Can Cattle Be Used to Control Sericea Lespedeza?

By Gregory K. Mantz, Juan J. Villalba, and Frederick D. Provenza

On the Ground

- Supplemental polyethylene glycol (PEG), a polymer that neutralizes the negative effects of tannins, can increase intake and preference of cattle for fresh-cut sericea lespedeza (*Lespedeza cuneata*), an invasive, tannin-containing legume for the tallgrass prairie region of the Great Plains.
- In grazing trials, steers supplemented with PEG plus a high-protein supplement tended to eat more sericea than did steers only supplemented with the high-protein supplement.
- Supplementing cattle with PEG, protein, or a combination of the two has the potential to enhance the amount of sericea consumed by cattle, contributing to the control of this weed.

Keywords: polyethylene glycol (PEG), season, sericea lespedeza, intake, preference, grazing, tallgrass prairie.

Rangelands 35(4):6–12
doi: 10.2111/RANGELANDS-D-13-00006.1
© 2013 The Society for Range Management

Sericea lespedeza (*Lespedeza cuneata*) is an important forage in some parts of the southeastern United States. An introduced legume that thrives in soils of low fertility, older varieties of sericea introduced in the tallgrass prairie region of the Great Plains became invasive because of their competitive characteristics that are, in part, attributable to high concentrations of condensed tannins (CTs), which discourage grazing and reduce performance of cattle.[1–3] CTs in concentrations below 50–60 g CT/kg dry matter (DM) benefit ruminants by reducing incidence of bloat and improving nitrogen balance.[4,5] Higher concentrations of CT negatively affect digestive processes,[6] rumen microbes,[7] and gut mucosa,[8] which collectively deter foraging. CT content of older sericea varieties often exceeds 100 g/kg DM.[9]

Biological control of sericea with insects is problematic because of their potential to spread and decimate important forage. Although goats can control sericea,[10] cattle ranchers in the tallgrass prairie region are not inclined to use goats in numbers large enough to provide effective control of sericea. Accordingly, we evaluated cattle grazing as a means of reducing the density of sericea stands enough to allow the native plant species to coexist with sericea. Yellow sweet clover (*Melilotus officinalis*), abundant in the mid- and short-grass prairies of western Kansas, is a good analogy. Although sweet clover is an aggressive species that can replace native species, this seldom occurs because grazing by cattle keeps the density of sweet clover low. In doing range inventories, we observed that if the cover of sericea is less than 60%, native plant species can coexist with sericea. Our challenge was how to help cattle cope with the high concentrations of CT.

Phase I: Tannins, Sericea, and Feedback

Polyethylene glycol (PEG) binds with tannins to form an insoluble complex that prevents CT from binding to protein in the rumen.[11] PEG has been used to counteract the adverse effects of CT, improving digestibility, palatability, and intake.[12,13] The premise behind using PEG to induce cattle to eat sericea is the postingestive feedback theory of diet selection.[14] According to this theory, cattle do not avoid sericea and other tannin-rich plants because they find them inherently distasteful but because they associate the taste of forages with negative postingestive consequences because of excesses of compounds like CT. If so, using PEG to reverse the negative postingestive effects of tannins in sericea should entice cattle to eat it.

We conducted a pen trial to measure intake and preference using procedures approved by the Utah State University Institutional Animal Care and Use Committee (IACUC No. 1297). In the intake experiment, eight control steers and eight PEG-supplemented steers were offered prairie hay and fresh-cut sericea in separate meals across six trial periods with each trial period lasting 6 days. The day after each of trial periods 2 to 6, we conducted a preference test in which the

