CHANGES IN INTAKE AND NUTRITIONAL QUALITY OF SALTCEDAR

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CHANGES IN INTAKE AND NUTRITIONAL QUALITY OF SALTCEDAR

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ABSTRACT

Recently weaned Boer-cross (n=20) and Angora (n=6) goats were individually penned and fed increasing amounts of saltcedar. Weight, intake, and water consumption data were monitored. In addition, saltcedar samples were collected during the months of June, July, August, September and October and analyzed for chemical composition. Boer-cross and Angora goats consumed 3.7 $g \cdot kg^{-1}$ of BW and 3.8 $g \cdot kg^{-1}$ of BW, respectively, of saltcedar ($P > 0.05$). Water consumption differed by breed at 0.8 $L \cdot d^{-1}$ and 2.1 $L \cdot d^{-1}$ for Angora and Boer-cross, respectively, but did not differ by period. Both breeds lost weight during the final period of the trial. Crude Protein of saltcedar ranged from 16.0% to 19.6% ($P < 0.05$) , and TDN averaged 68.5%. Sodium content of saltcedar varied from 0.1% to 2.4%. Dry Matter content averaged 32.2%.

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INTRODUCTION

The deciduous shrub saltcedar (*Tamarisk spp.*) grows throughout the southwestern United States. Its range encompasses lands as far north as Montana and south into Mexico (Edward and Nagler 2005). Seedlings grow quickly, 3 to 4 m during the growing season, and reach heights of 9 m (Di Tomaso 1998; Hart 2003). Since its introduction in the early nineteenth century, saltcedar has invaded over 600,000 ha of riparian habitat in the western United States (Lovich et al 1994). Saltcedar out-competes native mesic species because of its higher salt, drought, and fire tolerances coupled with its ability to resist water stress (Edward and Nagler 2005).

Originally, nurserymen brought saltcedar to the new world as early as 1823 to sell for decorative purposes. Through the remainder of the nineteenth and early twentieth century, settlers planted saltcedar to serve as windbreaks, offer shade, and provide erosion control on stream banks. During the 1920s, people realized the severity of the rapidly encroaching saltcedar as it spread along stream banks through the Southwest and up through the Rocky Mountains (Brotherson and Winkel 1986; Di Tomaso 1998).

Biodiversity suffers because of the intrusion of saltcedar into native riparian areas. Saltcedar outcompetes native vegetation, and can infest an area to the point that saltcedar makes up the majority of vegetative cover, which in some cases ranges from 70 to 80% (Engel-Wilson and Ohmart 1978; Egan et al. 1993; Di Tomaso 1998). Studies by Anderson and Ohmart (1985) and Engel-Wilson and Ohmart (1978) indicate that both mammals and birds prefer habitats consisting of native vegetation to those predominantly made up of

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saltcedar. In addition to saltcedar curbing biodiversity, its extensive root systems in stream channels prevent natural erosion, leading to a buildup of sediment which causes an increase of water flow and subsequent flooding (Egan et al. 1993; Di Tomaso 1998).

Efforts to control the spread of saltcedar have proven difficult. Traditional control options such as burning, chaining, cutting, and plowing only serve to top kill vegetation, which allows saltcedar to sprout from their root crown and aggressively envelop an area. Two known herbicides, Triclopyr (Garlon 4®) and Imazapyr (Arsenal®) can be used to manage saltcedar. However, chemical application may be problematic in some areas like river banks and thick stands of tall saltcedar, and more than one application is typically necessary (Hart 2003; Johnson et al. 2007). In recent years, steps have been taken to provide a biological control for saltcedar, specifically insects and goats that forage on saltcedar. The leaf beetle, *Diorhabda elongate*, shows promise in controlling saltcedar. Leaf beetles released in the Humboldt River area in Nevada have defoliated around 2,025 hectares of saltcedar from 2001 to 2005 (Deloach and Carruthers 2005). Studies conducted by Muñoz (2007) and Garcia (2011) have demonstrated that goats will consume saltcedar in a pen setting.

OBJECTIVES

The objectives of this study were to determine the nutritional quality of saltcedar in various stages of maturity and determine the amount of saltcedar goats can consume without adversely affecting growth performance. Assessing saltcedar forage quality will allow future researchers to discern whether supplementation is necessary to support goats foraging on saltcedar. Discerning whether goats have a preference for saltcedar during various stages of maturity will help structure control regimens.

