

Effects of Intensive Late-Season Sheep Grazing Following Early-Season Steer Grazing on Population Dynamics of *Sericea lespedeza* in the Kansas Flint Hills

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Introduction

Sericea lespedeza (*Lespedeza cuneata*; SL) is a high-tannin, invasive forb in the Tallgrass Prairie ecosystem. In Kansas, *sericea lespedeza* infests 980 square miles of pasture, primarily in the Flint Hills region. *Sericea lespedeza* infestations reduce native grass production by up to 92% through a combination of aggressive growth, prolific reproduction, canopy dominance, and chemical inhibition (allelopathy). Herbicides retard the spread of *sericea lespedeza*, but application is laborious and expensive; moreover, herbicides are lethal to ecologically-important, non-target plant species.

Increased grazing pressure on *sericea lespedeza* by domestic herbivores may slow its spread and facilitate some measure of biological control. Unfortunately, mature plants contain high levels of condensed tannins, which are a strong deterrent to grazing by beef cattle. Small ruminants have greater tolerance for condensed tannins than beef cattle. Sheep, in particular, appear less susceptible to certain plant toxins than beef cattle and may be useful to selectively pressure noxious weeds like *sericea lespedeza*.

The predominant grazing management practice in the Flint Hills region of Kansas involves annual spring burning followed by intensive grazing with yearling beef cattle from April to August. During seasonal grazing, 40 to 60% of annual graminoid production is removed and pastures remain idle for the remainder of the year. Under this prevailing management practice, invasion by *sericea lespedeza* into the Tallgrass Prairie biome has steadily increased. *Sericea lespedeza* flowers and produces seed in late summer from August to September. The absence of grazing pressure during this interval strongly promotes seed production, seed distribution, and continued invasion of the Flint Hills ecoregion by this noxious weed. Therefore, the objective of our study was to evaluate effects of late-season sheep grazing following locally-conventional steer grazing on vigor and reproductive capabilities of *sericea lespedeza*.

Key words: *sericea*, sheep, defoliation

Experimental Procedures

Our experiment was conducted during 2013 and 2014 at the Kansas State University Bressner Range Research Unit located in Woodson County, Kansas. Native tallgrass pastures ($n = 8$; 77 ± 8.9 acres) infested with sericea lespedeza (SL; initial basal frequency = 1.4%) were burned annually in early April. Pastures were assigned randomly to one of two treatments: early-season grazing with beef steers (3.3 acres/steer; approximate initial birth weight = 600 lb) from April 15 to July 15 followed by rest for the remainder of the year (control; steers) or steer grazing from April 15 to July 15 followed by intensive grazing by mature ewes (0.5 acres/ewe; sheep) from August 1 to October 1. Ewes ($n = 815$ in year 1 and 811 in year 2; mean initial birth weight = 148 ± 3.7 lb) were assigned randomly to graze one of four pastures; the remaining pastures were not grazed from August 1 to October 1.

Mature ewes were obtained from two commercial sheep producers located in western Kansas. Ewes were transported to the site on approximately July 30 each year. Ewes were weighed immediately before grazing began on August 1 and immediately after grazing was halted on October 1. Final birth weight of sheep averaged 159 ± 6.6 lb. Sheep were monitored daily to assure they remained in assigned pastures and that fresh water and minerals were available continually. Death loss was $< 2\%$ annually (13 sheep in year 1 and 15 sheep in year 2) and assumed to occur through predation or disease.

Vegetation responses to treatment were measured along four permanent 100-yard transects ($100 \times 12\text{-in}^2$ plot points/transect) and in two permanent 16×16 -foot grazing exclosures in each pasture ($25 \times 12\text{-in}^2$ plot points/exclosure). Transects were laid out on a north-south gradient; ends were marked using steel posts. Immediately before and immediately after sheep grazing, a 100-yard measuring tape was stretched from the southern end to the northern end of each transect. At 1-yard intervals along each transect, biomass was measured using a visual obstruction technique. A 12×12 -inch plot was projected on the eastern side of transects at each point of measurement. Within the plot, canopy type (i.e., grass- or forb-dominated) was noted, presence of sericea lespedeza was noted (e.g., yes or no), and evidence of herbivory was noted (i.e., obvious truncation of leaves or stems). Grazing exclosures were examined at the same times and in the same manner as transects; except that biomass, canopy type, and herbivory were evaluated in the approximate center of each square yard of the exclosure ($n = 25$ /exclosure). A total of 3,250 data points were collected twice annually using these procedures.