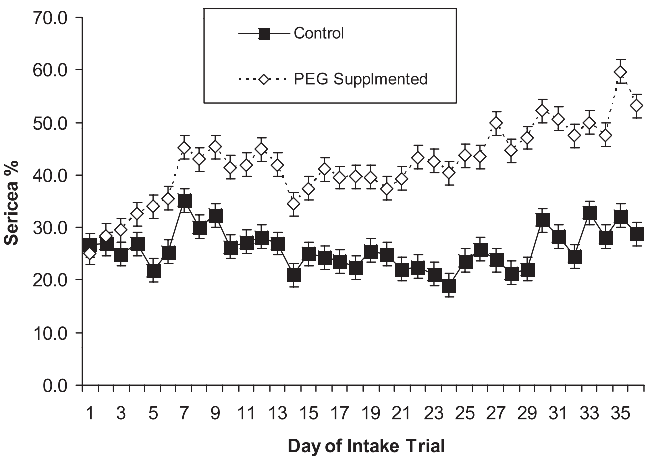

Figure 1. Daily consumption of sericea lespedeza (SL) by control and polyethylene glycol (PEG)–supplemented steers as a percentage of total forage dry matter intake (SL %) during the intake phase of six trial periods, each 6 days in duration. Data are least squares means (± SEM). Treatment means differed ($P<0.05$) all days except days 1 and 2. From Mantz et al. (2009),[15] used by permission.

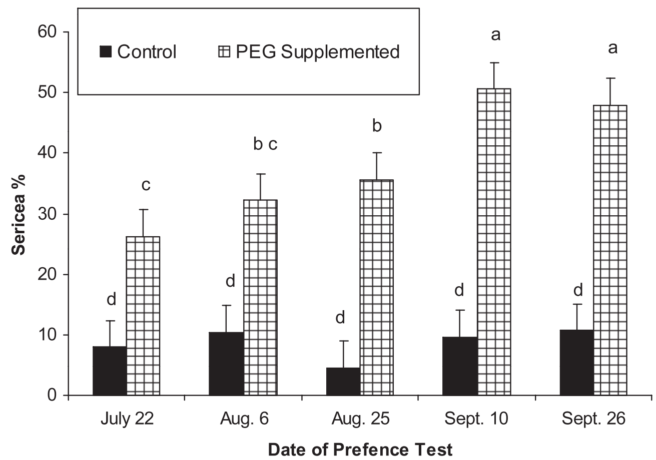

Figure 2. Preference for sericea lespedeza (SL) by control and polyethylene glycol (PEG)–supplemented steers relative to prairie hay (PH) as measured by percentage of SL in the diet (SL %) in the five preference tests. Data are least squares means (± SEM). Means represented by bars lacking common letters differ ($P<0.05$). From Mantz et al. (2009),[15] used by permission.

steers were offered prairie hay and fresh-cut sericea simultaneously (for detailed discussions see Mantz et al.[15]).

We found PEG increased the intake of sericea. The two groups of steers consumed a similar amount of sericea (sericea dry matter intake as a percentage of total dry matter intake) during the first 2 days of the intake trials, but beginning on day 3, the PEG-supplemented steers began consuming more sericea than the control steers did and continued to do so throughout the remainder of the trials (Fig. 1). The preference tests showed PEG had an even stronger influence on the percentage of sericea consumed by the steers (Fig. 2).

Phase II: Pasture Trials

Following the successful pen trial in 2003, we initiated the first of two seasons of pasture trials in 2004. The trials were conducted in Greenwood County, Kansas, which is predominately (83%) native rangeland or tame pasture with tall and mid grasses comprising more than 80% of the climax vegetation on most range sites.[16] Greenwood County, Kansas, is part of the 14-county area termed the *bluestem pasture region*.[17] Most of the county, including the areas used in our study, is in the Bluestem Hills land resource area, which is immediately east of the Flint Hills land resource area.[16] The topography is gently to moderately sloping with clay subsoil. Bedrock material is a mixture of shale and limestone.[16] Elevation ranges from 267 m to 354 m above sea level. The county receives an annual average of 95.6 cm of precipitation, 70 percent of which is received in April through September.[18]

In the fall of 2003, four adjacent pastures between 21.5 ha and 27.5 ha were mapped by global positioning system. The vegetative cover of these pastures was determined in November 2003, and those measurements were repeated in June 2005 and October 2005 (Table 1).

