EFFECTS OF PROTEIN SUPPLEMENTATION ON THE CONSUMPTION OF SALT CEDAR IN GOATS

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EFFECTS OF PROTEIN SUPPLEMENTATION ON THE CONSUMPTION OF SALT CEDAR IN GOATS

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ABSTRACT

Saltcedar (*Tamarix ramosissima* Ledeb.) has encroached upon many Texas riparian and floodplain areas, causing decreases in water quality and plant/animal diversity. The objectives of this study were to determine if (1) goats would increase consumption of salt cedar, and (2) if protein supplementation improved salt cedar intake. Goats (n=20) were randomly selected and divided into 2 separate treatments. Treatment 1 was supplemented daily with a 37% crude protein ration and Treatment 2 (control group) was not supplemented. All treatments were given a basal ration of alfalfa (2.5% BW) and offered salt cedar. Salt cedar intake increased ($P<0.05$) on a daily basis in both treatments. Protein supplementation did not affect salt cedar intake. Alfalfa intake was similar between treatments. Both treatments gained weight during the study. Collectively, the results of this study suggest that goats will readily consume salt cedar, and protein supplementation has little apparent effect on salt cedar intake.

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INTRODUCTION

Salt cedar (*Tamarix ramosissima* Ledeb.), a plant which originated from Eurasia, was introduced in the 1800's as an ornamental and as a means of erosion control along the banks of riparian areas throughout the southwestern U.S. (Kennedy and Hobbie 2004; Bartlet and Cosse 2005). Salt cedar's ability to tolerate highly saline soils, long periods of drought, water stress, and fire allowed it to out-compete most native species of trees (Glenn and Nagler 2005). The first known herbarium record of salt cedar in Texas was made on the San Jacinto River in 1884 (Reynolds and Alexander 1974). By 1960, there were 364,000 ha of invaded land within the United States and by 1970 that number increased to 526,000 ha (Robinson 1965). In 2003, Texas alone had in excess of 600,000 ha of land invaded by salt cedar (DiTomaso 1998; Hart 2003). Salt cedar's rapid expansion and growth has allowed it to range from the Great Plains to the Pacific and from Canada to Mexico (DeLoach and Carruthers 2005).

Salt cedar can reproduce both sexually and asexually. It produces seeds that are wind and water dispersed with high germination rates and rapid root production of new plants under a wide variety of soil conditions (Horton 1957). Salt cedar's rhizome growth beneath the soil allows it to reproduce even when seed production is lowered because of harsh environmental conditions (DeLoach and Carruthers 2005).

Rangeland Ecology and Management

Salt cedar tolerates high saline soils and quickly out-competes native species creating a monoculture and is deemed by many to be a “biological desert” (Anderson and Ohmart 1977). Salt cedar uses allelopathy in order to aid in competitiveness by its saline excretions on the base of leafy matter that are then deposited in the soil, thereby rapidly increasing soil salinity (Deloach 1989a, 1989b).

Control methods including fire and mechanical control such as chopping, root plowing, and chaining can all reduce canopy cover but have little or no effect on plant mortality (Wiedemann and Cross 1979). Chemical methods are costly (e.g., $500/ha) and have been deemed unsafe in certain instances because of environmental concerns and are also cost prohibitive (Brock 1994).

As control options have been eliminated, biological control seems to be a cost effective alternative. The only known predator and considered biological control method of salt cedar is an introduced insect known as the leaf beetle (*Diorhabda elongate)* (Shafroth et al. 2005). Unfortunately, establishment of new colonies of leaf beetles has been difficult in some locations (Knutson et. al. 2003).

Boer-cross goats increased consumption when introduced to salt cedar at weaning but had reduced body condition scores (Munoz 2007). Pre-conditioning of goats with other invasive plant species, such as redberry juniper (*Juniperus pinchotti* Sudw.), have been successful while maintaining body condition with the aid of proteins that have a high rumen escape value (George et al. 2010). In addition, amino acids that escape rumen degradation may improve metabolism and excretion of some toxic compounds in the liver (George et al 2010). This study will attempt to determine potential intake of salt cedar by goats and determine if supplementation with protein improves salt cedar intake.