LITERATURE REVIEW

Saltcedar in North America

Saltcedar, native to the Mediterranean and commonly found in Africa, Asia, and Europe, arrived in North America early in the nineteenth century (Brotherson and Winkel 1986). Early records demonstrate sales of saltcedar on the eastern coast of the United States as early as 1823 (Horton 1964). Saltcedar sales spread to the West Coast, selling in California nurseries in 1854 (Robinson 1965). In 1868, the U. S. Department of Agriculture reported growing multiple species of *Tamarix* (Horton 1964). However, saltcedar remained in cultivation until the 1870s, and by 1877 saltcedar showed up in herbarium collections near Galveston, Texas. Shortly after, collections appeared in Arizona, California, New Mexico, and Utah (Robinson 1965; Brotherson and Winkel 1986).

A review of the literature reveals no record that anyone regarded the spread of saltcedar as a problem through the early twentieth century (Brotherson and Winkel 1986). In fact, farmers and ranchers commonly used the plant as a form of erosion control (Everitt 1980). By the 1920s, saltcedar spread along streams throughout the Southwest before creeping to the North through the Great Basin and the Rocky Mountains (Brotherson and Winkel 1986). At that time, saltcedar encompassed around 4,000 ha (Neill 1985). By 1960, studies reported an infestation of 362,000 ha of riparian habitats, which increased to 540,000 ha by 1970 (Gay and Gritschen 1979; Neill 1985: Friederici 1995). The latest estimate reported by Brotherson and Field (1987) indicated that saltcedar now covers over 600,000 ha with over 200,000 ha in Texas alone (Hart 2009). Currently, saltcedar infests most river systems in Arizona, southern California, Colorado, New Mexico, Nevada, Texas, and Utah (Robinson 1965; Horton 1977; DiTomaso 1998).

Contributing Factors in the Spread of Saltcedar

Several factors have led to the encroachment of saltcedar into rivers and streams in the Southwest, but key elements have been the development of dams, reservoirs, and irrigation projects. Before these alterations in the 1900s, spring and early summer snow melt filled the river and stream beds to peak capacity and flow creating bare moist soil for native species such as cottonwood and willow to seed and sprout. Diverting water from these areas left poor conditions for the native plants to grow, allowing saltcedar to outcompete native species and colonize rapidly (Engel-Wilson and Ohmart 1978; Shafroth et al. 1995; DiTomaso 1998). Changes in water flow also promote higher soil salinity in rivers and streams in the southwestern United States, encouraging saltcedar growth and reducing density of native salt-sensitive species (Brotherson and Field 1987; Sala and Smith 1996; DiTomaso 1998). Other contributing factors include over grazing, off-road vehicle traffic, harvesting wood for lumber and fires, and the use of saltcedar to control bank erosion (Horton 1977; Brotherson and Winkel 1986; Lovich et al. 1994; DiTomaso 1998). In addition to human activities providing saltcedar with competitive advantages, the plant possesses numerous physiological advantages. Glenn and Nagler (2005) reported the advantages as: (1) increased seed production; (2) accelerated germination rates; (3) rapid growth rate; (4) increased evapotranspiration (ET); (5) large leaf area index; (6) extreme salt resistance; (7) flood resistance; and (8) its ability to re-sprout after fire (Neil 1985; Brotherson and Field 1987; Friederici 1995; DiTomaso 1998).

Impact of Saltcedar

The extensive root system of saltcedar provides excellent erosion prevention compared to most native riparian trees and shrubs (DiTomaso 1998). However, Graff (1978) points out that the increased stability creates stream channels that are immobile and inflexible, which allows sediments to build up and constrict channel width. As the channel width diminishes, water flow rates increase, as does the potential for flooding (Kerpez and Smith 1987; Fraiser and Johnsen 1991; Egan et al. 1993; Friederici 1995). As an example, saltcedar laden areas of the Gila River in Arizona had 30% higher water flow velocity and a 13% increase in water depth than areas that were not infested (Great Western Research 1989). The Brazos River in Texas experienced increased incidences of flooding as the channel narrowed from 155 m in the year 1949 to 66 m in 1979 (Blackburn et al. 1982).

