Rangeland Ecology & Management 71 (2018) 115–118

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Original Research

Intake of Salt Cedar by Two Different Breeds of Sheep☆

Zach B. Borroum [a], Cody B. Scott [b,*], Corey J. Owens [c]

[a] Former Graduate Assistant, Department of Agriculture, Angelo State University, San Angelo, TX 76904, USA
[b] Professor, Department of Agriculture, Angelo State University, San Angelo, TX 76904, USA
[c] Research Associate, Department of Agriculture, Angelo State University, San Angelo, TX 76904, USA

ARTICLE INFO

Article history:
Received 3 March 2017
Received in revised form 7 August 2017
Accepted 23 August 2017

Key Words:
goats
intake
Rambouillet
Suffolk
weight gain

ABSTRACT

Salt cedar (*Tamarix* spp.) readily invades and dominates riparian areas and lake basins throughout the western United States. Traditional control efforts (chemical and mechanical control) are expensive and provide limited long-term control. The salt cedar leaf beetle *(Diorhabda elongata)* provides a method of biological control through reduction in cover. However, population establishment of leaf beetles in some locations is often difficult because of environmental conditions. In previous research, goats readily consumed salt cedar, offering an alternative method of reducing salt cedar cover. For this study, we determined if sheep would consume salt cedar and consume a similar amount as goats. Twelve Rambouillet and 12 Suffolks lambs were fed salt cedar once daily (Trial 1) and three times daily (Trial 2). Intake of salt cedar by sheep was compared between breeds and with intake of salt cedar by goats ($n = 10$). Salt cedar was fed once a day in Trial 1 for 30 min over 15 d. Intake was recorded daily for individual animals. In Trial 2, salt cedar was offered three times daily for 13 d with intake recorded. There were no differences ($P > 0.05$) between breeds of sheep. In addition, sheep consumed more salt cedar than goats except on the last day of the study. When salt cedar was offered three times daily, both breeds of sheep increased intake and gained weight over the 13 d of feeding in Trial 2. By the end of the study, intake appeared to still be increasing. Collectively, these results illustrate that both Rambouillet and Suffolk sheep will consume a similar amount of salt cedar as goats and will provide another species of livestock that can be potentially used to reduce salt cedar cover.

Introduction

Salt cedar (*Tamarix* spp.), an introduced halophyte, has had a detrimental impact on riparian zones and lake basins across the western portion of the United States since its arrival in the 19th century (Edward and Nager, 2005). Salt cedar has replaced native plants within its realm, primarily dominating riparian zones and flood plains (Shafroth et al., 2005). Once the plant invades, rapid encroachment is inevitable without expensive control efforts. Salt cedar outcompetes native species, causing dense monocultures resulting in a reduction of biodiversity and degradation of stream flow (Di Tomaso, 1998). Attempts to control salt cedar have been made, but none yet have been found to be entirely feasible.

Salt cedar is native to Eurasia but was brought to North America by settlers and intended for ornamental purposes. The plant escaped cultivation and invaded riparian areas and lake basins. The spread of salt cedar was the result of multiple factors. Settlers planted salt cedar to serve as wind breaks, provide shade for livestock, and help battle erosion in arid and semiarid areas. Around the 1870s, salt cedar was believed to have escaped cultivation, and by the 1930s it had become a serious issue along lake shores (Brotherson and Winkel, 1986). It is estimated that salt cedar has already replaced native species in 470 000 − 650 000 ha of riparian floodplain habitat in 23 states (Zavaleta, 2000).

In 2001, the salt cedar leaf beetle *(Diorhabda elongata)* was released in six states in an attempt to control the plant. Leaf beetles consume the plant, resulting in defoliation and a reduction of cover (Dudley and Deloach, 2004). Unfortunately, beetle populations are often difficult to establish in some locations. In many regions in the south, imported fire ants are also prevalent in riparian habitats. The presence of imported fire ants also reduces the likelihood of successful establishment of leaf beetle populations (A. Knutson, personal communication).

