Research Note

Short-Term Mesquite Pod Consumption by Goats Does Not Induce Toxicity

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Abstract

Goats, unlike cattle, disperse few viable mesquite (*Prosopis glandulosa* Torr.) seeds in feces. However, there is some evidence that goats may suffer from toxicosis from overingestion of mesquite pods. We assessed the likelihood that short-term ingestion of mesquite pods would induce toxicosis in goats. Twenty-four goats were randomly allocated to one of four treatments with treatments fed different concentrations (0%, 30%, 60%, or 90% of the diet) of whole mesquite pods fed with alfalfa pellets. The mixture of mesquite pods and alfalfa pellets was fed for 12 d to 14 d. Because there were only 12 pens available for the study, two trials were used so that all 24 goats could be housed in individual pens. Intake, serum metabolite levels, and fecal output were measured to assess physiological status. In Trial 1, intake and fecal output decreased on days 12 through 14 for goats consuming a diet of 90% mesquite pods. In the second trial, intake and fecal output were similar across days of feeding within each treatment, but the trial only lasted 12 d. Serum metabolite levels remained within normal levels irrespective of the amount of mesquite pods in the diet in both trials. Goats appear to be able to consume mesquite pods on a short-term basis without experiencing toxicosis.

Resumen

Los caprinos, a diferencia de los bovinos, dispersan pocas semillas de mezquite (*Prosopis glandulosa* Torr.) que sean viables. Sin embargo, existe evidencia que los caprinos quizás sean víctimas de toxicidad debido al consumo excesivo de vainas de mezquite. Evaluamos la posibilidad que el consumo de vainas pudiera en un periodo corto producir toxicidad en cabras. Se distribuyeron veinticuatro cabras al azar en cuatro tratamientos donde se alimentaron con diferentes concentraciones (0%, 30%, 60%, o 90% de la dieta) de vainas de mezquite con pellets de alfalfa. La mezcla de vainas de mezquite y los pellets de alfalfa fueron alimentados por un periodo de 12 a 14 días. Debido a que únicamente existían 12 corraletas disponibles para este estudio, se llevaron a cabo dos experimentos, de esta manera las 24 cabras pudieron acomodarse individualmente en cada corraleta. Se midió el consumo de forraje, los niveles de metabolitos en el suero, así como la producción fecal para evaluar el estado fisiológico. En el primer experimento, tanto el consumo como la producción fecal disminuyeron en los días 12 al 14 en las cabras que consumieron la dieta que contenía 90% de vainas de mezquite. En el segundo experimento, el consumo y la producción fecal fueron similares durante los días de alimentación entre cada tratamiento, pero el experimento duro únicamente 12 días. Los niveles de metabolitos en el suero se mantuvieron entre los niveles normales independientemente de la cantidad de vainas de mezquite utilizadas en la dieta durante los dos experimentos. Parece ser que los caprinos pueden consumir vainas de mezquite en un periodo corto sin sufrir toxicidad.

Key Words: compaction, fecal, Intake, *Prosopis*, serum

INTRODUCTION

Before the development of the livestock industry, mesquite (*Prosopis glandulosa* Torr.) cover was probably limited on range sites in Texas because of a lack of an efficient method of seed dispersal (Archer 1994). Both livestock and wildlife consume mesquite pods and disperse viable seeds across the landscape, which accelerates the rate of reinvasion of mesquite into grasslands (Vines 1960; Kramp et al. 1998; Lynes and Campbell 2000). Most control efforts rely on expensive mechanical or chemical treatments with limited longevity of control (10–20 yr; Jacoby et al. 1990; Ansley et al. 2001, 2004).

Mesquite seed production and seed dispersal limit the longevity and economic feasibility of most control efforts. Mesquite seeds are encapsulated in a hard coat that must be scarified before rapid germination will occur; passage of seeds through a ruminant digestive tract typically enhances germination and provides a method of dispersing seeds across the landscape (Scifres and Brock 1972). Consumption of mesquite seeds by most species of livestock appears to be the primary vector of seed dispersal (Kramp et al. 1998). One exception appears to be goats, which disperse few viable seeds in feces (Knueper et al. 2003).