Anderson et al. (1977) and Busch and Smith (1993) report saltcedar as having more efficient fire recovery mechanisms than native species. Saltcedar stands tend to have an increased incidence of fire because of high accumulation of leaf litter and dead woody material (Kerpez and Smith 1987; Busch and Smith 1993; Busch and Smith 1995). Riparian areas dominated by species like cottonwood, willow, and mesquite typically have long intervals between fires, whereas areas infested with saltcedar can experience fire more often without adversely affecting cover (Busch and Smith 1993). Lovich et al. (1994) reports the fuel from saltcedar leaf litter and woody material promotes fire in 10-20 year intervals.

Plant and animal diversity both suffer from saltcedar infestations. Saltcedar can make up 70 to 80% of vegetative cover in riparian areas historically covered in cottonwood, willow, and mesquite (Engel-Wilson and Ohmart 1978; Weeks et al. 1987; DiTomaso 1998; Egan et al. 1993; Hughes 1993; Lovich et al. 1994). Saltcedar's ability to cover an area, coupled with its increased fire frequency, hinders development of native riparian species (Shrader 1977). Bird migration routes often overlap with flowering and seed production of native riparian species that provide food and shelter for birds, as well as insects which birds also consume (Ohmart et al. 1988). Seeds from saltcedar are too small to be eaten by most animals, and the sticky secretions damage the plumage of birds (Cohan et al. 1978; Neill 1985). Wood rats (*Neotoma spp*.) and desert cottontails (*Sylvilagus audubonii*) are the only known native species to consume mature saltcedar (Anderson and Ohmart 1977).

Control

Traditional mechanical controls such as plowing, cutting, mowing, chaining, and burning show little promise in controlling large saltcedar infestations because saltcedar vigorously sprouts from the damaged root crowns (Johnson et al. 2007). Even chemical control of saltcedar has historically proven difficult. Two known herbicides, Triclopyr(Garlon 4®) and Imazapyr(Arsenal®), can effectively control saltcedar, but application procedures are labor intensive, time consuming, and costly considering the large amount of herbicide needed per acre (Belzer 2005; Johnson et al. 2007). In the 1970s, the USDA's Agricultural Research Service (ARS) began searching for biological controls for saltcedar, including insects. After decades of research in collaboration with many nations, scientists discovered the leaf beetle (*Diorhabda elongata*), and began outdoor testing in 1998. Beetles were released along an 80-mile stretch of the Humboldt River in Nevada in 2001, and as of 2005, the beetles have defoliated more than 2,000 ha of saltcedar. Their populations have increased exponentially and now number in the millions (USDA 2005). However, Knutson et al. (2003) reported that establishing populations of leaf beetles in some locations can be difficult. Researchers have also experimented with other forms of biological control, including domestic livestock such as goats. Munoz (2007) demonstrated that individually-penned Boer-cross goats increasingly consumed saltcedar over 14 days; however, goats were unable to maintain body condition. A study conducted by Garcia (2011) placed recently weaned Boer-cross goats (n = 20) in individual pens and fed saltcedar along with either protein supplements or alfalfa pellets. Both groups gained weight throughout the trial.

MATERIALS AND METHODS

Recently weaned Boer-cross (n = 20) and Angora (n = 6) goats were individually penned at the Angelo State University (ASU) Management, Instruction, and Research (MIR) Center in San Angelo, TX. Initial weights were recorded before and after each feeding period (described below), and goats were given 4 d to acclimate to the pens. For the first 14 d of trial, goats were fed 2.0% BW of a basal diet (Table 1). Following the first 14 d, goats were then fed the basal diet at 1.5%, 1.0%, 0.5%, and 0.0% BW for 7 d sequentially in addition to saltcedar. On Day 1 of 42, goats were fed 50 g of freshly harvested saltcedar for 30 min prior to their basal diet. Saltcedar was incrementally increased by 25 g when goats presented no refusals for 2 consecutive days. Goats had *ad libitum* access to fresh water and mineral.

At 0800 each morning, basal ration refusals from the previous day were collected and weighed to estimate intake. Thereafter, goats received fresh saltcedar for 30 min and refusals were weighed to estimate intake. At 0900, goats received their basal diet for the remainder of the day. Water consumption was recorded daily at 0930. In addition to intake and BW data, blood samples were taken using jugular venipuncture at the end of each period. Samples were placed in a centrifuge to separate serum and stored at -80°C until analyzed for serum aspartate transaminase (AST), gamma-glutamyltransferase (GGT), serum urea nitrogen (SUN), creatinine, and glucose.

