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Intake and Nutritional Quality of Salt Cedar

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ABSTRACT

In previous studies, both sheep and goats readily consumed salt cedar (*Tamarisk* spp.) after exposure to the plant in individual pens. Unfortunately, little is known regarding the nutritional content of salt cedar or animal performance as the amount of salt cedar in the diet increases. This study monitored intake and change in body weight as the amount of salt cedar in the diet increased from 0% to 100% of the diet. In addition, we monitored the nutritional quality of salt cedar monthly throughout the growing season. Boer-cross goats were placed in individual pens and fed salt cedar daily for 42 days with intake monitored daily. Weight change and serum metabolite levels, indicative of metabolic issues, were also monitored throughout the study. Samples were collected from randomly selected salt cedar trees each month and frozen at -80 ºC until nutritional analysis. Goats increased intake of salt cedar over days of exposure and increased intake of salt cedar as the amount of the basal diet was reduced. Goats initially lost weight but after receiving treatment for internal parasites, maintained weight until the end of the study. Once salt cedar was the only dietary item, goats again lost weight but were apparently suffering from internal parasites again. Serum metabolite levels varied throughout the study but remained within normal levels except for glucose levels, which dropped below normal levels at the end of the study. Salt cedar remained nutritious throughout the growing season. Moisture content ranged from 65.6% to 69.8%, crude protein ranged from 17.6% to 19.6%, and total digestible nutrients (TDN) ranged from 67.5% to 69.4%. Collectively, these results suggest that salt cedar is relatively nutritious and goats will readily consume the plant, especially as the amount of the basal ration is reduced. However, alternative forages or supplements may be required to maintain body weight.

Key Words: Boer-cross; intake; quality; weight; salt cedar.

INTRODUCTION

The deciduous shrub salt cedar (*Tamarisk spp.*) grows throughout the western 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 2009). Since the introduction in the early

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nineteenth century, salt cedar has invaded over 600,000 ha of riparian habitat in the western United States (Lovich et al. 1994). Salt cedar out-competes native mesic species because of its higher salt and fire tolerances coupled with its ability to resist water stress (Edward and Nagler 2005).

Originally, nurserymen brought salt cedar 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 salt cedar to serve as windbreaks, offer shade, and provide erosion control on stream banks. During the 1920s, people realized the severity of the rapidly encroaching salt cedar as it spread along stream banks through the Southwest and up through the Rocky Mountains (Brotherson and Winkel 1986; Di Tomaso 1998).

Biodiversity suffers with the intrusion of salt cedar into native riparian areas. Salt cedar out-competes native vegetation and can infest an area to the point that salt cedar makes up the majority of vegetative cover, which in some cases ranges from 70% to 80% (Engel-Wilson and Ohmart 1978; Di Tomaso 1998). Both mammals and birds prefer habitats consisting of native vegetation to those predominantly made up of salt cedar (Anderson and Ohmart 1985; Engel-Wilson and Ohmart 1978). In addition to salt cedar reducing 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 (Di Tomaso 1998).

The herbicides Triclopyr and Imazapyr can be used to manage salt cedar. However, chemical application may be problematic in some areas like riverbanks and thick stands of tall salt cedar and more than one application is typically necessary (Hart 2009; Johnson et al. 2007). In recent years, steps have been taken to provide a biological control for salt cedar, specifically insects that forage on salt cedar. The leaf beetle (*Diorhabda elongate*) shows promise in controlling salt cedar. Leaf beetles released in the Humboldt River area in Nevada have defoliated around 2,025 hectares of salt cedar from 2001 to 2005 (DeLoach and Carruthers 2005). Both sheep (Borroum et al. 2018) and goats (Muñoz et al. 2017) readily consume salt cedar in individual pens and will consume a diet of salt cedar with limited impacts on animal performance over short periods of time. However, prior to recommending sheep or goats as a viable option for biological control, more information is needed regarding the nutritional value of salt cedar and changes in animal performance as the amount of salt cedar in the diet increases. Thus, the objectives of this study were to determine the nutritional quality of salt cedar in various stages of maturity and determine the amount of salt cedar goats can consume without adversely affecting growth performance.

MATERIALS AND METHODS

Recently weaned, mixed sex Boer-cross (n = 20) goats were individually penned at the Angelo State University (ASU) Management, Instruction, and Research (MIR) Center in San Angelo, TX (Lat. 31.38, Long. 100.5). Initial weights (56.0±2.5 kg) were recorded and body weights were again recorded before and after each feeding period (increasing percentage of salt cedar in the diet). Prior to initiation of the study, goats were given 4 d to acclimate to the pens (1 X 1.5 m). 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 salt cedar. On Day 1 of the 42 trial, goats were fed 50 g of freshly harvested salt cedar for 30 min prior to their basal diet. Salt cedar was incrementally increased by 25 g when goats presented no

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refusals for 2 consecutive days. Goats had *ad libitum* access to fresh water and a calcium-phosphorus mineral mix. All research protocols were approved by the ASU Institutional Animal Care and Use Committee.