OBJECTIVES

1. Quantify intake of salt cedar by Boer-cross goats.

2. Determine if protein supplementation will improve consumption of salt cedar.

LITERATURE REVIEW

Salt cedar

Salt cedar was introduced in the early 1800's as an ornamental plant and was later used to reduce stream bank erosion along many southern rivers such as the Pecos River in New Mexico and Texas (Everitt 1998). Since its introduction, salt cedar has spread throughout North America where it is estimated that it controls well over 600,000 ha of waterways (Kunzmann and Bennett 1989). The dominance of salt cedar primarily occurs in arid to semi-arid regions, where it is estimated that it has spread up to 20 km/yr along favorable river systems (DiTomosa 1998; Glenn and Naglar 2005). Salt cedar's growth and morphology allow it to out-compete most native plant species. Once salt cedar dominates riparian areas, plants such as cottonwoods (*Populus* sp) and native willows (*Salix* sp.) are typically unable to survive (Bailey et al. 2001). Salt cedar has a high establishment rate and individual plants grow rapidly (Tomanek and Ziegler 1960). Most adult trees in the Central Texas region grow 6-9 m tall and in densities of approximately 700-1000 plants/ha (Hart et al. 2005). Salt cedar begins seeding in early spring and continues into late fall, typically April to October.

Salt cedar seeds are dispersed and readily germinate once soil moisture is available. Seeds have also been known to germinate while floating on the water especially in warmer months (Frasier and Johnsen 1991). Seedlings can survive long periods of water submergence and high saline soils. Growth is slow at first as most plants reach 10 cm within 60 days and they are vulnerable to drought conditions (Horton 1959). Once mature, salt cedar becomes highly tolerant to cold, fire, drought, flooding and most mechanical control methods (McGinty and Hart 2001; Knutson et al. 2003).

Water and Environmental Concerns

Salt cedar's high evapotranspiration rate allows the plant to withstand soils that have increased saline soils (Walker and Smith 1997). Thereafter, the plant uses what is thought to be allelopathy, to absorb salt and deposit it on the base of leaves, then depositing them to the soil (DeLoach 1997). A single salt cedar plant can withstand 15,000 ppm of salt whereas most native plant species can only withstand 2,500 ppm (Munoz 2007; Hart 2003; Belzar and Hart 2004).

The ability of mature salt cedar plants to reach groundwater tables up to 6 m deep is another competitive advantage it has to out-compete native riparian plants while also depleting groundwater recharge supplies (Vandersandae et al. 2001). Water depletion is a primary concern of the State of Texas. The Pecos River Ecosystem Project was developed in 1997 in order to increase efficiency of water delivery in river irrigation districts and to improve water quality by eradicating salt cedar (Hart et al. 2005). Water usage measurements taken by evapotranspiration measurements are 0.3 to 3.1 m per year suggesting that salt cedar domination has substantially reduced flow in the Pecos River (Hays 2003).

Water usage is currently exceeding water available in Texas with the current population, and by 2050, the population is estimated to double causing high water demands (Munoz 2007; Hays et al. 1998). Initial attempts by the Pecos River Ecosystem Project to eradicate the weed through chemical and mechanical methods have shown some success. However, because of cost and the plants ability to survive some control methods, follow-up treatments are typically necessary (Dennison et al. 2009; Hart et al. 2005).

Other environmental concerns of salt cedar are based on the loss of biodiversity once the plant dominates riparian areas. The reduction of native plant species causes a loss in ecological diversity, therefore, having negative impacts on wildlife and livestock (Taylor and McDaniel 1998). Because salt cedar provides no food source its importance is limited to screening cover for wildlife and nesting cover for some birds (Bailey et al. 2001). Much concern has also been raised in national parks as salt cedar has reduced use of recreational areas causing economic loss for the parks (Penny 1991).

Biological Control

The aggressiveness of the salt cedar plant in conjunction with no known biological predators other than the leaf beetle has made it hard to control. The leaf beetle was chosen as it selectively feeds on the salt cedar plant during larval and adult stages, while pupation and adult wintering take place in the litter below the tree. Once the plant produces leaves the beetle begins to eat and may eventually cause mortality to the plant (Dennison et al.2009). The use of beetles has been minimal because of difficulty in establishing new colonies. Goats have been a previous choice for possible biological control of salt cedar. In pen studies, goats will consume salt cedar and increase consumption at a constant rate up to day 14 of a 14 day trial (Munoz 2007). Prior research has demonstrated the ability to condition goats to consume salt cedar. Unfortunately, goats lost weight while relying heavily on salt cedar to meet their nutritional requirements (Munoz 2007). Protein supplementation may alleviate some nutritional stress when goats are consuming salt cedar. In addition, supplementation of food sources with a high escape protein value has shown the ability to increase consumption of redberry juniper. This increased consumption is apparently due to escaped proteins reaching the liver allowing the goats to break down toxins in the juniper, therefore increasing consumption while maintaining a constant body conditioning score (George et al. 2010).