To determine changes in forage quality, samples were also harvested at the beginning of each month in June, July, August, September, and October. Saltcedar samples were collected in triplicate from 10 different plants in riparian areas near O.C. Fisher Reservoir in San Angelo, TX. Leaves were stripped from the base to tip of the branch, placed in freezer

Table 1. Ingredient and nutrient content of the basal diet. Data reported herein was on an as fed basis.

Ingredient	**Percent (%) in the Feed**
Sorghum grain	45.0
Cottonseed meal	10.0
Soybean hulls	22.5
Alfalfa pellets (dehydrated)	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
TDN	63.0

[1]Premix includes: Lasalocid, calcium, salt, manganese, zinc, selenium, copper, Vitamins A, D, and E

bags, and stored at -80°C. Sample replicates were combined to be analyzed for chemical composition at Dairy One Forage Laboratory in Ithaca, NY.

Means were compared between breeds and feeding periods using repeated measures analysis of variance. Animal within breeds served as replications with day of collection as the repeated measure. Forage samples were compared among collection times using analysis of variance with month of collection as the main effect. Means were separated using Tukey's LSD test when $P \leq 0.05$. Statistical analysis was performed on the JMP Statistical Software Package (SAS 2007).

RESULTS

Boer-cross and Angora goats consumed 3.7 $g \cdot kg^{-1}$ BW and 3.8 $g \cdot kg^{-1}$ BW, respectively, of saltcedar on average with no differences between breeds ($P = 0.6$) with one exception. At the end of the trial, Angora goats consumed 12.0 $g \cdot kg^{-1}$ BW of saltcedar while Boer-cross only consumed 8.6 $g \cdot kg^{-1}$ BW ($P < 0.05$)) (Figure 1). Both Boer-cross and Angora goats' saltcedar intake varied by period (Figure 2). As the amount of the basal ration offered decreased, saltcedar intake increased. Water consumption was significantly different between breeds at 0.8 $L \cdot d^{-1}$ and 2.1 $L \cdot d^{-1}$ for Angora and Boer-cross, respectively. However, water consumption remained constant throughout the trial, and did not vary between periods ($P = 0.65$). Weight gain(loss) data is present in Table 2. Both breeds exhibited a significant weight loss from the initial period of the trial compared to final, losing 29.1% and 18.8% BW for Angora and Boer-cross, respectively ($P = 0.01$). Average weight for goats also differed from each other at 32.9 kg and 49.9 kg, for Angora and Boer-cross, respectively ($P < 0.05$) with no breed by period interaction ($P = 0.97$).

Chemical composition data are presented in Table 3 on a month to month basis. Dry matter (DM) content of saltcedar for May through October 2011 ranged from 30.2% to 34.4%. Crude Protein (CP) varied from 16.0% to 19.6% throughout the collection period. Acid Detergent Fiber (ADF) averaged 16.9%, and the mean for Neutral Detergent Fiber (NDF) was 25.1%. Non Fiber Carbohydrates (NFC) values were between 43.6% and 52.8%. Relative Feed Value (RFV) increased from 244.7 in May to 336.0 in October ($P < 0.05$). Percentages of calcium, phosphorus, magnesium, potassium, and sodium averaged 0.2, 0.2, 0.93, 1.2, and 1.1%, respectively. Sodium increased from May to October ($P < 0.05$). Iron, copper, zinc, manganese, and molybdenum had means of 134.0, 6.2, 37.8, 128.1, and 2.1