We stocked 11 to 13 steers (initial weight = 251 kg) in each pasture to give a 2.0 ha per steer stocking rate in all pastures. This rate is considered light stocking.[19] It is 20% less than the average full-season stocking rate for cattle of this weight class in the bluestem pasture region of Kansas.[17] The light stocking rate was used to allow steers to express their dietary preferences throughout the season.

All animals received a supplement placed in covered feeders every other day. The supplement contained 25% crude protein (CP). Although this concentration of CP was higher than needed during the early season, concentrate-based supplements containing less than 20% CP negatively affect forage intake later in the season as forage quality declines.[20] Salt was added to limit intake of the base supplement to a target of 0.45 kg of supplement per steer per day.[21] We used a self-fed means to deliver the supplement because hand feeding of supplement can alter grazing behavior.[22]

Animals in the control group received only the base supplement, whereas animals in the PEG treatment received the base supplement with PEG. The base supplement, added salt, and PEG were mixed in an electric cement mixer the day of feeding with wet molasses (41 g per steer per day) added to prevent sorting. Salt content was adjusted up or down for each pasture as needed to regulate supplement intake to the target value. If the steers in a pasture consumed their supplement entirely before the scheduled feeding day, additional supplement was put out to ensure animals had constant availability of supplement. Supplementation began on 15 May 2004. On 22 May 2004, PEG was introduced to the supplement in pastures 1 and 3, which had been randomly assigned to the PEG treatment. PEG was added in incremental amounts starting with an average of 60 g per steer per day with an additional 20–40 g per steer per day added to the supplement during each feeding up to the target of 250 g per steer per day, which was reached by 3 June 2004; PEG supplementation remained at that level throughout the season. In the pen studies, we had shown that these levels of PEG markedly increase intake of sericea.

Table 1. Sericea lespedeza and other plant cover (%) in the four research pastures as determined by readings of a 0.1-m^2 Daubenmire frame along stratified random transects on three dates

Date/pasture	Sericea	Grass	Forbs + shrubs	Total	Sericea/total
November 2003					
1	2.9	72.1	25.8	100.8	2.9
2	2.5	82.0	14.0	98.4	2.5
3	5.6	81.7	9.7	96.9	5.7
4	4.1	85.8	8.0	97.9	4.1
July 2005					
1	11.8	59.9	54.4	126.1	9.4
2	7.6	60.1	52.6	120.3	6.3
3	14.7	67.9	34.7	117.3	12.6
4	4.9	74.8	28.9	108.6	4.5
October 2005					
1	11.7	82.8	27.2	121.6	9.6
2	11.3	74.9	36.6	122.8	9.2
3	12.9	78.7	18.9	110.5	11.7
4	11.3	76.1	20.6	107.9	10.4

Feeding behavior for every animal was recorded using scan sampling.[23] Steers in each pasture were sampled by two observers on horseback for 2 hours in the morning and 2 hours in the evening, once a week for each pasture. Scan sampling was performed by one observer in a control pasture and one observer in an adjacent PEG-supplemented pasture. Two days were required to sample both control and PEG-supplemented pastures.

Scan samples were obtained at 7-minute intervals from 7:00 am to 9:00 am and from 6:50 pm to 8:50 pm. These periods were adjusted as needed to compensate for the decreasing day-length during the latter half of each season by starting the evening scans earlier and the morning scans later. Every 7 minutes, the incidence of feeding on sericea, forbs, grass, trees, shrubs, supplement, or nonfeeding of each steer was recorded. Frequency of feeding on sericea was calculated as a percentage of the total number of scans when steers were foraging. In 2004, the scan sampling began the week of 28 June and concluded the week of 11 October.