A weekly estimate of herbivory was conducted to evaluate grazing pressure on select forb species in each pasture. The species of interest were sericea lespedeza (*Lespedeza cuneata*), Baldwin's ironweed (*Vernonia baldwinii*), and ragweed species (*Ambrosia artemisiifolia*, *Ambrosia bidentata*, and *Ambrosia psilostachya*). Individuals of each species or group of species ($n = 100$ /pasture weekly) were evaluated at temporary point transects. Point transect locations were determined randomly in control pastures. In treated pastures, point transects were located in areas where sheep were grazing at the time of observation. Evidence of herbivory (i.e., obvious truncation of leaves or stems) on individual plants was recorded.

Plant species composition and soil cover were assessed annually each October using a modified step-point technique. Pre-treatment bare ground percentage ($44 \pm 1.3\%$

for sheep and $47 \pm 7.2\%$ for steers), litter cover percentage ($47 \pm 2.6\%$ for sheep and $46 \pm 8.0\%$ for steers), and basal plant cover percentage ($8.7 \pm 2.82\%$ for sheep and $7.0 \pm 1.29\%$ for sheep) were not different ($P \geq 0.63$) between treatments. Trends in plant species composition and soil cover will be evaluated at the end of this 4-yr study.

A total of 100 mature sericea lespedeza plants were collected adjacent to permanent line transects in each pasture immediately after the first killing frost (approximately November 1 annually). Plants were placed into a labeled paper bag. Partial DM was measured using a forced-air oven. Individual plants in each sample were defoliated manually; seeds, chaff, and stems were placed into a seed cleaner to separate seeds. Cleaned seed was weighed for each sample. Seed weight was converted to seed count assuming a density of 770 seeds/gram. Average seed production was calculated by dividing the number of seeds by the number of sericea lespedeza plants in each sample ($n = 100$).

Results and Discussion

Pasture forage biomass was not different ($P=0.29$) between steers and sheep after steer grazing was halted and before sheep grazing began (Table 1). Conversely, forage biomass on rested pastures was greater ($P=0.01$) than that on sheep at the end of the sheep-grazing period.

After the steer grazing period ended and before the sheep-grazing period began, the number of grass-dominated plant canopies was greater ($P=0.02$) and the number of forb-dominated plant canopies was lower ($P=0.02$) on steers than on sheep (Table 1). Conversely, proportions of grass- and forb-dominated canopies were not different ($P=0.70$) between treatments at the end of the sheep-grazing period. The percentage of grass-dominated plant canopies that showed evidence of herbivory following steer grazing was relatively large and not different ($P=0.67$) between steers and sheep; however, the percentage of grazed forb-dominated plant canopies following steer grazing was relatively small and slightly less ($P=0.04$) on steers than on sheep. At the end of the sheep-grazing period, steers had fewer ($P<0.01$) grass- and forb-dominated plant canopies that showed evidence of herbivory than sheep. We interpreted these data to indicate that steers strongly preferred to graze graminoid-dominated plant communities, whereas sheep did not appear to discriminate between plant canopy types.

Pastures assigned to sheep had greater ($P \leq 0.02$) sericea lespedeza canopy frequency than those assigned to steers after steer grazing and after sheep grazing (Table 1). Herbivory of sericea lespedeza was not different ($P=0.76$) between steers and sheep following steer grazing and was generally minor. Conversely, herbivory of sericea lespedeza was much greater ($P<0.01$) in sheep than in steers following sheep grazing. We interpreted these data to indicate that sheep displayed much greater preference for sericea lespedeza than steers. This conclusion was supported by weekly estimates of herbivory during the sheep-grazing period (Table 2). Herbivory of sericea lespedeza was not different ($P=0.99$) and slight in steers and sheep immediately following the steer-grazing period. In contrast, sericea lespedeza herbivory was greater ($P \leq 0.01$) in sheep than in steers by the end of week 2 of the sheep-grazing period (14.5 vs. 0.8%); moreover, herbivory of sericea lespedeza steadily increased ($P \leq 0.01$) over time such that

89.4% of sericea lespedeza plants were grazed in sheep compared to 2.0% in steers by week 9 of the sheep-grazing period.