This proposed study will introduce freshly weaned Boer-cross kids to salt cedar, some with supplementation and the others without in a pen setting for a 34-day trial.

MATERIALS AND METHODS

Twenty recently weaned Boer-cross goats were individually penned at the Angelo State University (ASU) Management, Instruction, and Research (MIR) Center, San Angelo, TX. Goats were randomly allocated to one of two treatments: Treatment 1 consisted of 10 goats fed salt cedar and a high protein supplement (Table 1) for 1 hour daily for 10 days, and Treatment 2 consisted of 10 goats fed salt cedar and alfalfa pellets which served as the control group (i.e., no supplementation). Goats were placed in individual pens approximately 3m x 1m to monitor salt cedar intake, supplement intake, and intake of alfalfa pellets. All individuals received alfalfa pellets (2.5% BW), fresh water, and a commercially available mineral block to meet maintenance requirements (NRC 2007).

Amount of supplement for each goat was based on providing 1.9 g kg^{-1} BW to meet CP maintenance requirements. In addition, 2.9 g kg^{-1} BW of additional protein was fed each day to surpass daily protein requirements for growth (NRC 2007). The amount of each supplement fed was based on requirements for maintenance and growth minus the number of grams of protein provided by alfalfa pellets (17% CP). Supplements were offered from 0800 to 0900 daily. Salt cedar was offered from 0900 to 0930 daily while alfalfa was offered from 1000-1700 each day. After feeding each dietary item, refusals were collected and weighed to estimate intake. All individuals received all dietary components for 10 days. Prior to the trial, goats were allocated a period of 15 days to adjust to pen situations while being fed alfalfa. After 15 days of alfalfa, Treatment 1 goats received protein for 9 days prior to study for a

Table 1. Ingredients and nutrient content of protein supplement. All data is reported on an as fed basis.

Ingredient	**% as fed**
Cottonseed meal	77.5
Distiller's Grain	16.2
Molasses	3.4
Rice Bran	2.5
Trace Mineral Mix	0.02
Vitamin ADE	0.3
Nutrient Content	
Crude Protein	36.0
Fiber	10.3
Fat	2.3
TDN	72.3
Digestible energy	5.5 Mcal kg^{-1}

period of adjustment. During the pre-conditioning, all feedstuffs were weighed to estimate intake, acceptance of feedstuffs, and acclimation to the pen setting.

The salt cedar used for this study was harvested at the ASU MIR Center; leaves were stripped, composited, and stored at 4 degrees C until time of feeding. The amount of salt cedar, supplement, and alfalfa was converted to g /kg^{-1} BW to account for differences of body size. Performance between treatments was examined by measuring body weight at the beginning and end of the study.

Intake data and weight change data was analyzed as a completely randomized design. Individual animals nested within treatments, served as replications. Day of observation served as the repeated measure. Weight means were separated using Tukey's LSD when $P \leq 0.05$. Data was analyzed using the statistical computer package JMP (SAS 2008).

RESULTS

Goats were placed in individual pens on d 1 and were fed alfalfa for 15 days for a pen adjustment period. Initially, alfalfa intake was low but increased until all animals consumed a majority of alfalfa fed (Fig 1). Beginning on day 16, treatment animals were given protein at the beginning of each morning followed by alfalfa. Goats were fed protein and alfalfa for 9 days for a period of adjustment. The 10 goats given protein initially consumed an average of 2.5 g/kg^{-1} BW of protein, but on d 17 goat consumption decreased to 1.75 g/kg^{-1} BW. After day 17 goats consumption of protein steadily increased to average over 3 g/kg^{-1} BW (Fig 2). Alfalfa intake increased gradually until d 18, at this point intake fluctuated little throughout the rest of the 9 day protein adjustment period (Fig 2).

During the trial there were no differences in salt cedar intake between the two treatments (Table 2). In addition, alfalfa intake was similar between treatments. Weight change was also similar between treatments with goats within both treatments gaining weight throughout the study (Table 3).