Long-term control of mesquite will only be successful when seed dispersal, seedling establishment, or both are suppressed. We contend that using goats as a biological control agent may be one method to limit seedling establishment. Kneuper et al.

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(2003) showed that goats could reduce the number of viable seeds because they consume more seeds per kilogram of body weight and disperse fewer viable seeds than other species of livestock. However, there is some evidence that continuous consumption of mesquite pods as the primary dietary component may lead to rumen compaction and some toxicological effects (Tabosa et al. 2000, 2004). High sucrose production from digestion of mesquite pods decreases cellulose digestion, leading to rumen compaction, rumen stasis, and decreased blood glucose levels (Adler 1949). In west central Texas, mesquite pods usually disappear quickly after fruit senescence. Livestock and wildlife usually consume most pods within 2 wk to 4 wk (Kneuper et al. 2003). Our objective was to determine if mesquite pods, as the primary dietary component on a short-term basis (2 wk), would induce toxicity in goats.

MATERIALS AND METHODS

This study was conducted during the fall of 2003 at the Angelo State University Management, Instruction, and Research Center, San Angelo, Texas. Twenty-four recently weaned, male and female Boer-cross goats with an average weight of 32 $\pm$ 3.2 kg were used in this study. Goats were randomly allocated to one of four treatments ($n = 6$ goats per treatment). Treatments were fed different concentrations of whole alfalfa pellets mixed with whole mesquite pods. Treatment 1 consisted of goats fed alfalfa pellets alone. Treatment 2 consisted of goats fed a diet consisting of 70% alfalfa pellets and 30% mesquite pods. Treatment 3 was fed a diet of 40% alfalfa pellets and 60% mesquite pods, and Treatment 4 received a diet of 10% alfalfa pellets mixed with 90% mesquite pods. The diet for Treatment 1 (no mesquite pods) was fed to meet maintenance requirements (alfalfa fed at 2% of body weight; National Research Council 1981). For the remaining diets, the amount of alfalfa was decreased depending on the amount of mesquite pods included in the diet (30%, 60%, or 90%). The amount of alfalfa and mesquite pods fed to each goat was based on individual body weight and treatment allocation. Each goat's diet was mixed by hand and placed into a single feeding trough. Goats could select either mesquite pods or alfalfa pellets out of the diet before consuming the other dietary item.

Mesquite pods (beans) were collected from randomly selected trees on the Coleman Ranch, Colorado City, Texas, on three separate days in July 2003. Pods from all collections were mixed together before feeding. Mature mesquite pods that appeared fully elongated were collected and fed to goats. For this study, pods that were red-brown in color and falling to the ground were classified as mature. In a previous study, seeds from pods collected in this stage had the highest ingestion and germination rate (Kneuper et al. 2003). Once pods were collected, they were refrigerated at 4°C to maintain seed quality.

To facilitate feeding and data collection, individual goats were placed in 3 $\times$ 4 m metabolism stalls and fed their respective diet for 12 d to 14 d. The research facilities that were used for this study consisted of only 12 metabolism stalls. Twenty-four goats were purchased for the study. To accommodate all goats, the study was divided into two trials. Fourteen days of feeding was chosen because most pods disappeared from the ground within 2 wk on this same site during a previous study (Kneuper et al. 2003). Three goats from each treatment (0%, 30%, 60%, and 90% of the diet) were used in the first trial. Intake and serum metabolite levels were monitored to assess the degree of aversive postingestive feedback and soft tissue damage from toxicosis. Total fecal collections were measured to determine fecal output (dry matter basis).

The second trial was designed to include three goats from each treatment. At the conclusion of the first trial, it was obvious that we did not have enough mesquite pods for the second trial. Goats were larger than initially planned, which required more pods to be fed during Trial 1. In addition, mesquite pod production was low during 2003 and most pods had disappeared by the end of the first trial. Based on the results from Trial 1 and the lack of sufficient amounts of pods, the number of treatments was reduced to three (0%, 60%, and 90% of diet). Because one treatment was excluded from Trial 2, there were only 21 goats instead of 24 goats used in the experiment.

