Journal of Arid Environments 130 (2016) 62–67

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Defoliation of *Flourensia cernua* (tarbush) with high-density mixed-species stocking

R.E. Estell*, D.M. Anderson, D.K. James

USDA-ARS, Jornada Experimental Range, Las Cruces, NM 88003-0003, USA

ARTICLE INFO

Article history:
Received 2 September 2015
Received in revised form
25 March 2016
Accepted 26 March 2016
Available online 31 March 2016

Keywords:
Biocontrol
Browsing
Cattle
Goats
Sheep
Shrubs

ABSTRACT

Interest in shrub use by livestock is increasing along with the rising demands placed on rangelands worldwide. Historically, *Flourensia cernua* (tarbush) has increased in the Chihuahuan Desert but receives limited use by cattle. Cattle, sheep and goats co-grazed eight 0.6 ha tarbush-dominated paddocks during two periods for up to nine days during two consecutive years. Cumulative tarbush defoliation across periods and years averaged 75.6%, with a mean increase of 9.3%/day ($P < 0.0001$). Defoliation of individual shrubs varied from 5 to 99% in 1989 and 0–100% in 1990, indicating highly variable palatability among individual plants. Sheep lost 2.3–5.5 kg/hd ($P < 0.0001$) across periods and years when forced to browse tarbush. In 1989, goats gained ($P = 0.0345$) 0.6 kg/hd in period 1, but the gain in period 2 was not significant ($P = 0.2934$). During 1990, goats lost 3.1 kg/hd ($P = 0.0001$) across periods. High-density mixed-species stocking of small areas for short time periods resulted in extensive tarbush use, primarily due to browsing by sheep and goats. Targeted use of tarbush for short time intervals may increase use of this highly nutritious forage and potentially serve as a form of biocontrol for this shrub.

Published by Elsevier Ltd.

1. Introduction

Multiple demands currently placed on rangelands globally have led to increased interest in the use of shrubs by livestock as a source of nutrients (Estell et al., 2012). Tarbush *(Flourensia cernua* DC.) is currently underutilized on rangelands in the Chihuahuan Desert stocked only with cattle. This shrub is the principal shrub species on the fertile clay loam soils of approximately 35 million ha of the Chihuahuan Desert (Schmidt, 1979). Tarbush occurs on about 21% (>6.75 million ha) of the southern and south-central portions of New Mexico; however, it is also found in Arizona, Texas and northern Mexico (O'Laughlin, 1975). Jornada Experimental Range (JER) historical records indicate essentially no dense tarbush stands in 1858; however, by 1963, over 9% of the 78,266 ha JER contained dense tarbush stands (Buffington and Herbel, 1965). Tarbush sites normally have a high inherent productive potential because soils are fertile and often receive additional run-on water (Paulsen and Ares, 1962); consequently, tarbush has been considered an undesirable encroaching shrub to be controlled by mechanical or chemical means (Herbel and Gould, 1980).

Although cattle (Nelson et al., 1970; Anderson and Holechek, 1983) and goats (Laribi et al., 1988; Mellado et al., 1991) have been documented to browse tarbush on native rangeland, it is usually not consumed in significant quantities even though its nutrient content approximates alfalfa (Estell et al., 1996). In a three year study of the nutritional profile of tarbush during the growing season, the crude protein content ranged from 16.4 to 24.7% (dry matter basis) and *in vitro* dry matter digestibility ranged from approximately 60 to 67% of the dry matter. Fiber concentrations ranged from about 19 to 22% (NDF) and 14–18% (ADF), while lignin (ADL) content ranged from approximately 5 to 7% of the dry matter. Condensed tannin concentration ranged from 0.3 to 0.4%, while total phenolics ranged from approximately 6 to 8% of the dry matter across the growing season (Estell et al., 1996). The total volatile concentration of tarbush was about 3.6% (dry matter basis; Fredrickson et al., 2007). Tarbush leaves in the pre-bloom state have the potential to supply crude protein to foraging livestock if animals can maintain adequate dry matter intake (King et al., 1996b).

Secondary compounds on the leaf surface of this resinous shrub may be responsible for differences in palatability observed among individual tarbush (Estell et al., 1994b, 1998, 2001). When chemical extracts from tarbush leaves were applied to alfalfa pellets, consumption of pellets by sheep decreased (Estell et al., 2001). Furthermore, sheep that have experienced negative feedback from

* Corresponding author.
E-mail address: restell@nmsu.edu (R.E. Estell).

http://dx.doi.org/10.1016/j.jaridenv.2016.03.013
0140-1963/Published by Elsevier Ltd.

tarbush ingestion may subsequently exhibit lower intake of tarbush under free-ranging conditions (Fredrickson et al., 2000). Though tarbush has been fed safely to sheep at up to 30% of the diet for four weeks (King et al., 1996a) and up to 90 days at 15% of the diet, lambs fed a 15% tarbush diet from birth through 120 days of age exhibited apoptotic liver damage and possible muscle damage (Fredrickson et al., 1994).

Tarbush intake is highly variable among individual animals (King et al., 1996a); thus, some animals within a species may consume significant amounts without being forced. However, because livestock species differ in preference for plant species and small ruminants are typically better browsers than cattle, mixed-species stocking may be a viable option to increase shrub utilization on arid rangeland landscapes compared to cattle alone (Anderson et al., 2010). The objective of this research was to determine if cattle, sheep and goats managed together under relatively high-density stocking for short intervals would defoliate tarbush without negative consequences on livestock production.