The day effect for salt cedar intake differed ($P<0.05$) but the treatment X day effect was not significant. All goats increased intake of salt cedar throughout the study (Fig. 3). The study was stopped on day 10, because of a lack of salt cedar. Goats appeared to be still increasing intake of salt cedar at the end of the study.

Protein intake during the trial was consistent; all individuals readily consumed the supplement (Fig. 4). Intake of alfalfa differed between treatments because the individuals in the control were fed more alfalfa daily to meet maintenance requirements (Table 2). Intake was similar across days of feeding (Fig. 5).

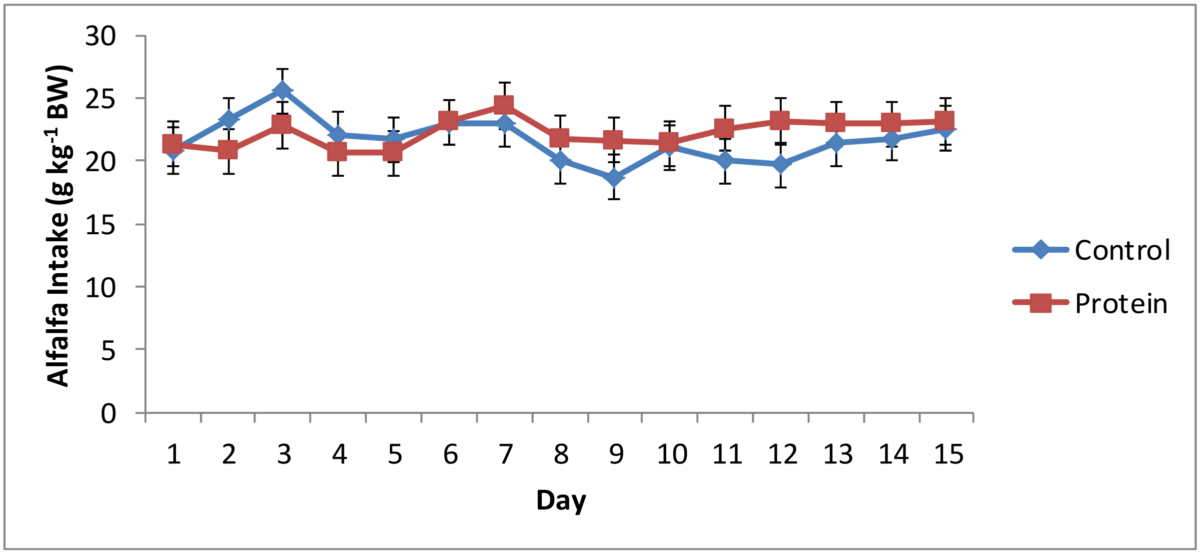

Figure1. Alfalfa intake by treatment prior to feeding protein supplement or salt cedar.