In both trials, goats were fed each afternoon (1600 hours) and had access to their diet (mesquite pods and alfalfa pellets) until 1600 hours the following day, when refusals were collected and weighed to determine intake. Both alfalfa pellet intake and mesquite pod intake were recorded daily on an as-fed basis. Fresh water and a calcium–phosphorus mineral mix with trace elements was provided ad libitum to all goats during testing in individual pens.

Blood was collected every 72 h via jugular venipuncture and serum was extracted by centrifugation, frozen, and sent to the Texas Veterinary Medical Diagnostic Lab in College Station, Texas, for analysis. The lab routinely measures changes in serum metabolite levels to assess physiological status (i.e., health) of ruminants. The metabolites analyzed for this study included creatinine, gamma glutamyltransferase (GGT), blood urea nitrogen (BUN), serum aspartate transaminase (AST), and glucose levels. Changes in creatinine, BUN, GGT, and AST levels are indicative of soft tissue damage from toxicosis (Cornelius 1989). Levels were measured and compared to levels considered normal for healthy goats (International Species Information Systems [ISIS] 2002). Serum glucose levels were monitored because blood glucose levels decreased when cattle consumed mesquite pods in a previous study (Adler 1949).

Total fecal output was collected and weights were recorded (dry matter basis) every 3 d to estimate daily fecal output. A subsample of feces (150 g) was placed in a forced-air oven for 48 h at 60°C for dry matter determination.

Intake data were analyzed on a body weight basis ($g \cdot kg^{-1}$) to account for variations in body size. Differences between treatments (fixed effect) for intake, serum metabolite levels, and fecal output were assessed using repeated-measures analysis of variance with individual goats as replications (random effect) nested within treatments and day of sampling as the repeated measure (Hicks 1993). Covariance structures were compared to determine the appropriate structure for each model. Autoregressive order-1 was used for all analyses. For the analysis of serum metabolite levels, initial serum levels were used as a covariate to account for differences between individual goats. Trials 1 and 2 were analyzed separately

because of a difference in number of treatments and days of observation within each trial. Differences among means were determined using Fisher's Protected Least Significant Difference test when $P < 0.05$ (Gomez and Gomez 1984). Data were analyzed using the statistical package JMP (SAS 1998).

RESULTS

Goats usually consumed mesquite pods before consuming alfalfa pellets, but typically consumed all of the mesquite pods and alfalfa fed each day. Because the level of alfalfa fed to treatments differed, alfalfa intake differed among treatments in both Trial 1 ($\bar{x}$= 40.0 g · kg^{-1}, 16.3 g · kg^{-1}, 10.2 g · kg^{-1}, or 1.8 g · kg^{-1}, SEM = 1.4, for goats receiving diets consisting of 0%, 30%, 60%, or 90% mesquite pods, respectively) and Trial 2 ($\bar{x}$ = 26.8 g · kg^{-1}, 10.2 g · kg^{-1}, or 1.4 g · kg^{-1}, SEM = 4.1, for goats receiving diets consisting of 0%, 60%, or 90% mesquite pods, respectively). Alfalfa intake remained constant within treatments across days of feeding throughout both trials (treatment by day interaction was not significant; $P > 0.05$). There was a treatment by day interaction ($P < 0.05$) for pod intake in Trial 1. Mesquite pod intake was constant across days for goats fed diets consisting of 30% mesquite pods. However, intake varied for goats receiving diets consisting of 60% and 90% mesquite pods (Fig. 1a). Goats receiving a diet with 60% mesquite pods decreased intake on days 7 and 8 of the first trial. Goats receiving a diet of 90% mesquite pods decreased intake on days 12, 13, and 14 of the trial. In Trial 2, mesquite pod intake within treatments remained constant across days of feeding throughout Trial 2 (Fig. 1b).