Sheep also appeared to preferentially select other problematic forb species that steers avoided. Herbivory of Baldwin's ironweed and ragweed spp. was not different ($P \geq 0.92$) in steers and sheep immediately following the steer grazing period (Tables 3 and 4, respectively). Conversely, herbivory of individual Baldwin's ironweed plants was greater ($P \leq 0.01$) in sheep than in steers by the end of week 1 of the sheep-grazing period and was complete by the end of week 4. Sheep did not put a significant amount of grazing pressure on ragweeds until the end of week 3 of the sheep-grazing period; thereafter, herbivory of ragweeds steadily increased over time such that 49.9% of ragweed plants were grazed in sheep ($P \leq 0.01$), compared to 0.8% in steers by the end of week 9 of the sheep-grazing period.

Tannin content of sericea lespedeza peaks during August and September. This circumstance effectively protects the plant from herbivory prior to production of seed. Suppression of seed production may be a key to achieving control of sericea lespedeza. Whole-plant sericea lespedeza weight immediately after the first killing frost was 2.3-fold less ($P = 0.03$) in sheep than steers following year 1 and 3.6-fold less ($P \leq 0.01$) in sheep than steers following year 2 (Table 5). We interpreted this to be an indication that sericea lespedeza vigor decreased as duration of treatment increased. Annual seed production by sericea lespedeza and total seed weight were less ($P \leq 0.01$) in sheep than in steers (Table 6). We concluded that late-season, intense grazing by sheep may be an effective means for controlling sericea lespedeza infestation.

Implications

Late-season, intensive sheep grazing on native Tallgrass Prairie appeared to decrease vigor and reproductive capabilities of sericea lespedeza, a noxious weed. Sheep appeared to preferentially select sericea lespedeza, Baldwin's ironweed, and ragweed spp., whereas steers avoided these plants. We interpreted herbivory patterns in pastures treated with late-season sheep grazing to indicate that condensed tannins in sericea lespedeza were not a deterrent to consumption by sheep. Late-season sheep grazing decreased forage biomass by 953 lb dry matter per acre compared with late-season rest; however, residual biomass on pastures grazed during the late growing season was likely sufficient to prevent soil-moisture loss and erosion during the dormant season.

Table 1. Effects early-season grazing by beef steers followed by late-season grazing by sheep and time of measurement on pasture forage biomass, canopy-type frequency, and grazing activity in native tallgrass prairie infested with sericea lespedeza (*Lespedeza cuneata*)

Item	After steer grazing, before sheep grazing		After steer and sheep grazing		SE
	Steer grazing only [*]	Steer + sheep grazing [†]	Steer grazing only [*]	Steer + sheep grazing [†]	
Pasture forage biomass, lb dry matter/acre	1,877 ^a	1,742 ^a	2,260 ^b	1,409 ^c	127.3
Grass-dominated canopies, % of total canopies	84.7 ^a	74.2 ^c	82.1 ^{a,b,c}	83.8 ^{a,b}	4.37
Forb-dominated canopies, % of total canopies	15.3 ^a	25.8 ^c	17.9 ^{a,b,c}	16.2 ^{a,b}	4.37
Grazed grass canopies, % of grass-dominated canopies	60.2 ^a	58.5 ^a	5.8 ^c	79.4 ^b	4.08
Grazed forb canopies, % of forb-dominated canopies	19.5 ^a	7.0 ^b	6.9 ^b	76.0 ^d	5.98
Plant canopies with sericea lespedeza, % of total canopies	9.3 ^a	25.8 ^b	12.9 ^a	25.5 ^b	5.45
Grazed sericea lespedeza, % of plant canopies with sericea lespedeza	1.7 ^a	7.1 ^a	0.1 ^a	91.2 ^b	5.06 [*]

^{*} Yearling steers were grazed on 4 pastures from approximately 4/15 to 7/15 annually (3.3 acres/steer; approximate initial birth weight = 600 lb); pastures were not grazed for the remainder of the year.

[†] Yearling steers were grazed on 4 pastures (n = 8) from approximately 4/15 to 7/15 annually (3.3 acres/steer; approximate initial birth weight = 600 lb); mature ewes grazed these pastures from approximately 8/1 to 10/1 annually (0.5 acres/ewe; initial birth weight = 148 ± 3.3 lb).

^{a, b, c} Within row, means with unlike superscripts are different ($P < 0.05$).