In addition to beetles, goats consume salt cedar and may be used to reduce salt cedar cover (Munoz et al., 2017). This study determined if another small ruminant, sheep, would consume salt cedar. Intake and performance (weight change) by two different breeds were measured at different levels of salt cedar in the diet. In addition, this study determined if sheep would consume a similar amount of salt cedar as goats.

☆ Research reported herein was supported by the Angelo State University Management, Instruction, and Research Center.

* Correspondence: Cody Scott, Box #10888 ASU Station, San Angelo, TX 76909, USA. Tel.: +1 325 486 6744; fax: +1 325 942 2183.
E-mail address: Cody.Scott@angelo.edu (C.B. Scott).

https://doi.org/10.1016/j.rama.2017.08.005
1550-7424/

Materials and Methods

Twenty-four freshly weaned female lambs averaging 36.0 ± 1.4 kg were housed in individual pens (1 × 1.5 m) at the Angelo State University (ASU) Management Instruction and Research (MIR) Center in San Angelo, Texas (lat 31.38, long 100.5). Before initiation of the study, goats were raised on native rangelands on the MIR Center and were naïve to salt cedar. Twelve Rambouillet lambs and 12 Suffolk lambs were used. A control group of 10 recently weaned female Boer goats averaging 28.0 ± 1.8 kg were used as well. Boer goats were used as the control group in conjunction with other ongoing research. All individuals, regardless of breed or species, were exposed to the same research protocol. *Ad libitum* access to water and a calcium-phosphorus trace mineral was provided. Both treatment and control groups were given a 2.5% body weight (BW) basal diet of RAM 20 (Table 1) to meet requirements for maintenance and growth (NRC, 2007). The basal diet was fed after weighing salt cedar refusals. After a 5-d pen adjustment period, individuals from each breed/species were offered salt cedar once daily for 30 min, and on d 16, offerings were increased to three times daily. The 5-d adjustment period took place before the experiment to allow the animals to acclimate to their pen settings and basal diet. BWs were recorded every 7 d. All research protocols were approved by the ASU Institutional Animal Care and Use Committee (IACUC).

The salt cedar used in the experiment was harvested at the Angelo State University MIR Center along the receding shorelines of O.C. Fisher Reservoir (lat 31.38, long 100.5). Salt cedar leaves were hand-stripped, composited, and placed in large contractor trash bags. Salt cedar not used that day was stored in a large walk-in cooler at 4°C until needed. Collections were stored no more than 4 d before being used to ensure freshness and palatability.

Trial 1

At 0800, any RAM 20 (basal diet) refusals from the previous day were collected and weights recorded. At 0830 on d 1, each animal was offered 50 g of salt cedar for 30 min. Any refusals were collected and weighed at 0900 to estimate daily intake of salt cedar. The basal ration was offered for the remainder of the day. Animals that exhibited zero refusals of salt cedar for that day were offered an additional 25 g the following day.

Trial 2

Following d 14 of the experiment, Rambouillet and Suffolk lambs were offered salt cedar at 0800, 1200, and 1700 to simulate feeding bouts in ruminant animals throughout a day. Goats were not fed salt cedar in Trial 2. Refusals were measured and recorded 30 min after each offering of salt cedar. Basal rations remained at 2.5% BW per day for each individual animal and were fed overnight after weighing refusals at the end of the day.

Salt cedar intake data and body weight gains were analyzed using repeated measures analysis of variance. Intake data were converted and analyzed on a g · kg^{-1} BW basis to account for variations in body size. Breed served as the main effect and day as the repeated measure. Individual animals were nested within treatments and served as replications. Trials were analyzed separately because of differences in feeding protocols (i.e., feeding once daily vs. 3 times daily). Means were separated using Tukey's HSD Test when $P < 0.05$. Statistical analysis was performed with the JMP Statistical Software Package (SAS, 2007).