Creatinine levels differed among treatments in Trial 1 but remained within the range for healthy goats (Table 1). Other serum metabolites that are indicative of soft tissue damage (e.g., liver damage), were similar among treatments in Trial 1. Serum glucose levels were also similar among treatments. Serum metabolite levels were similar among treatments in Trial 2 (Table 1). Fecal output differed among treatments in Trial 1

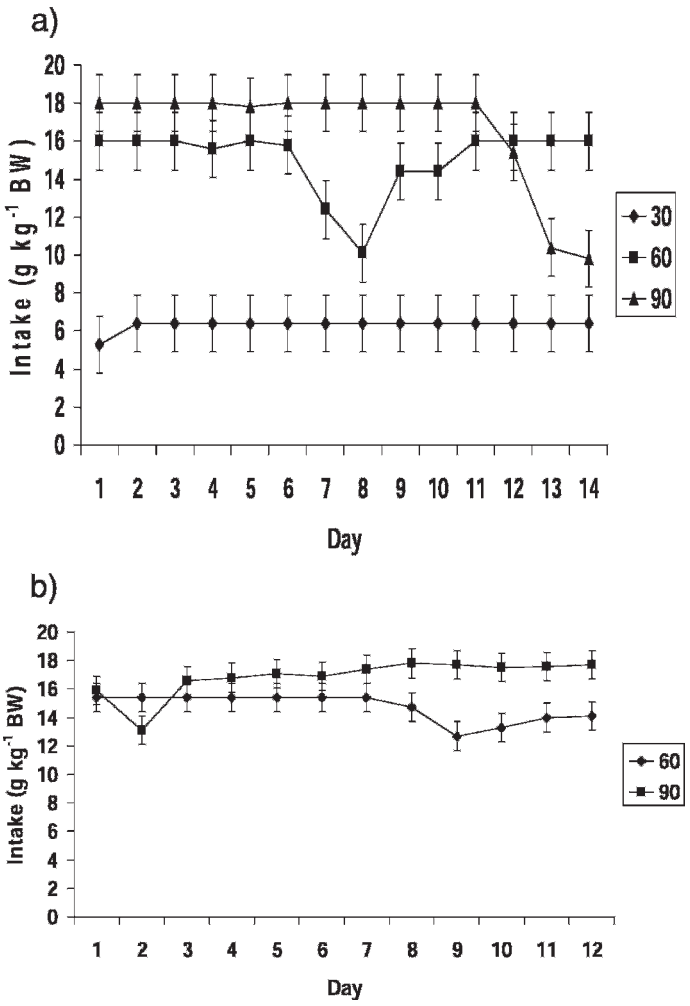

Figure 1. Mesquite pod intake (as-fed basis) for goats in **a,** Trial 1 and **b,** Trial 2. Goats were fed mesquite pods at 0%, 30%, 60%, or 90% of their diet. Intake was recorded daily for 14 d (Trial 1) or 12 d (Trial 2). BW indicates body weight.

Table 1. Average serum levels for goats fed mixtures of alfalfa and mesquite pods (0%, 30%, 60%, or 90%) for 14 d in Trial 1 and (0%, 60%, or 90%) for 12 d in Trial 2.

	Percentage of mesquite pods fed[2]					
Serum metabolite[1]	0%	30%	60%	90%	SEM	Normal range
Trial 1						
Creatinine (mg · dL^{-1})	0.8c	0.8c	0.9b	1.2a	0.02	0.4–1.2
GGT (U · L^{-1})	47.4	44.9	41.8	41.0	3.5	< 319
BUN (mg · dL^{-1})	26.1	23.0	18.9	23.3	2.0	17–31
AST (U · L^{-1})	76.2	48.8	49.1	50.8	11.8	32–152
Glucose (mg · dL^{-1})	61.9	61.7	64.8	63.2	3.4	26–126
Trial 2						
Creatinine (mg · dL^{-1})	0.9	—	1.0	1.0	0.1	0.4–1.2
GGT (U · L^{-1})	43.7	—	41.1	38.6	3.3	< 319
BUN (mg · dL^{-1})	22.0	—	20.9	25.7	2.8	17–31
AST (U · L^{-1})	128.3	—	53.8	56.4	31.1	32–152
Glucose (mg · dL^{-1})	63.7	—	66.1	63.4	1.5	26–126

[1]GGT indicates gamma glutamyltransferase; BUN, blood urea nitrogen; AST, serum aspartate transaminase.
[2]Means within rows with different lowercase letters differ ($P < 0.05$).

Table 2. Fecal output (dry matter basis) from Trial 1 and Trial 2. Goats were fed mesquite pods at 0%, 30%, 60%, or 90% of the diet in Trial 1 and 0%, 60%, and 90% of the diet in Trial 2. Fecal output was not measured for goats fed no pods in the first trial.