We continued the grazing trial in 2005 with a new set of steers. The pastures assigned to the PEG-supplemented treatment in 2004 were assigned to the control treatment in 2005 and vice versa. However, in 2005, the research pastures were damaged by vapor drift from an herbicide application used to control sericea in the pasture immediately east of the research pastures. Only the northwest corner of pasture 4 escaped major herbicide injury.[24] Therefore, we will mainly emphasize the results from 2004 with only passing mention made of the 2005 results.

In the 2004 pasture trial, steers used sericea extensively in late August and September (Fig. 3). Although steers in the PEG-supplemented pastures consumed nearly twice the

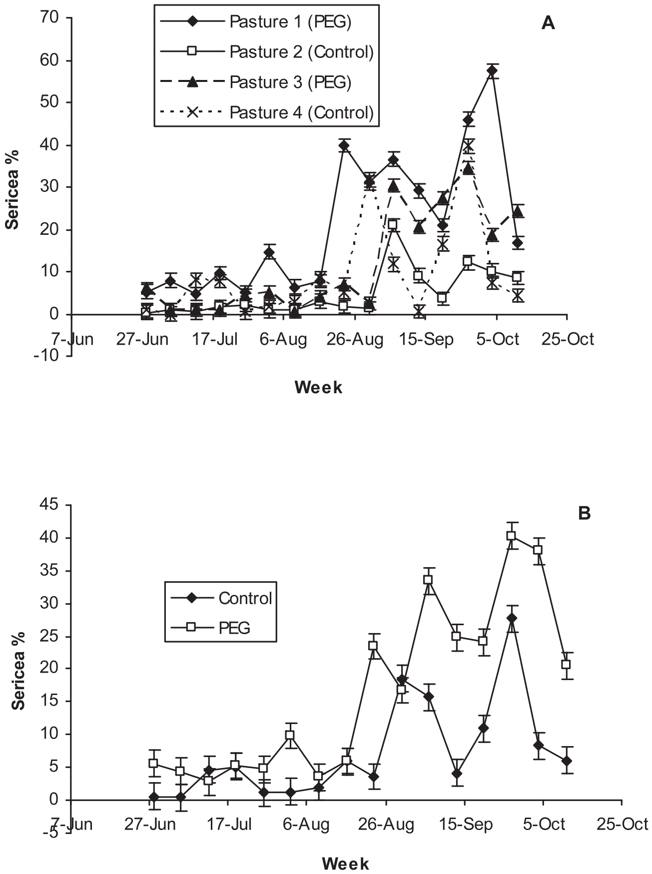

Figure 3. Weekly percentage of sericea lespedeza in total grazing scans in steers by **A,** pasture and **B,** treatment in 2004. Data are mean values (± SEM).

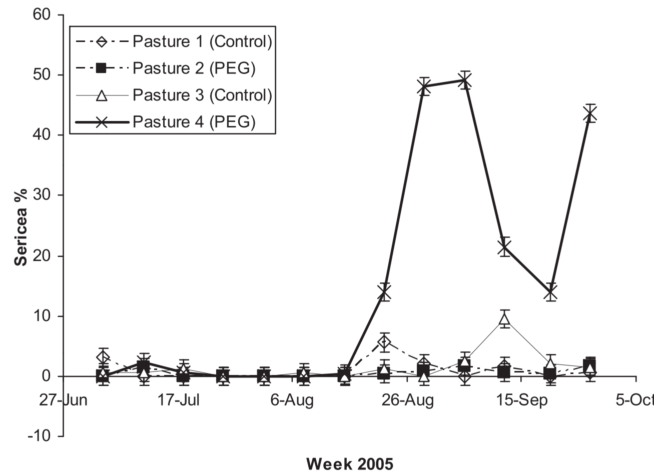

Figure 4. Weekly percentage of sericea lespedeza in total grazing scans in steers by pasture in 2005. Data are mean values (± SEM).

