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Targeted Grazing of White Locoweed: Short-Term Effects of Herbivory Regime on Vegetation and Sheep

Laura E. Goodman,[1] Andrés F. Cibils,[2] Stephanie C. Lopez,[1] Robert L. Steiner,[4] John D. Graham,[3] Kirk C. McDaniel,[5] Laurie B. Abbott,[2] Bryan L. Stegelmeier,[6] and Dennis M. Hallford[7]

Authors are [1]Research Assistant, [2]Associate Professor, and [7]Professor, Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM 88003, USA; [3]Extension Agent (deceased), Union County Extension, Clayton, NM 88415, USA; [4]Professor, Department of Economics, Applied Statistics and International Business, New Mexico State University, Las Cruces, NM 88003, USA; [5]Professor, Extension Animal Science and Natural Resources, New Mexico State University, Las Cruces, NM 88003, USA; and [6]Research Veterinary Pathologist, Poisonous Plant Research Lab, Logan, UT 84341, USA.

Abstract

White locoweed (*Oxytropis sericea* Nuttall) and nontarget vegetation response to 2 yr of targeted grazing by sheep, one treatment of picloram plus 2, 4-D (HER) or no treatment (CON) were compared. Serum of sheep that grazed locoweed intermittently (IGZ, 5 d on locoweed followed by 3 d off locoweed) vs. counterparts that grazed locoweed continuously for 24 d (CGZ) was also examined. Alkaloid toxicity was inferred by serum levels of thyroxine (T4), triiodothyronine (T3), alkaline phosphatase (ALKP), aspartate aminotransferase (AST), and swainsonine, as well as behavior and body weight gains. Three sites were used in a randomized complete block design. IGZ, CGZ, and HER treatments reduced locoweed density ($P < 0.01$), canopy cover ($P < 0.01$), number of flower stalks (IGZ: $P = 0.02$, CGZ and HER: $P = 0.01$), and plant size ($P < 0.01$). White locoweed seed density in the soil seed bank was not reduced with grazing, and nontarget vegetation was mostly unaffected by treatments. Grass canopy cover increased in grazed and herbicide plots throughout the study (IGZ: $P = 0.03$, CGZ and HER: $P < 0.01$). Percentage bare ground was unchanged (IGZ: $P = 0.46$, CGZ: $P = 0.44$) in grazed plots but decreased ($P = 0.03$) in HER plots. After 24 d, ewes in the IGZ treatment had lower levels of serum ALKP ($P < 0.01$) and AST ($P = 0.02$) and marginally lower swainsonine levels ($P < 0.07$) than CGZ ewes that tended to exhibit lower serum T3 ($P < 0.07$) and similar serum T4 ($P = 0.25$) levels. Time spent feeding on locoweed tended to differ ($P = 0.06$) between treatments. Body weight gain was the same ($P = 0.19$) regardless of treatment. IGZ of locoweed-infested rangeland with sheep may be a viable short-term means of reducing locoweed density without detrimentally affecting animal health.

Key Words: biological control, prescribed grazing, seed bank, swainsonine, toxic plants

INTRODUCTION

Targeted grazing (TG), defined as the "application of a specific kind of livestock at a determined season, duration, and intensity to accomplish vegetation or landscape goals" (Launchbaugh and Walker 2006), has been used successfully to control a wide variety of invasive plants. Diffuse (*Centaurea diffusa* Lam.), Russian (*Acroptilon repens* [L.] DC.), and spotted (*Centaurea stoebe* L.) knapweed, kudzu (*Pueraria montana* [Lour.] Merr.), musk thistle (*Carduus nutans* L.), yellow starthistle (*Centaurea solstitialis* L.), blackberry (*Rubus* spp.), juniper (*Juniperus* spp.), and cheatgrass (*Bromus tectorum* L.) are a few examples (Wilson et al. 2006). Sheep (*Ovis aries*) are often the livestock species used in TG programs, particularly if the target plants are forbs, as their rumen to body volume ratio make forbs their most preferred plant functional group (Demment 1982; Hanley 1982). Sheep have been used successfully to decrease larkspur (*Delphinium barbeyi* [Huth] Huth), an alkaloid-synthesizing forb, for a season because they are more resistant to its toxins than cattle (Olsen 1978). By grazing sheep prior to cattle in larkspur-infested (*D. glaucescens* Wats) pastures, subsequent larkspur use by cows was reduced by 43–93% (Ralphs and Olsen 1992).

