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The food habits of goats on rangelands with different amounts of fourwing saltbush (*Atriplex canescens*) cover

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ABSTRACT

Esophageally fistulated goats were released in a microphyll desert scrub habitat with 14.6% or 46.2% aerial cover of *Atriplex canescens* (induced by removal of all shrubs except *A. canescens*, with livestock grazing exclusion for 10 years) to determine the seasonal forage species selected by the goats. The shrub removal strongly influenced the goats' feeding habits. The goats grazing the *Atriplex*-dominated site consumed 4.5 times more *A. canescens* than the goats on the untreated (control) pasture during all seasons. Shrubs were used heavily during all seasons by goats in both pastures, with higher percentages (75.5–82.8%) in the diets of goats grazing the control pasture than in the diets of goats grazing the *Atriplex*-dominated area (62.5–68.5%). No differences were found between seasons. The goats in the *Atriplex*-dominated pasture ate more grass than the goats grazing the control area and used more perennial graminoids during the summer (15.0%) and spring (18.3%) than the goats on the control area (6.0–7.0%). Forbs were an important component of diets. It was concluded that the successful revegetation of the treated pasture affected the goats' feeding strategy, with an increase in the use of *A. canescens*, forbs and grasses in all seasons.

1. Introduction

Goat production on natural range is one of the main sources of income for peasants in many developing countries with arid and semiarid zones (Davran et al., 2009; Rumosa Gwaze et al., 2009). Because of severe overgrazing and the low and seasonal rainfall in these areas, natural forage resources fluctuate greatly in quantity and quality throughout the year (Manzano et al., 2000). This fluctuation hampers goat productivity in drought-prone environments.

Conservative grazing that will allow the maintenance of highly vigorous forage plants is good insurance against fluctuating forage production, but this practice is not applied by range ecosystem managers and goat producers in low-input, pastoral production systems in the arid zones of developing countries (Dickhoefer et al., 2010; Peacock and Sherman, 2010). In fact, a vicious cycle of degradation is occurring because overgrazing and mismanagement have drastically reduced the natural plant cover of extensive range areas in low-input, smallholder production systems in countries with high levels of poverty (Devendra, 2010; La Baume and Dahl, 1986; Manzano et al., 2000). Simple rest from livestock grazing may not be a effective method for the remediation of degraded conditions, and more intensive improvement practices are often neither ecologically nor economically sustainable (Fredrickson et al., 1996). Feed supplementation during drought is infeasible for goat producers in resource-poor countries. Thus, an alternative approach for overcoming such feed constraints is the propagation of nutritious local fodder shrubs on degraded land. One ligneous species suitable for browse in areas of severe aridity is fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.), an evergreen, highly palatable, drought-tolerant and high-quality browse for cattle (Pinos-Rodriguez et al., 2007). This perennial shrub represents a neglected resource. It not only offers high-quality winter forage but also represents an opportunity to upgrade disturbed landscapes with a substantial increase in primary productivity in arid zones (Goodin and Newton, 1984).

Published information on the food habits of goats in *A. canescens* stands is lacking. Therefore, the purpose of this study was to create two treatments differing in the proportion of *A. canescens* to represent the variability that is present in arid zones. It was hypothesized that a high density of *A. canescens* would increase the selection of this plant by goats and decreases the selection of other available plants.

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2. Materials and methods

2.1. Study site and vegetation sampling procedure

The study was established on an experimental range in northern México (24° 21′ N, 101° 22′ W). The average annual precipitation in the area during the 10 years of grazing exclusion was 241 mm. Most of the area's precipitation falls during high-intensity thunderstorms during the growing season (June–October). The mean annual temperature is 13.9 °C, ranging from 7.4 °C in January to 21 °C in July.

The vegetation is dominated by creosotebush (*Larrea tridentata* (DC) Coville) along with tarbush (*Flourensia cernua* DC.), lechuguilla (*Agave lechuguilla* Torr) and fourwing saltbush (*A. canescens* (Pursh) Nutt.). Suffrutescents, including mariola (*Parthenium incanum* H.B.K.) and desert zinnia (*Zinnia acerosa* DC), are abundant. The principal perennial grasses are *Bouteloua karwinskii* (E. Fourn) Griffiths.), creeping muhly (*Muhlenbergia repens* (J. Presl) Hitchc.) and fluffgrass (*Erioneuron pulchellum* (Kunth) Tateoka). The most abundant forbs are copper globemallow (*Sphaeralcea angustifolia* (Cav.) G. Don) and velvety Nerisyrenia (*Nerisyrenia camporum* (A. Gray) Greene).

Four sites, each one ha in size, were established 500 m apart. Two of the sites were fenced with six strands of barbed wire, and all shrub species except *A. canescens* were individually severed below the ground level with a pickax and removed by hand. The exclusion of livestock continued for 10 years. The two other sites were not fenced and were heavily used, as has been the case for decades, by cattle, horses and goats.