Table 1
Ingredients and nutrient content of the ration used to meet maintenance requirements. Data reported herein were on an as-fed basis

Ingredients	Percent (%) in feed
Sorghum grain	45.0
Cottonseed meal	10.0
Soybean hulls	22.5
Alfalfa pellets (dehy)	17.0
Cane molasses	3.5
Premix[1]	2.0
Nutrient content	
Crude protein	14.8
Digestible protein	10.0
Digestible energy (mcal/kg)	2.8
Crude fiber	14.1
Total digestible nutrients (TDN)	63.0

[1] Premix includes lasalocid, calcium, salt, manganese, zinc, selenium, copper, and vitamins A, D, and E.

Results

Salt cedar intake was similar between both breeds of sheep (Table 2). Both Rambouillet and Suffolk breeds consumed more ($P < 0.05$) salt cedar than goats. However, on the last day of the study, goats ate more salt cedar on a BW basis than either breed of sheep (Treatment × Day interaction $P < 0.05$; Fig. 1).

Regardless of breed, sheep increased intake of salt cedar daily (see Fig. 1). On d 1 of the experiment, animals were hesitant to consume the 50 g of salt cedar offered. Following the first exposure to salt cedar, consumption levels increased steadily throughout the duration of the experiment. By the end of the first trial, salt cedar consumption by Rambouillet sheep averaged 5.1 g · kg^{-1} BW, Suffolk sheep averaged 5.6 g · kg^{-1} BW, and goats averaged 6.4 g · kg^{-1} BW. Throughout the experiment, sheep and goats consumed all of the basal rations offered each day.

Weight fluctuated among both breeds of sheep, as well as goats, and differed between feeding trials. Average body weights of the animals decreased when animals received salt cedar once daily along with the basal ration (Fig. 2). Once salt cedar was fed three times daily (Trial 2), BWs began increasing and increased throughout the remainder of the study. Weight changes between Rambouillet and Suffolk breeds were not different ($P > 0.05$).

When salt cedar was fed thrice a day, intake increased from 17.4 g · kg^{-1} BW to 26.5 g · kg^{-1} BW across the 13 d of feeding (Fig. 3). On d 1 of the second feeding period, sheep readily consumed most of the salt cedar offered. The following 2 d, intake levels decreased slightly but returned to increasing levels until the end of the study (see Fig. 3). The breed × day interaction was similar ($P > 0.05$). During the thrice-daily feedings, no significant ($P > 0.05$) differences were found from the morning, noon, and evening feedings (Table 3).

Discussion

On the basis of these study results, it appears sheep will consume salt cedar at levels similar to those reported for goats (Munoz et al., 2017). Sheep consumed more salt cedar than goats in the first trial of the study. Salt cedar does not appear to cause aversive postingestive feedback or adversely affect production (i.e., weight gain). The decline in BWs recorded in the first trial was probably a function of animals unable to meet nutrient requirements from the basal ration (2.5% BW) and salt cedar fed once a day.

Table 2
Average intake (g · kg^{-1} body weight) of salt cedar and basal ration when salt cedar was fed once daily

Breed/Species	Intake	
	Salt cedar	Basal
Rambouillet	3.2^{a} ± 0.2	25.8 ± 0.3
Suffolk	3.4^{a} ± 0.2	25.8 ± 0.3
Goat	2.4^{b} ± 0.2	24.4 ± 0.3

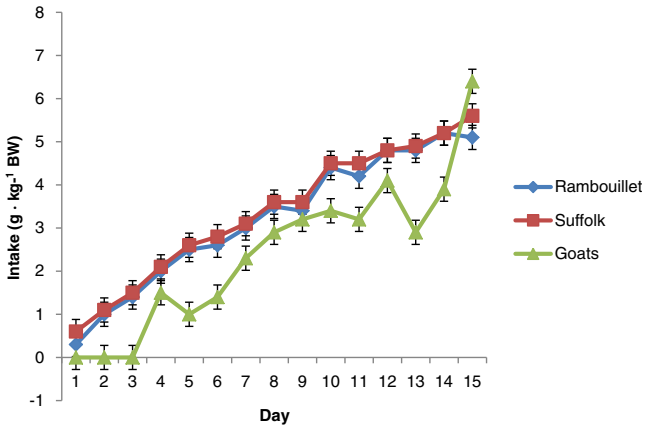

Figure 1. Average salt cedar intake (g · kg^{-1} BW) for Rambouillet, Suffolk, and goats during single-day feeding (Trial 1) period.