Percentage of mesquite pods fed	Fecal output (kg)[1]	SEM
Trial 1		
30%	0.30a	0.04
60%	0.27a	0.03
90%	0.19b	0.03
Trial 2		
0%	0.54	0.24
60%	0.47	0.20
90%	0.27	0.20

[1]Means within columns with different lowercase letters differ ($P < 0.05$).

but not in Trial 2 (Table 2). Goats fed a diet consisting of 90% mesquite pods excreted fewer feces. Weight change (gain/loss) was similar among treatments for both trials (data not shown).

DISCUSSION

Results of this study indicate that goats can consume large amounts of mesquite pods ($\leq 60\%$ of diet) for short periods of time without experiencing a decrease in intake, a decrease in fecal output, or soft tissue damage. When toxicosis from consuming mesquite pods has been reported, intake of pods has remained high for extended periods (2–10 mo) with pods as the primary dietary component (Burrows and Tyrl 2001). Both velvet mesquite (*Prosopis juliflora*) and honey mesquite are known to induce toxicosis (Alder 1949; Dollahite and Anthony 1957; Tabosa et al. 2000). Symptoms include malnutrition, muscle atrophy, weight loss, anemia, decreased blood glucose levels, and amino acid imbalances (Adler 1954; Tabosa et al. 2004). Blood glucose levels decrease and amino acid imbalances apparently occur because of decreased cellulose digestion from excessive release of sucrose. Decreased cellulose digestion results in rumen compaction or stasis because of an inability to digest mesquite pods and other plant material. There was some evidence of rumen compaction in Trial 1 when intake and fecal output decreased on days 12–14 for those goats fed a diet consisting of 90% mesquite pods. If Trial 2 was conducted for 14 d, fecal output may have declined in the 90% treatment group because of rumen compaction. Unfortunately, enough mesquite pods were only available for 12 d of feeding in the second trial.

Other evidence of toxicosis or rumen compaction were not obvious during this study. We would have expected alfalfa intake to decrease if rumen compaction or toxicosis had occurred. Alfalfa intake remained constant ($P > 0.05$) across days of feeding within treatments. Weight change was similar regardless of the amount of mesquite pods in the diet. In Trial 1, creatinine levels were higher for goats receiving a diet consisting of 60% or 90% mesquite pods. Elevated levels of creatinine indicate kidney damage (Cornelius 1989). However, creatinine levels, although higher, remained in the range that is considered normal (ISIS 2002). No other differences in serum metabolites were present in Trial 1. In Trial 2, there were no significant differences in any of the serum metabolite levels measured. Some fluctuations may have gone undetected because samples were collected on 72-h intervals.

Tabosa et al. (2000, 2004) reported clinical signs of intoxication in goats, including twitching of the lips, head tremors, excessive salivation, and emaciation. No overt signs of toxicosis were noted during our study. Our results suggest that short-term consumption of mesquite pods (≤ 2 wk) is not sufficient to cause toxicosis in goats.

Even when mesquite pods are available for longer periods, it seems unlikely that goats would consume sufficient mesquite pods to induce toxicosis if alternative forage is available. Ruminants consume a variety of foods to avoid toxicosis (Provenza 1995, 1996; Provenza et al. 1996) and rarely rely on a single dietary item to meet nutritional requirements (Bryant et al. 1979; Taylor et al. 1980). It seems unlikely that goats would select a diet consisting primarily of mesquite pods for an extended period of time particularly in areas where a diversity of forages is available. The one exception may be during droughts when forage availability is suppressed and mesquite trees increase pod production (Nilsen et al. 1991). During drought situations, mesquite pod intake could exceed levels necessary to induce toxicosis.

IMPLICATIONS

Given the lack of evidence of toxicosis and the low seed survival illustrated in other studies (Kneuper et al. 2003), goat herbivory should reduce the number of viable mesquite seeds dispersed across the landscape and increase the lifetime of mesquite control efforts. Undoubtedly, cattle, other livestock, and wildlife species will continue to consume mesquite pods and disperse viable seeds across the landscape. However, land managers could concentrate goats in pastures where some mesquite trees remain after brush control efforts to slow the reinvasion rate, especially during periods of pod production.

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