In 2007, the aerial cover was determined for each plant species prior to clipping by estimating the portion of the quadrat covered by plant foliage for all plants present in the quadrats. The standing crop biomass at all sites (both the control and the *Atriplex*-dominated sites) was determined using ten 16 m^2 quadrats randomly distributed over each of the stands to be sampled (40 quadrats in all). All edible components of the plants (shrub foliage, petioles and tender twigs, herbs and grasses) within the quadrats were clipped. The forbs and grasses were clipped to ground level. Collections were made during April (spring), the end of June (summer) and October (fall). The quadrats were moved to new locations after harvesting. The plant material from all species was separated, dried in a forced-air oven at 65 °C for 48 h, and weighed to the nearest 0.1 g. The amount of cover was expressed as kg ha^{-1}.

2.2. Chemical analyses of A. canescens

Four randomly selected samples of *A. canescens* representing the plant fractions eaten by goats were collected during spring, summer and fall in the *Atriplex*-dominated site. Samples for chemical analysis were oven dried at 65 °C for 48 h and then ground to pass through a 1 mm sieve in a Wiley mill. Protein content (N × 6.25) was determined by Kjeldahl analysis (AOAC, 1995). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were assayed according to Goering and Van Soest (1970). The sodium and potassium contents of forage samples were determined with standard methods for flame spectrophotometry. Hydrolyzable tannins were determined following the procedure of Makkar and Singh (1991), and condensed tannins were assayed according to the procedure described by Swain and Hills (1959).

2.3. Collection of esophageal fistula forage samples and species identification

Goat management for this study followed institutional guidelines approved by the Animal Care and Use Committee of The Agrarian Autonomous University Antonio Narro. Twelve esophageally fistulated adult non-lactating criollo goats (mean weight = 35 kg) fitted with removable cannulae were used to collect ingesta samples in each treatment (six goats per treatment) immediately after vegetation collection. Grazing by goats was alternated within treatments. Although the goats grazed in groups, individual goats were considered experimental units that responded to the treatments applied. This definition was based on the assumption that external factors did not affect the groups.

The goats had been raised and maintained in the pastures used in this study. Therefore, they were accustomed to the forage resources and spatial distribution of the plant species occurring in this landscape. The fistulated goats were corralled overnight and released at 0800 hours. The goats, fitted with screen-bottomed canvas collection bags, were allowed to roam freely for 60 min during five consecutive days. Upon return to the corral and removal of the collection bags, the goats were given oaten hay ad libitum. The forage samples selected by goats were pooled by goat over each of the 5 days collection periods and were analyzed for botanical composition.

The forage samples were oven dried for 48 h at 65 °C and were ground in a Wiley mill fitted with a 1-mm mesh screen. Five slides were made of each forage sample. Twenty fields were examined on each slide at 100× to identify plant species based on the epidermal characteristics. In all, 100 fields per sample were examined. The percentage frequency of each identified plant species was converted to a density value of particles per microscope field. All procedures followed the methodology described by Sparks and Malechek (1968).

The procedure used in the present study to evaluate the botanical composition of the diets selected by goats is not strictly precise because the esophageal extrusa represents only a small portion of the total diet that goats select and ingest throughout the day. However, no single analytical method currently available to assess the diet composition of grazing animals can be considered absolutely reliable.

Relative preference indices (RPI) for different plant species by different animals were determined using the following formula:

RPI = % frequency in the diet composition/% frequency in the range composition. An index value of 1.0 indicated nonselective use of the plant; values >1 or <1 indicate selectivity for or against plants, respectively. A 95% confidence interval was calculated for each mean selectivity value according to Hobbs and Bowden (1982). If the interval did not contain the value 1.0, the selectivity was considered significant.

2.4. Statistical analysis

Differences in forage production and aerial cover between the two sites (control and *Atriplex*-dominated pasture) were analyzed using a repeated-measures analysis of variance (PROC MIXED procedure with the "repeated" statement; SAS, 2000). The season (spring, summer and fall), vegetation transformation (*Atriplex*-dominated site and natural vegetation), and block (2 for both *Atriplex*-dominated and control sites) were the factors studied. Vegetation treatment and block were repeated within season. Season and vegetation treatment were considered fixed effects, whereas block was considered a random effect. Two-way interactions between fixed effects were included in the final model. If significant differences occurred, a Scheffe test was used to separate the means. For aerial cover values and the percentage of forages in the goat diets, the data were arcsine-square root transformed prior to analysis to meet the assumption of a normal distribution.

The botanical constituents of the diets were examined with an analysis of variance (PROC GLM procedure of SAS). The main effects