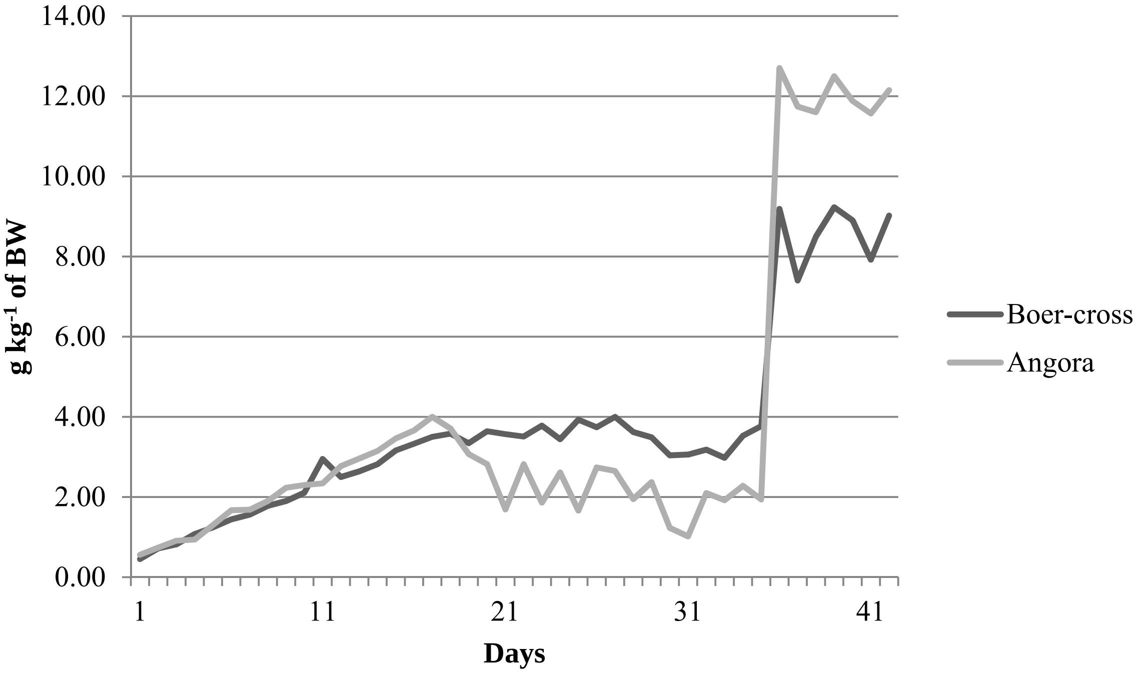

Figure 1. Intake (g·kg^{-1} BW) for Boer-cross and Angora goats across the 42 days of the study