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

Ingredients	**Composition (%)**
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^{-1})	2.8
Crude fiber	14.1
TDN	63.0

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

At 0800 hrs each morning, basal ration refusals from the previous day were collected and weighed to estimate intake. Thereafter, goats received fresh salt cedar 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 body weights, blood samples were taken using jugular venipuncture at the end of each of the 7 d periods. Samples were placed in a centrifuge to separate serum and stored at -80 °C until analyzed for serum aspartate transaminase (AST), gamma-glutamyltransferase (GGT), blood urea nitrogen (BUN), creatinine, and glucose. Samples were analyzed by the Texas Veterinary Medical Diagnostic Lab, College Station, TX.

To determine changes in forage quality, samples were also harvested at the beginning of each month in May, June, July, August, September, and October of 2011, the year the measurements were taken. Salt cedar samples were collected and stored in triplicate from 10 randomly selected plants in riparian areas near O.C. Fisher Reservoir in San Angelo, TX (Lat. 31.38, Long. 100.5). Different trees were randomly selected and sampled each month. Leaves were stripped from the base to tip of the branch, placed in freezer bags, and stored at -80 °C. Sample replicates were combined within each monthly sample to be analyzed for chemical composition at Dairy One Forage Laboratory in Ithaca, NY.

Means were compared between among feeding periods using repeated measures analysis of variance. Animals 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).

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RESULTS

Salt cedar intake varied by day and by period (Figs. 1 and 2). As the amount of the basal ration offered decreased, salt cedar intake increased. Water consumption remained constant throughout the trial and did not vary between periods ($P = 0.65$) (data not shown). Intake of the basal diet was also similar among individuals, with all of the basal diet consumed each day. Basal diet intake varied ($P < 0.05$) as the amount of the basal diet offered was reduced across feeding periods (data not shown). Goats exhibited a significant weight loss from the initial period of the trial compared to final, losing 18.8% BW ($P = 0.01$) (Table 2).

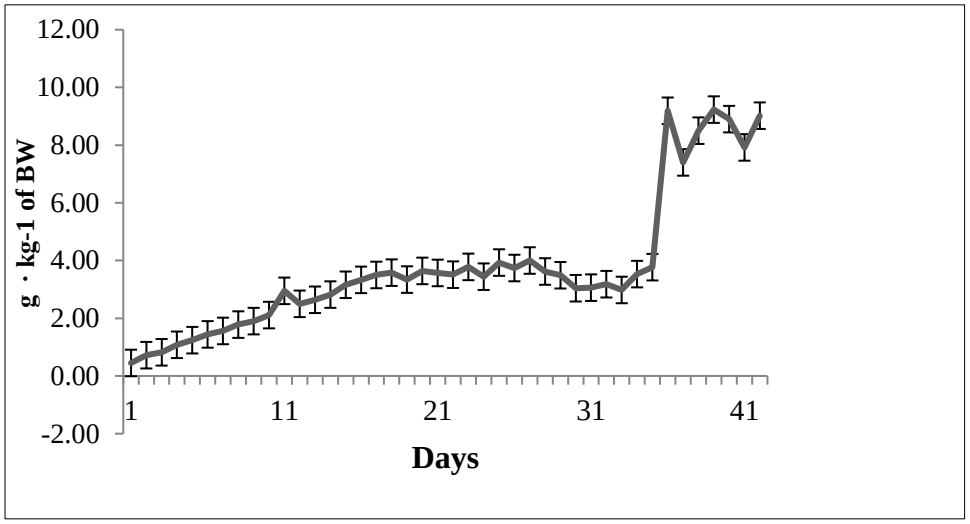

Figure 1. Intake (g · kg^{-1} BW) of salt cedar for Boer-cross goats across the 42 days of the study.

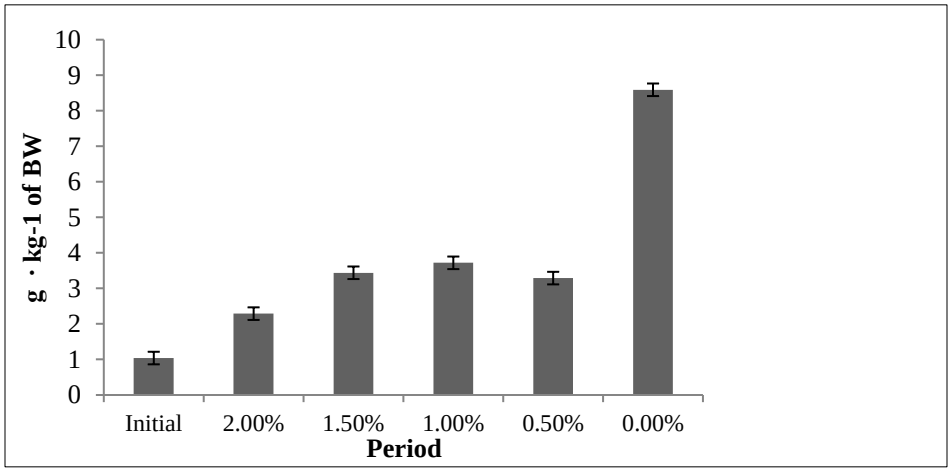

Figure 2. Salt cedar intake (g · kg^{-1} BW) for Boer-cross goats at different levels of the basal ration.