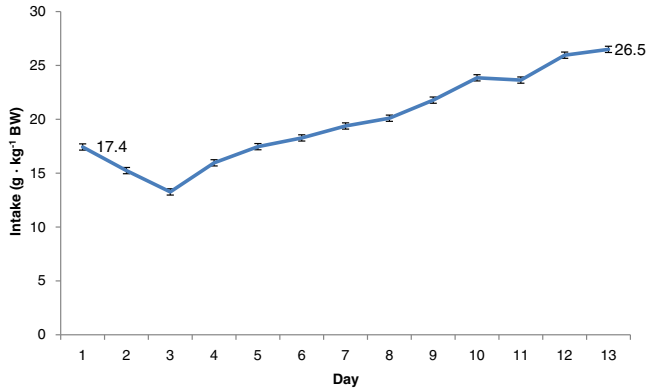

Figure 3. Average daily salt cedar intake (g · kg^{-1} BW) for sheep (across both breeds) during three-times-a-day feedings (Trial 2).

Salt cedar is apparently relatively high in nutrient quality. In Knight et al. (2017), crude protein (CP) ranged from 16% to 19.6% while Total Digestible Nutrients (TDNs) ranged from 67.5% to 69.4%. Given the results of this study and Munoz et al. (2017), both sheep and goats should consume salt cedar on a pasture setting and potentially reduce the amount of salt cedar cover while meeting nutrient requirements. Unfortunately, it is not known if sheep and goat browsing will result in a long-term reduction in salt cedar cover. Defoliation by leaf beetles slows encroachment, but a long-term control method has not been successfully established.

On d 1, sheep were hesitant to consume the first 50 g of salt cedar offered. Following this initial exposure, intake steadily increased throughout the study. Ruminants are typically hesitant to consume novel foods and increase intake slowly (Provenza, 1995). Animals will typically continue to increase intake until reaching satiation or experiencing aversive postingestive feedback (Provenza et al., 1994).

On d 2, of the thrice-daily feeding bouts, intake declined. Thereafter, salt cedar intake increased throughout the duration of the trial. By the end of the second wk of feeding three times daily, intake levels were still increasing steadily. Harvesting of the salt cedar had reached a point in which collecting enough for the thrice-daily feedings had become an issue. Consequently, the study was stopped at this point. On the basis of the results observed, it appeared that salt cedar intake would continue to increase as the amount offered increased. This observation also suggests that sheep could potentially survive and remain productive on a 100% salt cedar diet (Knight et al., 2017). In the Knight et al. study, goats lost weight at the beginning and end of the study, but internal parasites were apparently affecting BWs. The observation is also supported by concurrent research that has illustrated that goats perform well while foraging on salt cedar—dominated pasture (Rogers, unpublished data).

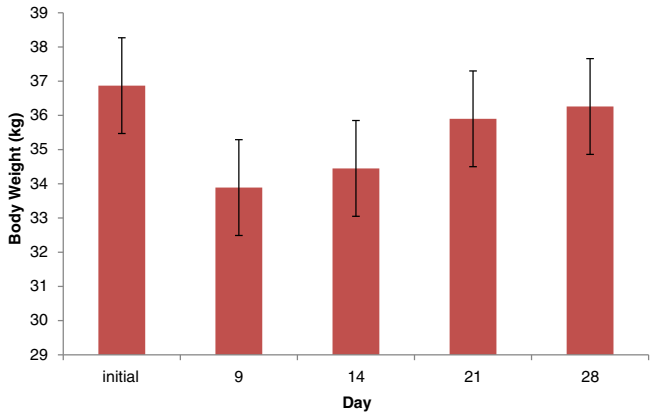

Figure 2. Average body weight (kg) of animals across the entire experiment (Trials 1 and 2). Trial 1 lasted for the first 14 d while Trial 2 lasted from d 16 through d 28.