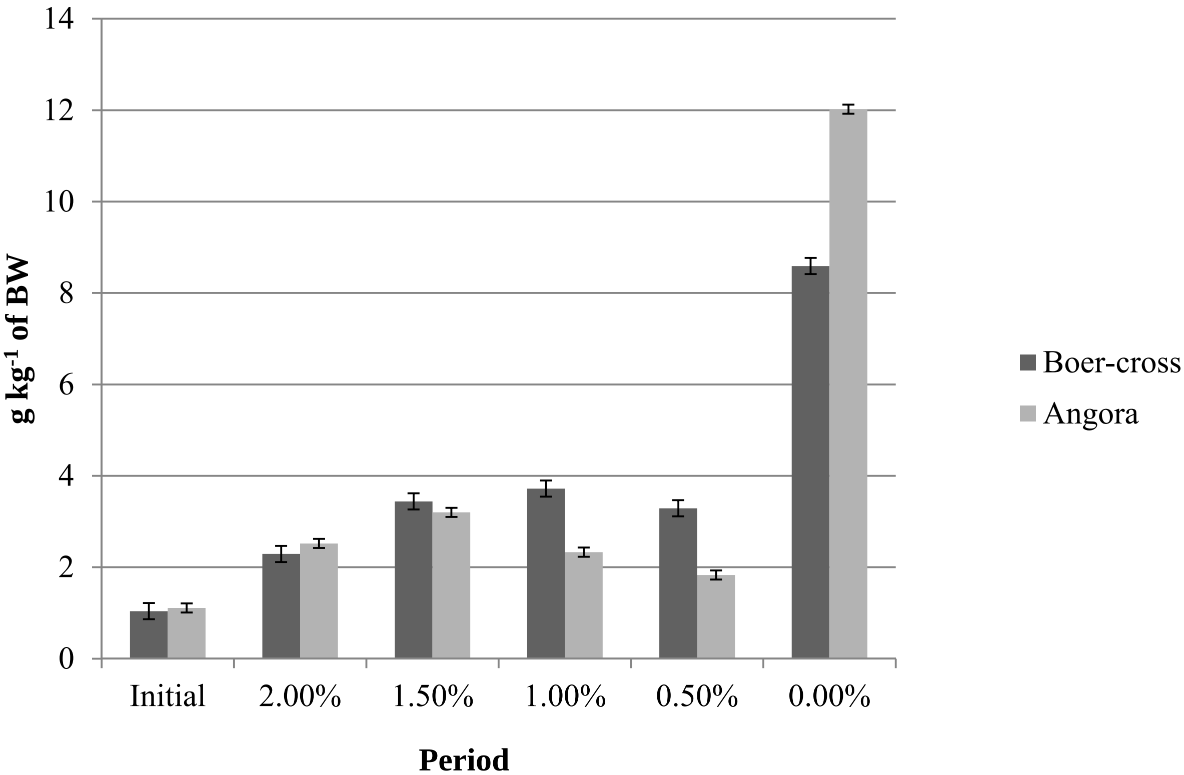

Figure 2. Saltcedar intake (g·kg^{-1} BW) for Boer-cross and Angora goats at different levels of the basal ration

Table 2. Body weight of Angora and Boer-cross goats by breed

Period	**Angora**	**Boer-cross**
Initial	38.5^{A}	56.0^{C}
2.0%	$34.2^{A,B}$	$49.4^{C,D}$
1.5%	$33.3^{A,B}$	$49.2^{C,D}$
1.0%	$32.7^{A,B}$	$48.5^{C,D}$
0.5%	$31.5^{A,B}$	$51.0^{C,D}$
0.0	27.3^{B}	45.5^{D}

Numbers with common superscripts within columns are not significantly different ($P > 0.05$)

Table 3. Chemical composition of saltcedar by month

	May	June	July	August	September	October
Moisture (%)	$68.9^{A,B}$	$67.0^{B,C}$	65.6^{C}	69.8^{A}	$67.8^{A,B,C}$	$67.5^{A,B,C}$
DM (%)	$31.1^{B,C}$	$33.0^{A,B}$	34.4^{A}	30.2^{C}	$32.2^{A,B,C}$	$32.5^{A,B,C}$
CP (%)	18.8^{A}	19.6^{A}	$18.2^{A,B}$	18.8^{A}	16.0^{B}	$17.6^{A,B}$
ADF (%)	19.3^{A}	$17.9^{A,B}$	$18.0^{A,B}$	$16.7^{A,B,C}$	14.1^{C}	$15.1^{B,C}$
NDF (%)	28.5^{A}	27.2^{A}	27.6^{A}	$25.1^{A,B}$	20.6^{B}	21.5^{B}
NFC (%)	43.6^{C}	44.2^{C}	44.7^{C}	$46.4^{B,C}$	52.8^{A}	$50.6^{A,B}$
TDN (%)	67.5	68.1	68.4	68.7	69.4	69.1
NEl ($mcal \cdot kg^{-1}$)	1.6^{B}	$1.6^{A,B}$	$1.6^{A,B}$	$1.7^{A,B}$	1.7^{A}	1.7^{A}
NEg ($mcal \cdot kg^{-1}$)	1.0	1.0	1.0	1.0	1.0	1.0
RFV	244.7^{C}	259.5^{C}	261.6^{C}	$290.0^{B,C}$	359.9^{A}	$336.0^{A,B}$
Ca (%)	$0.2^{A,B}$	$0.2^{A,B}$	$0.2^{A,B}$	0.2^{B}	0.1^{A}	0.2^{B}
P (%)	0.2^{A}	$0.2^{A,B}$	0.2^{B}	$0.2^{A,B}$	0.2^{B}	$0.2^{A,B}$
Mg (%)	0.8^{C}	$0.8^{B,C}$	$0.8^{B,C}$	$0.9^{A,B,C}$	1.2^{A}	$1.1^{A,B}$
K (%)	1.5^{A}	1.4^{A}	$1.3^{A,B}$	1.1^{B}	1.0^{B}	1.1^{B}
Na (%)	0.2^{C}	0.1^{C}	0.3^{C}	1.5^{B}	2.4^{A}	$2.0^{A,B}$
Fe (ppm)	$157.2^{A,B}$	93.8^{C}	$128.4^{B,C}$	95.4^{C}	178.3^{A}	$151.1^{A,B}$
Cu (ppm)	6.4	5.5	6.2	7.3	5.6	5.9
Zn (ppm)	42.7^{A}	44.0^{A}	36.3^{A}	43.2^{A}	30.2^{A}	30.2^{A}
Mn (ppm)	21.4^{D}	$46.2^{C,D}$	151.7^{B}	$179.1^{A,B}$	254.4^{A}	$116.0^{B,C}$
Mo (ppm)	0.0	1.2	3.8	2.0	3.1	2.7

All data except Moisture (%) are presented on a DM-basis.
Numbers with a common superscripts within a row are not significantly different ($P = 0.05$)

ppm, respectively. Copper, molybdenum, and zinc did not differ from month to month ($P >$ 0.05).