White locoweed (*Oxytropis sericea* Nuttall) is a common alkaloid-synthesizing toxic rangeland legume that is responsible for substantial economic losses to the livestock industry in western North America (Nielsen 1978; Torell et al. 2000). Relatively little is known about the efficacy of biological methods to suppress locoweed compared with more traditional chemical control techniques (McDaniel et al. 2007). The effectiveness of TG or severe defoliation in killing or decreasing vigor of locoweed plants is unknown. Most research has investigated methods to prevent locoweed grazing by livestock because it contains swainsonine, an indolizidine alkaloid (Molyneux and James 1982; Molyneux et al. 1999) that has negative effects on reproduction (James et al. 1967; James and Van Kampen 1971; McIlwraith and James 1982; Panter and James 1989; Ralphs et al. 1994b; Ortiz et al. 1997), weight gains (Stegelmeier et al. 1999a; Ralphs et al. 2000), and behavior (Panter et al. 1999; Pfister et al. 2006a, 2006b) of all classes of livestock (Molyneux et al. 1985; Stegelmeier et al. 2007).

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Correspondence: Andrés F. Cibils, Animal and Range Sciences Dept, New Mexico State University, Las Cruces, NM 88003, USA. Email: acibils@nmsu.edu

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Although sheep are susceptible to alkaloid intoxication if ingestion of white locoweed occurs continuously for 30 d at levels as low as 3% of their diet (James et al. 1967; Stegelemeier et al. 1995, 1999a, 2007), little is known about how animals are affected by intermittent grazing of locoweed-infested pastures. When sheep consume levels of swainsonine known to cause lesions, the distribution and extent of lesions do not increase with a higher toxin dose, suggesting that there is a threshold response to swainsonine ingestion (Stegelmeier et al. 1999a). Rapid recovery of animals receiving high concentrations of swainsonine for short periods of time has been reported (Stegelmeier et al. 1998, 2004). Furthermore, there is anecdotal evidence (James et al. 1986) as well as research results that suggest that an intermittent grazing regime may provide a way of preventing intoxication associated with white locoweed ingestion (Pfister et al. 1996; Stegelmeier et al. 1999b; Obeidat et al. 2005; Ashley et al. 2006). Because swainsonine exhibits rapid blood clearance rates, intermittent grazing of white locoweed may be an effective means of controlling this undesired plant while avoiding the intoxication of grazers.

The main objective of this study was to evaluate the influence of 2 yr of TG by sheep on the survival and reproductive vigor of white locoweed plants. The efficacy of TG was assessed by comparing it to a proven chemical control method (positive control) and to untreated, infested rangeland (negative control). The hypotheses tested were that 1) TG with sheep for two consecutive years would reduce locoweed abundance (including seed bank abundance of locoweed seeds) and that its efficacy would be intermediate compared to untreated and chemically treated rangeland, 2) abundance of grasses and other forbs would not be negatively affected by the TG prescription, and 3) intermittent and continuous TG for two consecutive years would affect locoweed abundance similarly. A secondary objective of this study was to evaluate the influence of intermittent TG prescriptions of white locoweed on serum constituents, grazing behavior, and body weight gains of sheep. The hypotheses tested were that sheep grazing locoweed-infested plots intermittently would have 1) lower serum swainsonine concentrations, 2) lower serum alkaline phosphatase [ALKP] and aspartate aminotransferase [AST] levels, 3) higher serum triiodothyronine [T3] and thyroxine [T4] levels, 4) similar foraging behavior, and 5) similar body-weight gains as sheep that grazed locoweed-infested plots continuously.

