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Original Research

Intake of Salt Cedar by Two Different Breeds of Sheep<sup>☆</sup>Zach B. Borroum<sup>a</sup>, Cody B. Scott<sup>b,\*</sup>, Corey J. Owens<sup>c</sup><sup>a</sup> Former Graduate Assistant, Department of Agriculture, Angelo State University, San Angelo, TX 76904, USA<sup>b</sup> Professor, Department of Agriculture, Angelo State University, San Angelo, TX 76904, USA<sup>c</sup> Research Associate, Department of Agriculture, Angelo State University, San Angelo, TX 76904, USA

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## 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.

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## 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.

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## Materials and Methods

Twenty-four freshly weaned female lambs averaging  $36.0 \pm 1.4$  kg were housed in individual pens ( $1 \times 1.5$  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  $28.0 \pm 1.8$  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

**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 <sup>1</sup>	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

<sup>1</sup> Premix includes lasalocid, calcium, salt, manganese, zinc, selenium, copper, and vitamins A, D, and E.

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  $\text{g} \cdot \text{kg}^{-1}$  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).

## 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  $\times$  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  $5.1 \text{ g} \cdot \text{kg}^{-1}$  BW, Suffolk sheep averaged  $5.6 \text{ g} \cdot \text{kg}^{-1}$  BW, and goats averaged  $6.4 \text{ g} \cdot \text{kg}^{-1}$  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  $17.4 \text{ g} \cdot \text{kg}^{-1}$  BW to  $26.5 \text{ g} \cdot \text{kg}^{-1}$  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  $\times$  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 post-ingestive 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 ( $\text{g} \cdot \text{kg}^{-1}$  body weight) of salt cedar and basal ration when salt cedar was fed once daily

Breed/Species	Intake	
	Salt cedar	Basal
Rambouillet	$3.2^a \pm 0.2$	$25.8 \pm 0.3$
Suffolk	$3.4^a \pm 0.2$	$25.8 \pm 0.3$
Goat	$2.4^b \pm 0.2$	$24.4 \pm 0.3$

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