Analysis of serum data indicated that glucose differed during the beginning, middle, and end of the trial, and ranged from 62.7 to 38.1 mg·dL^{-1} ($P < 0.05$) (Table 4). Serum Urea Nitrogen (SUN) fluctuated from 10.3 to 18.1 mg·dL^{-1}, and creatinine averaged 0.7 mg·dL^{-1}. Aspartate (AST) and gamma-glutamy transferase (GGT) averaged 76.45 U· l^{-1} and 52.07 U·L^{-1}, respectively. Sodium (Na) did not differ throughout at the trial, 142.1 -146.7 meq·L^{-1} ($P > 0.05$). Chloride increased from 106.1 meq·L^{-1} to 109.4 meq·L^{-1} from the first half of the trial to the second ($P < 0.05$). Sodium to potassium ratio varied from 26.7:1 to 28.7:1.

Table 4. Blood serum concentrations of Angora and Boer cross goats by month. Samples were collected at the end of each feeding period.

Item[1]	**7/19/2011**	**8/2/2011**	**8/10/2011**	**8/17/2011**	**8/23/2011**	**8/31/2011**
Gl (mg/dL)	62.0^{A}	62.7^{A}	52.4^{B}	$48.4^{B,C}$	38.1^{D}	45.4^{C}
BUN (mg/dL)	18.1^{A}	$17.8^{A,B}$	$17.5^{A,B}$	$17.0^{A,B}$	16.2^{B}	10.3^{C}
Cr (mg/dL)	0.6^{D}	0.7^{C}	$0.8^{A,B}$	0.8^{B}	0.8^{A}	0.7^{C}
AST (U/L)	$80.5^{A,B}$	73.4^{C}	$73.6^{B,C}$	70.9^{C}	$73.7^{B,C}$	86.6^{A}
GGT (U/L)	64.7^{A}	58.4^{B}	$54.1^{B,C}$	50.8^{C}	43.9^{D}	40.5^{D}
Na (meq/L)	142.1	145.6	145.9	146.7	146.2	145.1
Cl (meq/L)	106.1^{B}	106.4^{B}	105.9^{B}	108.8^{A}	109.6^{A}	109.7^{A}
Na:K	$27.7^{A,B}$	28.7^{A}	26.7^{B}	28.3^{A}	28.6^{A}	28.2^{A}

[1]Gl = glucose, Cr = creatinine, GGT = gamma-glutamyltransferase, AST = aspartate transaminase

Numbers sharing same superscripts are not significantly different (α = 0.05

DISCUSSION

Goats readily consumed and increased intake of saltcedar during the first period of the trial. Thereafter, consumption remained relatively constant during the following three periods, and increased drastically during the last period when the basal diet was removed. Previous trials conducted demonstrated goats consuming increasing amounts of saltcedar for 10 and 14 d periods; however, limited information is available for the consumption of saltcedar for longer durations (Garcia 2011; Munoz 2007). After initial consumption plateaued, goats may have reached a threshold for saltcedar consumption due to an unknown compound(s) present in the shrub, limiting consumption through post-ingestive feedback (Provenza 1995). During the last period of the study, the amount of the basal diet was reduced to 0, which coincided with a large increase in saltcedar intake. For the first four feeding periods (basal diet at 2.0%, 1.5%, 1.0%, and 0.5% BW) saltcedar was only fed once a day. When all of the basal diet was removed, goats were fed saltcedar twice daily to meet their maintenance requirements, which may have accounted for the large increase of intake of saltcedar.

Palatability may have decreased after initial consumption and increased after acclimation. Also, it is possible that saltcedar storage may have been inadequate. Saltcedar was collected on a bi-weekly and weekly basis, placed in black plastic trash bags, and stored in a cooler at 4^{o}C. Researchers noted that saltcedar stored for more than 4 to 5 d began to change color and produced a different odor. When researchers noticed a decline in saltcedar consumption, stored saltcedar was replaced with fresh, and consumption increased. In addition, San Angelo, TX experienced record high temperatures for the duration of the trial.