sericea of their counterparts in the control pastures, those differences were not statistically significant.[i] There are three reasons that the statistical models did not show a more-significant effect for PEG supplementation. First, pastures were the unit of replication, and each treatment was only replicated twice, making it hard to show highly significant differences between treatments. Second, the steers in the control pastures consumed a surprising amount sericea, likely because of the supplement they received. They were fed a 25% CP range supplement made primarily of rolled oats and soybean meal, both of which have a high content of rumen-degradable protein, which increases intake of high-tannin forages.[25] The supplement also contained a large percentage of molasses, which also increases consumption of high-tannin forages.[26] Third, the response to PEG supplementation was "trumped" by the even larger response to the week of sampling, which was highly significant.[ii] Most of the sericea consumption by steers in both treatments occurred from 23 August onward.

Perhaps the most important finding was that sericea seems to have a "window of vulnerability" in late August and September. In contrast to the commonly held belief that cattle will consume little, if any, sericea during the late season,[3] the highest levels of sericea use occurred in late August and September (Figs. 3 and 4). In 2004, the first major increase in sericea consumption occurred in pasture 1 during the week of 23 August, with the other pastures following during the next 2 weeks (Fig. 3). In 2005, during the same week (22 August 2005), there was a major increase in sericea consumption in pasture 4 (Fig. 4). In 2005, pasture 4 was in the PEG-supplemented treatment and had a large patch of sericea in its northwest corner that escaped the worst of the spray damage. Hart[10] observed that stocker goats on Kansas rangeland also consumed more sericea in the late season, although he attributed this phenomenon to the novelty of sericea causing the goats to avoid it until they had depleted familiar browse species. During August, cattle in the southeastern United States begin browsing large sericea plants ignored during the early part of the summer.[27]

Sericea never accounted for more than 13% of the plant cover in our pastures (Table 1), yet from late August through September, it accounted for 25–50% of grazing scans in the two PEG-supplemented pastures in 2004 and in one of the PEG-supplemented pastures in 2005. Steers also ate considerable sericea in the control pastures during late August and September 2004 (Fig. 3). Two factors likely influenced the selective grazing of sericea by cattle during late August and September. The first is a decline in the antinutritional effect of the CT in sericea. Although the seasonal declines in the concentration of extractable CT noted in the present study (Table 2) are modest, previous research suggests qualitative changes occur in sericea tannins during mid August, which decrease the inhibition of digestive enzymes (Fig. 5).[28] That same study showed that enzyme inhibition by aqueous extracts of sericea was only modestly correlated with total concentrations of extractable CTs.

The second factor is the decline in grass quality during late summer and fall,[24] which, in the tallgrass prairie, often leads to a nutritional deficit, as evidenced by declining aver-

[i] *P* value of the difference was only 0.20.
[ii] $P \leq 0.0001$.

Table 2. Concentrations of extractable condensed tannins and leaf-to-stem ratio of sericea lespedeza by sampling date in 2004–2005 pasture trials. Values for each date are averaged across all four research pastures

Date	Extractable condensed tannin (g/kg ± SE)	Leaf-to-stem ratio (± SE)
2004		
18 July	130.3 ± 6.48 a	1.27 ± 0.15 bc
12 August	135.5 ± 6.48 a	1.68 ± 0.14 a
8 September	123.2 ± 6.48 ab	1.45 ± 0.14 b
27 September	112.8 ± 6.48 b	1.18 ± 0.14 c
2005		
6 June	60.9 ± 4.84 cd	2.10 ± 0.10 a
12 July	66.8 ± 5.08 c	1.93 ± 0.08 a
3 August	61.4 ± 4.14 cd	1.10 ± 0.10 c
18 August	52.9 ± 4.44 d	0.97 ± 0.10 c
7 September	87.1 ± 4.14 a	1.35 ±0.10 b
21 September	86.8 ± 4.14 ab	1.52 ± 0.10 b
6 October	76.4 ± 4.14 bc	1.33 ± 0.10 b