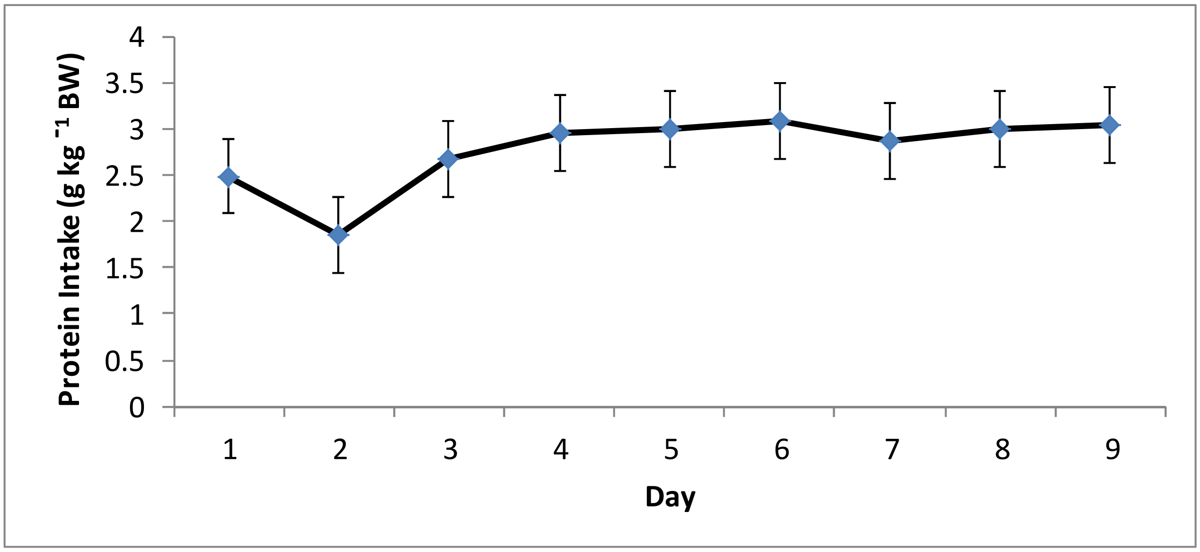

Figure 2. Protein prior to feeding salt cedar.

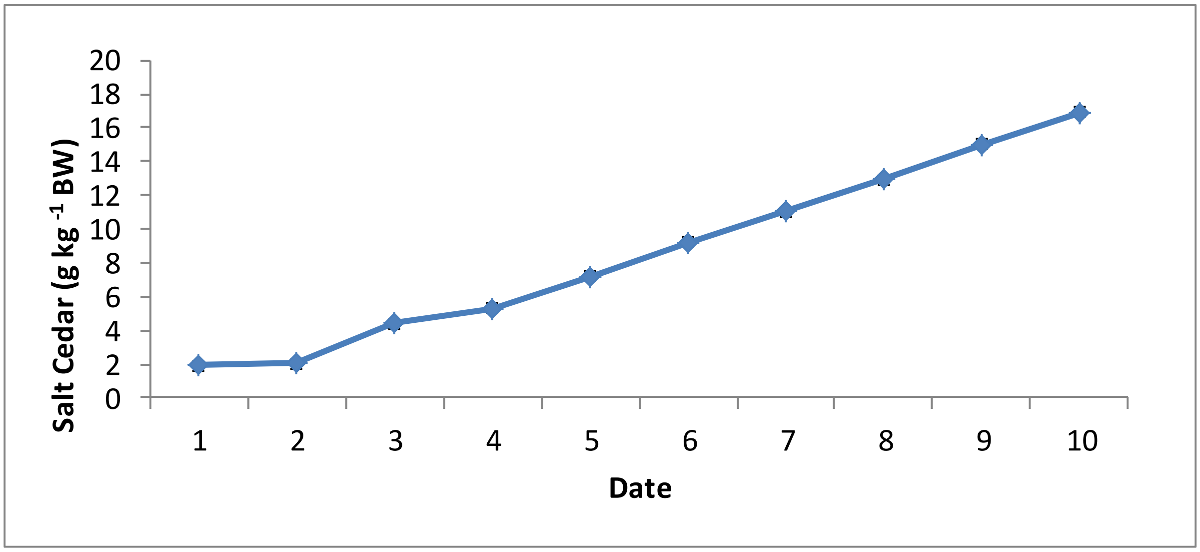

Figure 3. Salt cedar intake during the 10 days of feeding. Data was pooled across treatments.

Table 2. Average intake of protein, alfalfa, and salt cedar with $p \leq 0.05$ between treatments.

Item	Treatment	
	Protein	Control
Protein	3.2±0.1	---
Alfalfa	20.0±0.5	25.0±0.5
Salt Cedar	17.0±0.3	16.7±0.3

Table 3. Weight comparison ($p \leq 0.05$) between treatment.

Weight	Treatment	
	Protein	Control
Initial	24.2$\pm$1.3	24.0$\pm$1.3
Ending	48.3$\pm$1.3	49.1$\pm$1.3