2. Materials and methods

2.1. Study area and vegetation

Eight 0.6 ha paddocks containing dense tarbush stands at two sites (four paddocks per site) separated by approximately 1.6 km on the JER (Dona Ana County, New Mexico, USA, 32.52,251 latitude; −106.74,693 longitude and 32.54,681 latitude; −106.72,423 longitude for sites 1 and 2, respectively) were used. Paddocks were stocked with cattle, sheep, and goats in 1989 and 1990. Long-term mean annual precipitation for the area is 237 mm. Study dates were as follows: 29 August to 7 September (1989, Period 1), 12 September to 21 September (1989, Period 2), 20 August to 29 August (1990, Period 1), and 4 September to 11 September (1990, Period 2). Period length was 7–9 days, depending on forage availability. After each period, livestock were moved to an adjacent 16.2 ha paddock with abundant herbaceous forage for 4 days.

Shrub canopy cover and species composition were estimated in each paddock from 10 randomly located, permanently marked, 30-m line transects each year. Shrub height and canopy diameter at ground level were measured on each transect prior to animal introduction and immediately following livestock removal from paddocks. Height and canopy diameter of two additional randomly selected tarbush were measured in each paddock each year and then harvested prior to animal introduction. Harvested shrubs were transported to the laboratory, air-dried, and manually separated into five categories: leaves, flowers, current year's twigs, live stems and dead stems. Current-year twigs and older stems were separated based on color (older stems were darker). After separation, each component was dried at 60 °C. Mean biomass (kg) of each component was determined and standing biomass (kg/ha) was calculated from the ratio of biomass and canopy cover of harvested tarbush plants (n = 16 tarbush per year) and the canopy cover estimates for each paddock (Table 1). Also, use of 10 randomly selected tarbush plants (identified with metal tags at ground level) was monitored daily in each paddock both years (same plants each year). Disappearance of the current year's growth (leaves and small twigs) was visually estimated each morning beginning 24 h after livestock exposure.

2.2. Livestock

This experiment was conducted before Animal Care and Use protocols were required. Each year, four randomly selected paddocks were stocked per period (Table 2). Each of the four livestock groups contained mature crossbred cows (≥4 years of age; n = 8), white-faced sheep (6–48 months of age; n = 20 and 23 in year 1 and 2, respectively), Spanish goats (8–20 months of age; n = 17 and 14 in year 1 and 2, respectively), and Angora goats (8–32 months of age; n = 2). In 1990, six cows had a nursing calf at their side. Groups remained intact for both periods each year, and were reconstructed with different animals in year 2. Groups were randomly assigned to the eight paddocks each year (Table 2). All animals had access to fresh water at all times and had been previously exposed to tarbush. Physiological stage of cattle varied slightly between years (late gestation vs. late gestation/early lactation in year 1 and 2, respectively), while small ruminants were in similar physiological stages both years (sheep were in last trimester of gestation and goats were castrated males and barren females).

The decision was made *a priori* to maintain constant livestock numbers and vary number of days in a paddock based on visual appraisal of available herbaceous vegetation, animal health, and tarbush foliage disappearance. Consequently, the number of days paddocks were stocked ranged from 5 to 9 days across years (Table 2). All livestock were removed from a paddock when tarbush defoliation within a paddock was ≥80%. A species was removed if one or more animals appeared lethargic or refused to eat tarbush after herbaceous material was removed.

Sheep and Spanish goats were weighed in the morning on a portable scale before entering paddocks (initial), upon removal from paddocks (final), and after four days in a larger adjacent paddock (a 16.2 ha paddock located next to treatment paddocks at each site). These large paddocks contained abundant grasses, forbs, and browse (including tarbush). The weight after four days in the large pasture following period 1 served as the initial weight for period 2 (Table 3). Cattle generally refused to eat tarbush and therefore were not weighed. Angora goats were not weighed due to limited sample size; thus, all references to goats hereafter refer to Spanish goats.

Livestock time budgets were assessed with a modified bite-count procedure (Bjugstad et al., 1970). Activity of individual animals was observed on day 3 in period 1 (1989) and on days 1, 3, and 7 in the latter three periods. Eighteen randomly selected animals (6 of each species, excluding Angora goats) in each paddock were observed at 1 min intervals for 16 consecutive minutes by trained observers to determine foraging activity during the morning foraging bout, beginning at 0630 h.

2.3. Statistical analyses

Mean daily tarbush defoliation of the 10 individual plants monitored each day was calculated for the level of experimental unit (paddock). A repeated measures linear mixed effects model (PROC MIXED; SAS V9.4; SAS Institute, Cary, NC) was then used to model effects of day, year and their interaction on paddock tarbush defoliation. Day was implemented as a repeated effect with paddock nested within year as the subject, using a heterogeneous first-order autoregressive temporal covariance matrix (determined by the minimum small-sample Akaike Information Criterion [AIC_c]). The model included a random paddock x period effect nested within year. The Kenward-Roger method was used to adjust denominator degrees of freedom. Goat and sheep weights were analyzed by year as a completely randomized design with data arranged as a split plot in time. For fixed effects with significant overall F tests ($P < 0.05$), means were separated using LSD.