during 1991, but increased by 2.5 cm with each advance during 1992. This may be attributed to the differences in growing season precipitation between 1991 and 1992. With the increased forage production in 1992 grazed heights should accordingly have been higher. Grazed heights were reduced 0.5 cm from the middle observation to the exit observation \((P<0.10)\), indicating more grazing pressure on little bluestem during the second half of each grazing period.

The percentage of tillers defoliated in both the middle and exit observations across the grazing cycles was increased by increasing the stocking rate (Table 3). Heitschmidt et al. (1982) stated the pattern of tiller defoliation will change if stocking rate is increased and all other factors remain constant. An increase in stocking rate will result in defoliation of a greater number of tillers of the same species or defoliation of a greater number of plant species (Heitschmidt et al. 1982). Hart et al. (1993) found fewer undefoliated blue grama tillers and more tillers defoliated once under heavy than under moderate stocking.

There were 12% fewer tillers defoliated in 1992, reflective of increased forage production. With each advance in grazing cycle, 3.5% more tillers were defoliated. This was to be expected due to the lengthening of the grazing period over the grazing season.

Six percent more tillers were defoliated in the exit observations compared with middle observations in 1991. At light stocking rates in 1992 differences in percent of tillers defoliated between the middle and exit observations were small; larger differences were found at heavy stocking rates in 1992. This indicated more grazing pressure on little bluestem during the second half of each grazing period. Walker et al. (1989) also found cattle were more selective at the beginning of a rotational grazing period than at the end.

Prediction equations were developed for number of defoliations within a grazing cycle using individual models for defoliation categories none, once, and twice (Table 4). The percentage of undefoliated tillers decreased and the percentage of tillers defoliated once and twice increased with increasing stocking rate (averaged over cycles, Fig. 3). Less than 10% of the tillers were regrazed

![Fig. 3. Predicted effect of stocking rate on number of defoliation events within a rotational grazing cycle.](image)

The percentage of tillers defoliated in both the middle and exit observations across the grazing cycles was increased by increasing the stocking rate. Prediction equations were developed for number of defoliations within a grazing cycle using individual models for defoliation categories none, once, and twice (Table 4). The percentage of undefoliated tillers decreased and the percentage of tillers defoliated once and twice increased with increasing stocking rate (averaged over cycles, Fig. 3). Less than 10% of the tillers were regrazed.

Table 2. Coefficients of multiple regression equations for continuous grazing system: 1) grazed height and 2) percent of tillers defoliated per sampling period; SR = stocking rate, YR = year, SD = sample date, \(R^2\) = coefficient of determination. All regression coefficients significant at \(P<0.05\).

<table>
<thead>
<tr>
<th>Equation</th>
<th>(b_0)</th>
<th>SR</th>
<th>YR</th>
<th>SD</th>
<th>SR(^2)</th>
<th>SR*SD</th>
<th>SD*YR</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazed height</td>
<td>25.1</td>
<td>-31.8</td>
<td>2.0</td>
<td>-4.0</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Defoliated</td>
<td>141.5</td>
<td>872.4</td>
<td>-8.5</td>
<td>-1049.4</td>
<td>-0.3</td>
<td>0.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Coefficients of multiple regression equations for rotational grazing system: 1) grazed height and 2) percent of tillers defoliated per cycle; SR = stocking rate, YR = year, CY = cycle, OBS = observation, \(R^2\) = coefficient of determination. All regression coefficients significant at \(P<0.05\).

<table>
<thead>
<tr>
<th>Equation</th>
<th>(b_0)</th>
<th>SK</th>
<th>YK</th>
<th>CY</th>
<th>OBS</th>
<th>SR*YR</th>
<th>CY*YR</th>
<th>OBS*YR</th>
<th>SR*OBS</th>
<th>(R^2)</th>
<th>(YR*OBS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazed height</td>
<td>48.5</td>
<td>-63.0</td>
<td>-12.5</td>
<td>-1.0</td>
<td>-0.5</td>
<td>30.5</td>
<td>-5.3</td>
<td>-1.2</td>
<td>23.3</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>% Defoliated</td>
<td>-14.9</td>
<td>71.5</td>
<td>-12.3</td>
<td>3.5</td>
<td>6.1</td>
<td>0.1</td>
<td>0.65</td>
<td>0.72</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\text{Significant at } P<0.10.\)
Table 4. Coefficients of multiple regression equations for number of defoliation events in a rotational grazing cycle. D.E. = defoliation events, SR = stocking rate, YR = year, $R^2$ = coefficient of determination. All regression coefficients significant at $P<0.05$.

<table>
<thead>
<tr>
<th>D.E.</th>
<th>b0</th>
<th>Cycle</th>
<th>SR</th>
<th>YR</th>
<th>SR*Cycle</th>
<th>SR*YR</th>
<th>SR*YR</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>116.5</td>
<td>-4.5</td>
<td>-116.7</td>
<td>25.0</td>
<td>-59.4</td>
<td>45.5</td>
<td>94.4</td>
<td>0.77</td>
</tr>
<tr>
<td>1</td>
<td>-7.5</td>
<td>4.1</td>
<td>85.2</td>
<td>-18.6</td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>2</td>
<td>2.9</td>
<td>-2.5</td>
<td>-0.3</td>
<td>-22.5</td>
<td>10.6</td>
<td></td>
<td></td>
<td>0.60</td>
</tr>
</tbody>
</table>

Significant at $P<0.10$.

As the grazing cycles progressed, the percentage of tillers undefoliated decreased and the percentage of tillers defoliated once and twice increased (averaged over stocking rates, Fig. 4). In Texas, Briske and Stuth (1982) found a large percentage of brownsedge paspalum (*Paspalum plicatulum* Michx.) tillers were undefoliated or were only lightly defoliated even at relatively high stock densities with an 11-day grazing period. Gammon and Roberts (1980) found less than 6% of the tillers from the most selected species in livestock intake may be the primary reason rotational grazing systems do not maximize animal performance. Investigations of forage intake by livestock (unpublished data, McCollum et al.) and animal performance (unpublished data Gillen et al.) on the study area support this hypothesis.

Fewer tillers remain undefoliated during a grazing season in continuous grazing systems compared to rotational grazing systems at similar stocking rates; correspondingly, the frequency distribution of defoliated tillers shifts to higher defoliation classes in continuous grazing systems. Little bluestem plants should not receive multiple defoliations in consecutive years unless the purpose is to weaken large plants so that remaining tillers at the periphery will form new, smaller plants (Mullahy et al. 1990). Fragmentation of individual large plants results in greater plant density but smaller basal areas per individual plant (Butler and Briske 1988).

Continuous and rotational grazing systems differ little in terms of their effects on range condition in the short-term (Denny et al. 1977, Pitts and Bryant 1987, Hart et al. 1988, O’Reagain and Turner 1992). However, we hypothesize higher range condition will be maintained over the long-term in rotational system pastures. As a result of fewer defoliation events throughout the grazing season, little bluestem plants in the rotational system pastures would remain more competitive and productive than those in the continuous system pastures. Thus, little bluestem plants in rotational system pastures would be more effective competitors for available water and nutrient resources. Conversely, little bluestem plants in continuous system pastures which have been exposed to more defoliation events throughout the grazing season will be subjected to more intense competition for available water and nutrient resources. Over an extended period of time, little bluestem plants in continuous grazed pastures may be replaced by more resource competitive and defoliation-tolerant species which are of a lower seral state.

**Literature Cited**