It should be noted that goats readily consumed saltcedar regardless of the amount of basal diet offered. Given the nutritional quality of the basal diet, goats should have met their maintenance requirements without consuming saltcedar, especially during the first period when the basal diet was fed at 2.0% BW.

Water intake differed between breeds, most likely due to significant size difference between breeds. While goats consumed less water than expected, it is important to note that saltcedar contains nearly 70% moisture, and goats are known for their ability to store and utilize water efficiently, as well as, coping with high temperatures. In fact, goats approach the camel in the use of water per unit of bodyweight (Maloiy and Taylor 1971; Macfarlane and Howard 1972). Interestingly, water intake did not change as saltcedar consumption increased.

During the first period of this trial, researchers suspected internal parasites, and animals were treated with a commercially available drench. Afterwards, weight change remained constant until the final period of the trial. Decreased performance could also be associated with shifts in amylytic and fibrolytic bacteria populations in the rumen. Fecal samples collected at the end of the trial revealed several goats suffered from coccidiosis, which could explain the sudden loss of average body condition during the last period of the trial. In addition, glucose levels fell below normal range (48 to 76 $mg \bullet dL^{-1}$) which could be attributed to the illness or inability to meet maintenance requirements (Merck Veterinary Manual 2012). Other aspects of blood chemistry presented in normal range indicating saltcedar poses no metabolic issues when consumed by Angora or Boer-cross goats. Weight loss may be attributed to providing goats with one dietary item (saltcedar). Ruminants typically increase intake and gain more weight when a variety of food items are available for consumption (Provenza 1995).

Chemical composition data (Table 3) revealed saltcedar compares to both alfalfa cubes and alfalfa hay at 18.2% CP. Other common protein sources, such as rolled corn, cottonseed hulls, ground milo, and bermuda grass hay are lower in percentage of CP, while soybean meal and corn DDG have greater percentages (Table 5). In addition, TDN for saltcedar, 68.5%, is greater than alfalfa cubes, alfalfa hay, cottonseed hulls or bermuda grass, and falls below rolled corn, corn DDG, ground milo, and soybean meal. However, when compared to alfalfa cubes, alfalfa hay, bermuda grass hay, cottonseed hulls and corn DDG, saltcedar has less ADF at 16.8%, but contains a greater percentage of ADF when compared to grains such as rolled corn, ground milo, and soybean meal. The same is true for percentage of NDF. Using ADF and NDF values, Dairy One utilizes an index to rank feeds based on digestibility and intake potential called Relative Feed Value (RFV). Relative Feed Value is commonly used to compare legume and grass hays. As a basis for comparison, Dairy One lists the RFV of alfalfa hay with 41% ADF and 53% NDF as 100. Saltcedar scores range from 244.7 to 359.9.

Table 5. Nutritional quality of several common feedstuffs

	DM(%)	CP(%)*	ADF(%)*	NDF(%)*	TDN(%)*
Saltcedar	32.2	18.2	16.8	25.1	68.5
Alfalfa (Cubes)	91.0	18.0	36.0	46.0	57.0
Alfalfa (Hay-fullbloom)	88.0	16.0	40.0	52.0	54.0
Bermuda grass (Hay)	89.0	10.0	37.0	77.0	53.0
Corn Grain (Rolled)	88.0	9.0	3.0	9.0	88.0
Cottonseed Hulls	90.0	5.0	68.0	87.0	45.0
Distillers Grain(Corn-dry)	91.0	29.0	21.0	42.0	92.0
Milo(Ground)	89.0	11.0	6.0	15.0	82.0
Soybean Meal	91.0	49.0	10.0	15.0	84.0

*Values reported on a Dry Matter basis (NRC 2007)

IMPLICATIONS

Chemical composition data indicate saltcedar has value as a supplemental feed source and its use should be studied further to determine if any biochemical aspects have deleterious effects on animals consuming the shrub, as well as determining proper acclimation periods in order to fully utilize the shrub as a feed. Furthermore, the data demonstrate that goats will consume increasing amounts of saltcedar after exposure in individual pens without increased need for water. The use of goats as a biological control of saltcedar could serve ecologists and ranchers alike. Ranchers could utilize infested stands of saltcedar as an inexpensive feed source, while ecologists could exploit goats as a biological control.

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