Means in the same year and column without a common superscript letter differ. ($P<0.05$)

age daily gains in our study and in the study of Smith and Owensby.[29] The decline in forage quality leads cattle to seek alternative nutrient sources, as evidenced by both higher sericea consumption in the late season and higher levels of salt needed to limit supplement intake.[24] In the intake and preference trials we conducted in pens,[15] the alternative forage was harvested prairie hay, the quality of which did not change across season. Although sericea intake increased in the late season during that study, the relative magnitude of that increase was less than seen in the pasture study.

Summary and Need For Future Research

Our research shows that PEG enhanced intake and preference of steers for sericea in pen trials and in grazing trials

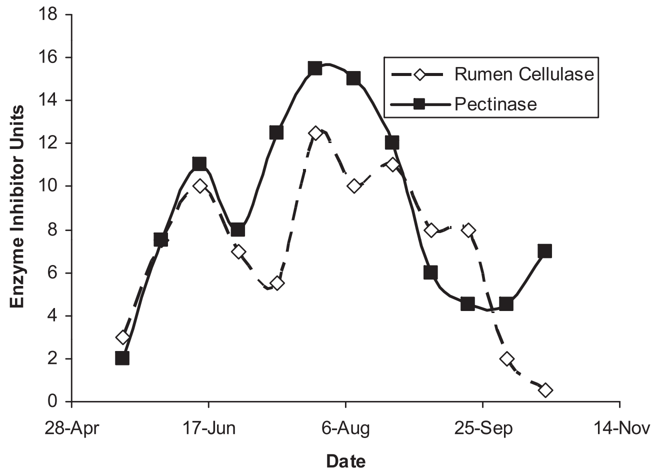

Figure 5. Seasonal changes in enzyme inhibition of aqueous extracts of high-tannin sericea in North Carolina. Data from fig. 1 of Cope et al. (1971),[31] used by permission.

in late August and September. In the grazing trials, steers supplemented with PEG ate more sericea than did the steers not supplemented. The 25% CP range supplement (primarily of rolled oats, soybean meal, and molasses) we fed likely increased intake of sericea by steers not supplemented with PEG. Cattle fed corn steep liquor, a protein supplement that contains large concentrations of the amino acid proline, increased intake of sericea-contaminated prairie hay by 25%.[30] Further research and management may explore the relative merits of supplementation with PEG or protein in terms of cattle performance and ability to use sericea, the influence of supplements on the abundance of sericea, and the costs of supplements relative to the use of herbicides.

Acknowledgments

We thank John Bills and Stan Daniels of the Kansas Department of Wildlife and Parks for their help with machinery maintenance; Jeff Davidson of the Greenwood County Extension Service and Brian Obermeyer of the Kansas Nature Conservancy for facilitating access to private land used in this research project; Philip Flock, Doug Spencer and Luke Westerman, Jon Biering, Homer Wilson, Grant Davidson, Bernie Obermeyer, Melissa Stanfield, Lisa Brown, and Michelle Elling for their help in data collection; Beth Burritt of Utah State University, Chris Krueger and Jess Reed of the University of Wisconsin, and Tom Terrill of Fort Valley State University for help with laboratory analyses; and Susan Durham of Utah State University for statistical advice.

References

1. Wilkins, H. L., R. P. Bates, and P. R. Henson. 1993. Palatability in sericea lespedeza (*L. Cuneata*). *Agronomy Journal* 45:335–336.
2. Donnelly, E. D., W. B. Anthony, and J. W. Langford. 1971. Nutritive relationships in low- and high-tannin sericea lespedeza under grazing. *Agronomy Journal* 63:749–751.