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Table 2. Body weight of Boer-cross goats as the amount of the basal diet was decreased.

Period	Boer-cross
Initial	56.0^{A}
2.0%	$49.4^{A,B}$
1.5%	$49.2^{A,B}$
1.0%	$48.5^{A,B}$
0.5%	$51.0^{A,B}$
0.0	45.5^{B}

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

Table 3. Chemical composition of salt cedar by month in 2011

Item	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 · 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 · 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 superscript within a row are not significantly different ($P > 0.05$)

Chemical composition data are presented in Table 3 on a month to month basis. Dry matter (DM) content of salt cedar 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 ppm, respectively. Copper, molybdenum, and zinc did not differ from month to month ($P > 0.05$).

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Analysis of serum data indicated that glucose differed during the beginning, middle, and end of the trial, and ranged from 62.3 to 40.0 mg · dL^{-1} ($P < 0.05$) (Table 4). As the amount of the basal ration was reduced, glucose levels dropped below levels for healthy animals. Blood Urea Nitrogen (BUN), creatinine, AST, and GGT fluctuated as the amount of the basal ration was reduced but remained within normal ranges. Serum sodium (Na) did not differ throughout the trial, while serum chloride levels increased as the amount of the basal ration was reduced.

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

Item[1]	Collection Day						Normal Range
	1	2	3	4	5	6	
Gl (mg · dL^{-1})	62.0^{A}	62.4^{A}	48.7^{BC}	49.5^{B}	39.0^{D}	43.2^{CD}	58-109
BUN (mg · dL^{-1})	21.0^{A}	21.1^{A}	$19.6^{A,B}$	$18.9^{A,B}$	18.4^{B}	12.1^{C}	12-32
Cr (mg · dL^{-1})	0.64^{D}	0.81^{C}	0.97^{B}	0.92^{B}	1.08^{A}	0.91^{BC}	0.3-1.3
AST (U · L^{-1})	81.4^{A}	$72.2^{A,B}$	68.4^{B}	66.8^{B}	67.2^{B}	$74.2^{A,B}$	51-130
GGT (U · L^{-1})	51.4^{A}	$48.0^{A,B}$	$46.6^{A,B}$	$44.2^{B,C}$	$39.0^{C,D}$	35.8^{D}	34-82
Na (meq · L^{-1})	138.8	145.8	147.0	146.9	147.4	144.9	151-168
Cl (meq · L^{-1})	1046.2^{C}	104.6^{C}	105.4^{C}	108.7^{B}	110.5^{B}	113.2^{A}	106-124

[1]Gl = glucose, Cr = creatinine, GGT = gamma-glutamyltransferase, AST = aspartate transaminase
Numbers sharing same superscripts are not significantly different (P > 0.05)

CONCLUSION AND DISCUSSION

Goats readily consumed and increased intake of salt cedar during the first period of the trial. Thereafter, consumption remained relatively constant during the following three periods and increased during the last period when the basal diet was removed. Previous trials demonstrated goats increased intake of salt cedar for 10 d and 14 d periods; however, limited information is available for the consumption of salt cedar for longer durations (Munoz et al. 2017). During the last period of the study, the amount of the basal diet was reduced to 0, which coincided with a large increase in salt cedar intake. For the first four feeding periods (basal diet at 2.0%, 1.5%, 1.0%, and 0.5% BW), salt cedar was only fed once a day. When all of the basal diet was removed, goats were fed salt cedar twice daily to meet their maintenance requirements, which may have accounted for the large increase in intake of salt cedar.

Goats consumed less water than expected; it is important to note that salt cedar contains nearly 70% moisture, and goats are known for their ability to store and utilize water efficiently. Water intake did not change as salt cedar consumption increased.

During the first period of this trial, we suspected internal parasites were present in goats and affecting performance; therefore, animals were treated with a commercially available anthelmintic. Afterwards, weight change remained constant until the final period of the trial. 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 · dL^{-1}) which could be attributed to internal parasite infestations or inability to meet

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maintenance requirements (Merck Veterinary Manual 2012). Other aspects of blood chemistry presented in normal range indicating salt cedar poses no apparent metabolic issues when consumed by goats. Weight loss may also be attributed to providing goats with one dietary item (salt cedar). Ruminants typically increase intake and gain more weight when a variety of food items are available for consumption (Provenza 1995).

In summary, chemical composition data indicate salt cedar has value as a forage source for goats. Furthermore, the data demonstrate that goats will consume increasing amounts of salt cedar after exposure in individual pens without increased need for water. The use of goats as a biological control of salt cedar could serve ecologists and ranchers alike. Ranchers could utilize infested stands of salt cedar as an inexpensive feed source, while ecologists could exploit goats as a biological control thereby potentially increasing biological diversity.

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