Table 3
Average salt cedar intake (g · kg^{-1} BW) when salt cedar was fed three times daily

Breed	Time		
	Morning	Noon	Afternoon
Rambouillet	6.5 ± 0.4	6.2 ± 0.4	6.3 ± 0.4
Suffolk	6.8 ± 0.4	6.9 ± 0.4	7.0 ± 0.4

Even though the basal ration was fed at levels reportedly adequate to meet maintenance requirements, both sheep and goats consumed salt cedar throughout the study. Satiety is food specific, resulting in animals continuing to eat when alternative foods are offered (Newman et al., 1992; Parson et al., 1994; Provenza, 1995). When a variety of foods are available, intake typically increases and animals potentially gain more weight (Provenza et al., 1994).

Water consumption was not recorded during this study. However, in previous studies with goats, salt cedar intake did not cause increased water consumption even though it is relatively high in sodium (Knight et al., 2017; Munoz et al., 2017). More recently, field observations have suggested that goats consume very little water while consuming salt cedar, apparently due to the high moisture content in the plant (Rogers, unpublished data).

Implications

The use of sheep and goats to browse salt cedar could serve as a viable alternative where leaf beetle populations cannot be established or where population numbers remain low. Furthermore, using livestock to reduce salt cedar cover would produce a product (kids, lambs, wool) that could be sold as a commodity. The long-term impact of sheep and goat browsing on salt cedar remains largely unknown. However, defoliation of the plant should reduce its competitive ability, allowing the establishment and persistence of native vegetation.

References

Brotherson, J.D., Winkel, V., 1986. Habitat relationships of salt cedar (*Tamarix* ramosissima) in central Utah. Great Basin Naturalist 46, 535–541.
Di Tomaso, J.M., 1998. Impact, biology, and ecology of Saltcedar (*Tamarix* spp.) in the Southwestern United States. Weed Technology 12, 326–336.
Dudley, T.L., Deloach, C.J., 2004. Salt cedar (*Tamarix* spp.) endangered species, and biological weed control: can they mix? Weed Technology 18, 1542–1551.
Edward, P.G., Nager, P.L., 2005. Comparative ecophysiology of *Tamarix ramosissima* and native trees in western U.S. riparian zones. Journal of Arid Environments 61, 419–446.

Knight, C.W., Scott, C.B., Owens, C.J., 2017. Changes in nutritional quality and intake of salt cedar. Texas Journal of Agriculture and Natural Resources (submitted for publication).

Munoz, A., Garcia, A., Scott, C., Owens, C., 2017. Consumption of salt cedar and willow baccharis by Boer-cross goats. Rangeland Ecology & Management 70, 374–379.

National Research Council, 2007. Nutrient requirements of small ruminants: sheep, goats, cervids and new world camelids. National Research Council, Washington, DC, USA, pp. 246–255.

Newman, J.A., Parsons, A.J., Harvey, A., 1992. Not all sheep prefer clover: diet selection revisited. Journal of Agricultural Sciences 199, 275–283.

Parson, A.J., Newman, J.A., Penning, P.D., Harvey, A., Orr, R.J., 1994. Diet preference of sheep: effects of recent diet, physiological state and species abundance. Journal of Animal Ecology 63, 465–478.

Provenza, F.D., 1995. Postingestive feedback as an elementary determinant of food preferences and intake in ruminants. Journal of Range Management 48, 2–17.

Provenza, F.D., Lynch, J.J., Burritt, E.A., Scott, C.B., 1994. How goats learn to distinguish between novel foods that differ in postingestive consequences. Journal of Chemical Ecology 20, 609–624.

SAS Institute Inc, 2007. JMP user's guide. Version 7.0. SAS Institute Inc., Cary, NC, USA 487 p.

Shafroth, P.B., Cleverly, J.R., Dudley, T.L., Taylor, J.P., Riper III, C.V., Weeks, E.P., Stuart, J.N., 2005. Control of *Tamarix* in the western United States: implications for water salvage, wildlife use, and riparian restoration. Environmental Management 35, 231–246.

Zavaleta, E., 2000. The economic value of controlling an invasive shrub. Ambio: A Journal of the Human Environment 29, 462–467.