METHODS

Study Sites

The study was conducted on three ranches in Union County, New Mexico, during May and June 2009 and 2010. Sites were selected for their similar white locoweed densities and equidistance from water (< 0.4 km). Mean annual, spring, and summer precipitation for this area are 408, 114, and 239 mm respectively, based on approximately 12 yr of records from the National Weather Service Cooperative Observation station in Capulin, New Mexico (lat 36°44′N, long 103°59′W) ([NOAA] National Oceanic and Aeronautics Administration 2010). Spring (January through May) precipitation was 81 mm (dry) and 212 mm (wet) for 2009 and 2010, respectively, while summer (June through September) precipitation was 242 mm (average) and 167 mm (dry) for each of the two study years, respectively. The 2 yr following the study were also dry with mean annual precipitation of 345 mm (2011) and 267 mm (2012).

The first site was located on Archuleta Ranch, 1.48 km southwest of Des Moines, New Mexico (lat 36°45′12.43″N, long 103°51′00.99″W) at an elevation of 2062 m above sea level. It had a moderate slope with northern exposure and the soils consisted of cobbly loam and cobbly clay loam with basalt rock outcroppings. Basalt fragments occupy 5–35% of the surface and soil at this site ([USDA, NRCS] United States Department of Agriculture, Natural Resource Conservation Service 2007). Dominant grasses included blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. ex Griffiths), little bluestem (*Schizachyrium scoparium* [Michx.] Nash), western wheatgrass (*Pascopyrum smithii* [Rydb.] Á. Löve), sideoats grama (*B. curtipendula* [Michx.] Torr.), and hairy grama (*B. hirsuta* Lag.). Forbs consisted of white locoweed, globemallow (*Sphaeralcea* spp.), and dalea (*Dalea* spp.), with white locoweed being the most frequent. Fringed sagewort (*Artemisia frigida* Willd), skunkbush sumac (*Rhus trilobata* Nutt.), yucca (*Yucca* spp.), one-seed juniper (*Juniperus monosperma* [Engelm.] Sarg.), and pinyon pine (*Pinus edulis* Engelm.) were common woody plants, while plains pricklypear (*Opuntia polyacantha* Haw.) was the predominant cactus.

The second site was located on Mondragon Ranch, 2.18 km northwest of Des Moines, New Mexico (lat 36°46′21.18″N, long 103°51′32.13″W) at an elevation of 2 042 m above sea level. This area of open grassland had loam, clay loam, and gravelly loam soils. Dominant grasses were blue grama, galleta (*Pleuraphis jamesii* Torr.), tobosa (*P. mutica* Buckley), buffalograss (*Buchloe dactyloides* [Nutt.] J.T. Columbus), sideoats grama, sand dropseed (*Sporobolus cryptandrus* [Torr.] A. Gray), and western wheatgrass. Here too the most prevalent forb was white locoweed. Other forbs included globemallow and sunflower (*Helianthus annuus* L.). Shrubs were rare, although winterfat (*Krascheninnikovia lanata* [Pursh] A. Meeuse & Smit) and groundsel (*Senecio* spp.) were present.

The third site was at the base of Capulin Volcano (lat 36°45′22.87″N, long 103°58′24.47″W), 2.34 km northeast of Capulin, New Mexico, at an elevation of 2 099 m above sea level. Blue grama, western wheatgrass, bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey), sideoats grama, perennial threeawn (*Aristida* spp.), and buffalograss were common grasses. Again the dominant forb was white locoweed, with western ragweed (*Ambrosia psilostachya DC.*), dotted gayfeather (*Liatris punctata* Hook.), prairie coneflower (*Ratibida columnifera* [Nutt.] Woot. & Standl.), sunflower, and globemallow also present. The only shrub present in the study plots was fringed sagewort, although skunkbush sumac, one-seed juniper, and pinyon pine were nearby.

Experimental Protocol

At each of the three sites four 200 m^2 plots (10 m $\times$ 20 m) with similar density of locoweed plants were established and randomly assigned to one of the following treatments: 1) control with no treatment [CON]; 2) herbicide as a positive control [HER]; 3) grazed for 5 d by ewes exposed to locoweed