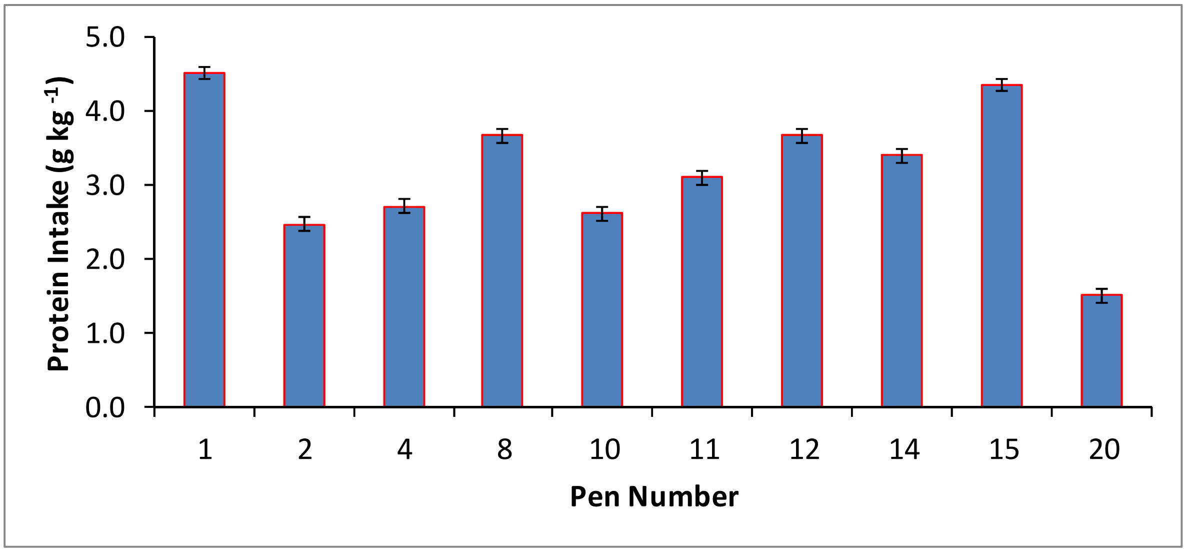

Figure 4. Protein intake by individual goats during the feeding trial. Intake was similar (P>0.05) among individual goats.

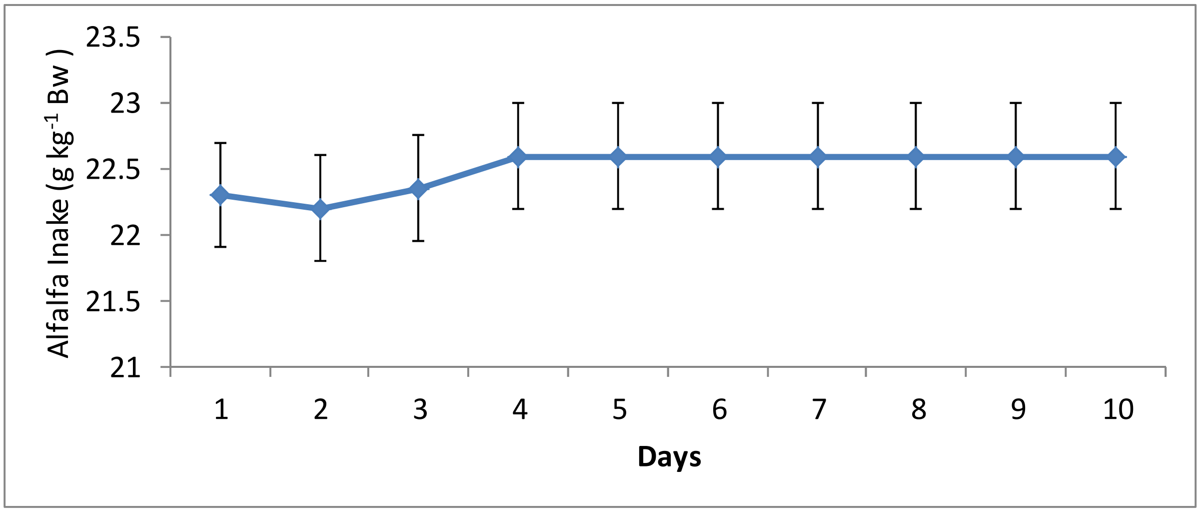

Figure 5. Alfalfa Intake during trial when goats were fed salt cedar. Intake is pooled across treatments.

DISCUSSION

Preliminary studies found that goats would consume some salt cedar and consumption would increase over days of exposure, but body condition declined (Munoz 2007). Results of this study are consistent with Munoz (2007) illustrating that goats will readily consume salt cedar and increase intake with days of exposure. However, results in the current study showed that animals gained weight both with and without protein supplementation. It is unclear why goats lost weight in the Munoz (2007) study but did not lose weight in the current study.

Protein supplementation does improve intake of some poisonous and non-poisonous plants (Campbell et al. 2007). Ruminants require at least 6-8% crude protein in the diet to maintain healthy microbe populations in the rumen (NRC 2007). Apparently feeding alfalfa either with or without a protein supplement along with salt cedar provided a sufficient source of protein to meet maintenance requirements.