3. Ohlenbush, P. D., T. Bidwell, W. H. Fick, G. Kilgore, W. Scott, J. Davidson, S. Clubine, J. Mayo, and M. Coffin. 2001. Sericea lespedeza: history, characteristics and identification. Manhattan, KS, USA: Kansas State University Agriculture Experiment Station and Cooperative Extension Service. Publication MF-2408. 6 p.
4. Reed. J. D. 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. *Journal of Animal Science* 73:1516–1528.
5. Aerts, R. J., T. N. Barry, and W. C. McNabb. 1999. Polyphenols and agriculture: beneficial effects of proanthocyanidins in forages. *Agriculture Ecosystems and Environment* 75:1–12.
6. Petersen, J. C., and N. S. Hill. 1991. Crop quality and utilization (enzyme inhibition by sericea lespedeza tannins and the use of supplements to restore activity). *Crop Science* 31:827–832.
7. McSweeney, C. B., B. Palmer, R. Bunch, and D. O. Krause. 2001. Effect of the tropical forage *Calliandra* on microbial protein synthesis and ecology in the rumen. *Journal of Applied Microbiology* 90:78–88.
8. Foley, W. J., G. R. Iason, and C. McArthur. 1999. Role of plant secondary metabolites in the nutritional ecology of mammalian herbivores: how far have we come in 25 years? H. Joachim, G. Jung, and G. C. Fahey, Jr. [eds.]. Nutritional Ecology of Herbivores: Proceedings of the 5th International Symposium on the Nutrition of Herbivores; 11–16 April 1999; San Antonio, TX, USA. Savoy, IL, USA: American Society of Animal Science. p. 130–209.
9. Terrill, T. H., W. R. Windham, J. J. Evans, and C. S. Hoveland. 1990. Condensed tannin concentration in sericea lespedeza as influenced by preservation method. *Crop Science*. 30:219–224.
10. Hart, S. 2000. Stocker goats for controlling sericea lespedeza. 2000. *In:* P. D. Ohlenbush [ed.]. Sericea lespedeza and the future of invasive species: a symposium with a look to the future. Manhattan, KS, USA: Kansas State University Agriculture Experiment Station and Cooperative Extension Service. p. 12–13.
11. Jones, W. T., and J. L. Mangan. 1977. Complexes of the condensed tannins of sainfoin (*Onobrychis viciifolia* Scop.) with fraction 1 leaf protein and with submaxillary mucoprotein and their reversal by polyethylene glycol and pH. *Journal of Science Food and Agriculture* 28:126–136.
12. Barry, T. N., and S. J. Duncan. 1984. The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep, 1: voluntary intake. *British Journal of Nutrition* 51:485–491.
13. Titus, C. H., F. D. Provenza, A. Perevolotsky, N. Silanikove, and J. Rogosic. 2001. Supplemental polyethylene glycol influences preferences of goats browsing blackbrush. *Journal of Range Management* 54:161–165.
14. Provenza, F. D. 1995. Postingestive feedback as an elementary determinant of food preference and intake in ruminants. *Journal of Range Management* 48:2–17.
15. Mantz, G. K., J. J. Villalba, and F. D. Provenza. 2009. Supplemental polyethylene glycol affects intake of and preference for sericea lespedeza by cattle. *Journal of Animal Science* 87:761–769.
16. [USDA] United States Department of Agriculture. 1982. Soil survey of Greenwood County Kansas. Washington, DC, USA: National Cooperative Soil Survey, USDA–Soil Conservation Service, Kansas Agricultural Experiment Station. 127 p.
17. Kansas Department of Agriculture. 2007. Bluestem Pasture Release, April 25, 2007. In cooperation with the national agriculture statistics service. Available at: http://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/Economics_and_Misc/Bluestem. Accessed 11 July 2007.
18. Kansas Department of Agriculture. 2007. Bluestem pasture release. Available at: http://www.nass.usda.gov/Statistics_by_State/Kansas/Publications/Economics_and_Misc/Bluestem/bluest07.pdf. Accessed 13 July 2007.
19. Owensby, C. E., R. C. Cochran, K. Anderson, E. F. Smith, and E. S. Vanzant. 1995. Fifty years of range research revisited (with a special focus on current research): KSU range field day, October 27, 1995. Manhattan, KS, USA: Cooperative Extension Service, Kansas State University. 57 p.
20. DelCurto, T., R. C. Cochran, D. L. Harmon, A. A. Beharka, K. A. Jacques, G. Towne, and E. S. Vanzant. 1990. Supplementation of dormant tallgrass-prairie, II: performance and forage utilization characteristics in grazing beef cattle receiving supplements of differing protein concentrations. *Journal of Animal Science* 68:532–542.
21. Galgan, M. W., and M. E. Ensminger. 1956. Salt for cattle (as a regulator of concentrate consumption). Pullman, WA, USA: Washington Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington. Bulletin 569. 24 p.
22. Adams, D. C. 1985. Effect of time of supplementation on performance, forage intake and grazing behavior of yearling beef steers grazing Russian wild ryegrass in the fall. *Journal of Animal Science* 61:1037–1042.
23. Altman, J. 1974. Observational study of behavior: sampling methods. *Behaviour* 49:227–265.
24. Mantz, G. K. 2007. Using polyethylene glycol to enhance the intake of sericea lespedeza by cattle [dissertation]. Logan, UT, USA: Utah State University. 182 p.
25. McMeniman, N. P., D. R. Niven, D. Crowther, R. J. W. Gartner, and G. M. Murphy. 1981. Studies on the supplementary feeding of sheep consuming mulga (*Acacia aneura*). 5: the effect of cobalt and cottonseed meal supplementation. *Australian Journal of Experimental Agriculture and Animal Husbandry* 21:404–409.
26. Pritchard, D. A., P. R. Martin, and P. K. O'Rourke. 1992. The role of condensed tannins in the nutritional value of mulga (*Acacia aneura*) for sheep. *Australian Journal of Agricultural Research* 43:1739–1746.
27. Bailey, R. Y. 1951. Sericea in conservation farming. Washington, DC, USA: U.S. USDA. Farmers' Bulletin No. 2033. 28 p.
28. Cope, W. A., T. A. Bell, and W. W. G. Smart, Jr. 1971. Seasonal Changes in an enzyme inhibitor and tannin content in sericea lespedeza. *Crop Science* 11:893–895.