Table 2. Effect^a of late-season grazing by sheep on herbivory of sericea lespedeza cuneata (*Lespedeza cuneata*)

Item	Steer grazing only	Steer + sheep grazing	P-value
Pre-treatment [‡] , % target species grazed	0.6	0.6	0.99
Week 1 [§] , % target species grazed	0.6	5.0	0.16
Week 2 [§] , % target species grazed	0.8	14.5	< 0.01
Week 3 [§] , % target species grazed	0.9	40.6	< 0.01
Week 4 [§] , % target species grazed	0.8	54.5	< 0.01
Week 5 [§] , % target species grazed	1.0	65.0	< 0.01
Week 6 [§] , % target species grazed	1.6	73.1	< 0.01
Week 7 [§] , % target species grazed	2.3	83.6	< 0.01
Week 8 [§] , % target species grazed	2.0	89.4	< 0.01

^a Treatment × week (SE = 3.10; $P < 0.01$).

[‡] Percentage of sericea lespedeza plants showing evidence of defoliation immediately after yearling steers were removed and before sheep were allowed access to pastures.

[§] Percentage of sericea lespedeza plants showing evidence of defoliation each week during a 60-d period in which mature ewes were grazed on 4 pastures.

Table 3. Effect^a of late-season grazing by sheep on herbivory of Baldwin's ironweed (*Vernonia baldwinii*)

Item	Steer grazing only	Steer + sheep grazing	P-value
Pre-Treatment [†] , % target species grazed	11.0	11.0	0.99
Week 1 [§] , % target species grazed	11.5	77.4	< 0.01
Week 2 [§] , % target species grazed	20.9	86.1	< 0.01
Week 3 [§] , % target species grazed	13.0	99.9	< 0.01
Week 4 [§] , % target species grazed	14.1	100	< 0.01
Week 5 [§] , % target species grazed	14.3	100	< 0.01
Week 6 [§] , % target species grazed	14.0	100	< 0.01
Week 7 [§] , % target species grazed	21.6	100	< 0.01
Week 8 [§] , % target species grazed	25.9	100	< 0.01

^aTreatment × week (SE = 3.87; $P < 0.01$).

[†]Percentage of ironweed plants showing evidence of defoliation immediately after yearling steers were removed and before sheep were allowed access to pastures.

[§]Percentage of ironweed plants showing evidence of defoliation each week during a 60-d period in which mature ewes were grazed on 4 pastures.

Table 4. Effect^a of late-season grazing by sheep on herbivory of ragweed species (*Ambrosia psilostachya*, *Ambrosia bidentata*, and *Ambrosia artemisiifolia*)

Item	Steer grazing only	Steer + sheep grazing	P-value
Pre-treatment [†] , % target species grazed	1.3	1.6	0.92
Week 1 [§] , % target species grazed	1.3	3.1	0.61
Week 2 [§] , % target species grazed	0.3	5.1	0.19
Week 3 [§] , % target species grazed	0.5	11.8	< 0.01
Week 4 [§] , % target species grazed	0.5	15.4	< 0.01
Week 5 [§] , % target species grazed	1.0	15.9	< 0.01
Week 6 [§] , % target species grazed	0.5	18.5	< 0.01
Week 7 [§] , % target species grazed	0.4	42.4	< 0.01
Week 8 [§] , % target species grazed	0.8	49.9	< 0.01

^aTreatment × time (SE = 3.66; $P < 0.01$).

[†]Percentage of ragweed spp. plants showing evidence of defoliation immediately after yearling steers were removed and before sheep were allowed access to pastures.

[§]Percentage of ragweed spp. plants showing evidence of defoliation each week during a 60-d period in which mature ewes were grazed on 4 pastures.

Table 5. Effects^a of year and early-season grazing by beef steers followed by late-season grazing by sheep on whole-plant DM weight of sericea lespedeza (*Lespedeza cuneata*), as measured immediately following a killing frost

Item	Year 1		Year 2		SE
	Steer grazing only	Steer + sheep grazing	Steer grazing only	Steer + sheep grazing	
Whole plant dry matter, mg/plant	2,020.6 ^c	865.9 ^d	3,743.3 ^b	1048.5 ^d	467.85

^aTreatment × year ($P = 0.04$).

^{b, c, d}Within row, means with unlike superscripts are different ($P \leq 0.05$).

Table 6. Effects^a of early-season grazing by beef steers followed by late-season grazing by sheep on seed production by sericea lespedeza (*Lespedeza cuneata*), as measured immediately following a killing frost

Item	Steer grazing only	Steer + sheep grazing	SE	<i>P</i> -value
Total seed weight, mg/plant	712.1	90.9	180.23	≤ 0.01
Seeds, no./plant	548.0	69.9	138.67	≤ 0.01

^aTreatment × time ($P < 0.01$).