Illius and Jessop (1995) suggested that animals limit consumption of toxins when nutritional stress reduces their tolerance to toxins. During times of starvation, the body can undergo depletion of glycogen stores, increased gluconeogenesis from degraded amino acids and fatty acids utilized for energy. This response to starvation can result in a loss of the mixed function oxidase (MFO) reactions that reduce an animal's ability to handle plant toxins (Bidlack 1982). Detoxification also requires additional expenditures of amino acids and glucose to conjugate with toxins and maintain an animal's acid-base balance (Illius and Jessop 1995). Levels of cytochrome P-450 and reductase are reduced in animals fed protein-deficient diets (Owens and Zinn 1988).

In addition to supplying building blocks for protein, amino acids also supply a major portion of the glucose needed by ruminant animals. Alanine, aspartate, glutamate and glutamine are the primary amino acids used as a source of carbon for glucose; alanine being the most glucogenic, accounting for 40–60% of the glucose formed from amino acids (Fahey and Berger 1988). Thus, feeding excess amino acids or protein sources high in escape protein may provide a source of amino acids that can be used for synthesis of glucose in the liver, which may play a role in the conjugation of toxins to be secreted from the body (Illius and Jessop 1995).

Goats supplemented with protein sources high in amino acids that escape rumen degradation improve intake of the toxic shrub juniper (George et al. 2010). For this study, a protein source that was high in amino acids that escape rumen degradation was fed as the protein supplement. Protein supplementation has improved intake of other chemically defended plants as well. For instance, Villalba et al. (2002a, 2002b) argued that protein sources high in ruminally degradable protein sources soy bean meal (SBM) may increase intake of big sagebrush (*Artemisia tridentata*) while protein supplements with a high escape value increased intake of one-seeded juniper (*Juniperus monosperma* [Engelm.] Sarg) (Utsumi et al. 2009). While it is clear that ruminants typically avoid salt cedar while grazing on pasture, it is not clear why. Prior to this study, it was assumed that salt cedar contained a toxin that limited intake. Given that protein supplementation did not affect salt cedar intake and that goats readily consumed salt cedar, toxins may not be present in the plant. Ruminants may avoid salt cedar because of its high salt content.

Salt cedar for this project was collected in early fall. Toxicity of salt cedar is still unknown if any exist at all, but saline content is extremely high and may vary throughout the growing season. Likewise, nutrient quality may vary throughout the growing season. Future research should focus on possible early season vs. late season consumption. In addition, future studies should quantify nutrient quality of salt cedar throughout the growing season to determine if goats will require additional feedstuffs to avoid weight loss.

All goats in this study and others (Munoz 2007) readily accepted salt cedar as a dietary item and continued to increase intake throughout the studies. Increased consumption of salt cedar offers alternatives to beetles as biological control. Goats could be used as a preventative measure in areas where salt cedar is invading. In some cases, only limited success has been reported in establishing beetle colonies. Goats could be a viable alternative in these areas. Cases in which salt cedar has become a well-established monoculture, goats can be offered as a primary control measure to thin out tree populations to a more manageable rate. Because goats can only reach certain areas, browse lines will be developed and salt cedar may continue growth upwards as do many plants under herbivory conditions. In this instance, if possible (i.e. fuel load), a prescribed burn may help lower browse lines, such that goats can reach all areas of the plant and can consistently control the plants growth and spread.

Salt cedar monocultures limit plant species to other halophytic species therefore decreasing nutrient choices for livestock (Belzer and Hart 2004). Often, plants that grow in extreme conditions will be highly nutritious and very toxic. In many cases, ruminant animals consume foods that meet nutritional requirements although they may be toxic (Provenza 1995). Regardless of the impact on overall salt cedar consumption, supplementation of goats that are consuming salt cedar may improve the nutritional status of goats given the limited variety of plant species that typically grow on salt cedar-dominated sites.

IMPLICATIONS

The findings of this study indicate that goats could reduce salt cedar cover. Goats could be especially beneficial in areas where salt cedar seedlings are evident. Also, goats should be introduced to areas in which herbicides have been used to reduce cover. Goats should slow the rate of reinvasion of salt cedar after herbicidal control efforts. Goats may be particularly useful when establishment of leaf beetle populations is difficult.

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