29. Smith, E. F., and C. E. Owensby. 1978. Intensive-early stocking and season-long stocking of Kansas flint hills range. *Journal of Range Management* 31:14–17.
30. Eckerle, G. J., K. C. Olson, J. R. Jaeger, J. W. Waggoner, J. L. Davidson, and L. A. Pacheco. 2011. High-tannin, forage utilization by beef cows, III: effects of corn steep liquor supplementation on voluntary selection of tallgrass prairie hay contaminated with sericea lespedeza (*Lespedeza cuneata*) and uncontaminated tallgrass prairie hay. *Proceedings, Western Section, American Society of Animal Science.* 62:207–210.
31. Cope, W. A., T. A. Bell, and W. G. Smart, Jr. 1971. Seasonal changes in an enzyme inhibitor and tannin content in sericea lespedeza. *Crop Science* 11:893–895.

Authors are Student, College of Veterinary Medicine, Kansas State University, Manhattan, KS 66506, USA (Mantz); and Associate Professor, juan.villalba@usu.edu (Villalba), and Emeritus Professor (Provenza), Wildland Resources Dept, Utah State University, Logan, UT 84322, USA. *Funding to support authors and the research summarized in this article was provided by the Utah Agricultural Experiment Station and the Initiative for the Future of Agriculture and Food Systems, USDA (agreement no. 2001-52103-11215). This paper is published with the approval of the Director, Utah Agricultural Experiment Station, and Utah State University, as journal paper no. 8088.*