Journal of Arid Environments 74 (2010) 1061–1065

Contents lists available at ScienceDirect

Journal of Arid Environments

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

Dietary supplementation in domestic goats may reduce grazing pressure on vegetation in semi-arid thornscrub

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ARTICLE INFO

Article history:
Received 24 September 2009
Received in revised form
15 February 2010
Accepted 2 March 2010
Available online 31 March 2010

Keywords:
Biosphere reserve
Dietary selection
Endemic species
Livestock feed
Plant conservation
Sustainable development

ABSTRACT

Small herds of domestic goats play an important role in the subsistence of farmers in semi-arid subtropical areas. Dietary supplementation of these animals may help these farmers to improve productivity, but an assessment of compatibility with the sustainable development of these areas is necessary prior to the implementation of such a management strategy. In this study, we examined the effects of diet supplementation on domestic goat foraging behavior during the dry season, by analyzing the forage diet composition of supplemented and unsupplemented goats over a period of four months (February–May). Diet composition was analyzed using direct observation of each animal and recording time spent on consumption of each different plant species. Initial and final live weights of all the animals were taken. Supplementation allowed animals to maintain higher bodyweight with low modification of dietary selection and no increase in consumption of endemic or sensitive plant species. Supplementation could also help to reduce the detrimental consequences of free foraging during the dry season, by decreasing the time spent foraging, which would indirectly benefit the conservation of natural vegetation during this critical period.

1. Introduction

Arid and semi-arid subtropical areas are typically inhabited by subsistence farming communities that conduct various socio-economic activities in constant interaction with the ecosystem. Of these activities, the rearing of domestic goats is one of the most important production processes for the communities (Peters, 1987; Hernández, 2000; Lebbie, 2004). However, goat productivity is very low due to the long and pronounced dry season which often causes serious food shortages for the livestock, leading to diseases and increased mortality (Papachristou and Nastis, 1993; Kronberg and Malechek, 1997; Hernández et al., 2001). Domestic goat production has also been considered to be extremely detrimental to vegetation, due to the impact on soils and direct damage to plants (Manzano and Navar, 2000; Cardel et al., 1997; Esparza-Olguín et al., 2002; Dhillion et al., 2004).

Such damage to vegetation may be controlled by appropriate management (Mellado et al., 2003), and it is possible to implement management strategies in order to reduce vegetation degradation at the same time as increasing herd health (Papachristou et al., 2005; Baraza et al., 2008). It has been demonstrated that the variable administration of nutritional supplementation, in response to changes in forage availability, can allow the nutritional optimization of the system and increase both plant primary productivity and livestock profitability (Galina et al., 1998; Morales et al., 2000). Supplementation during the dry season has therefore been proposed as a viable method to improve livestock productivity in these arid areas (Baraza et al., 2008).

Supplementation can ease grazing pressure on vegetation by altering foraging behavior, since the nutritional state of a herbivore may affect its dietary preference (Parsons et al., 1994; Baraza et al., 2005). Rates of detoxification are influenced by the nutritional state of herbivores: herbivores with access to nutritious food will be able to maintain the necessary nutritional requirements for detoxification of a greater amount of plant secondary metabolites (Banner et al., 2000; Villalba et al., 2002; Provenza et al., 2003; Campbell et al., 2007). This permits animals to consume greater quantities of plants rich in these metabolites. However, increased consumption of such species could have important consequences for plant performance (Esparza-Olguín et al., 2002), considering that species with a high investment in such defense mechanisms may be less tolerant to herbivory (Strauss and Agrawal, 1999; Mauricio, 2000; Stowe et al., 2000).

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doi:10.1016/j.jaridenv.2010.03.001

The Biosphere Reserve of the Tehuacán-Cuicatlán Valley, located in southern-central Mexico, is one of the semi-arid zones of greatest biological diversity in the world (Dávila et al., 2002). Since the colonial period, extensive goat herding has become the most important productive subsistence activity for farmers in this area (Hernández, 2000; Hernández et al., 2001). At present, domestic goat production is a key resource for marginal farming communities, providing an important source of dietary protein, but also serving as a financial asset for each family (García, 1996; Hernández, 2000). The Biosphere Reserve was created to promote a balanced relationship between humans and the environment, in order to reconcile the conservation of biodiversity with its sustainable use (Batisse, 1982). It is therefore necessary to develop natural resource management programs which improve the quality of life within the reserve, without increasing anthropogenic environmental impact. Dietary supplementation of livestock can help farmers to improve productivity, but it is necessary to fully assess the compatibility of this management strategy with vegetation conservation prior to implementation, and to generate data which will enable a forecast of the possible impacts on vegetation diversity. The present study addresses this issue through the experimental evaluation of the effects of protein supplementation on domestic goat foraging behavior during the dry season in the thorn scrub of the Tehuacán Valley. We measured the effect of a period of dietary supplementation on the live weight of goats, and analyzed the degree of overlap between the diets of animals within and between experimental treatments (supplemented vs. unsupplemented). We also measured the specific differences between forage consumption patterns in livestock subjected to each treatment.

2. Materials and methods

2.1. Study area description

The study was conducted in the village of San Juan Raya (18°11′N 97°23′W, 1750 m.a.s.l.), located in the river basin of Zapotitlán, in the Tehuacán-Cuicatlán Valley in the state of Puebla, Mexico. Domestic goat production is an important economic practice in San Juan Raya, involving 37.5% of the families (Osorno-Sánchez, 2005). It has an annual mean rainfall of 380 mm, most of which occurs during the months of June to September, and an annual mean temperature of 21 °C with infrequent frosts. The soils are calcareous, shallow and rocky. The main vegetation type is known locally as “tetechera”, and is characterized by the presence of *Neobuxbaumia mezcalaensis* and *N. macrocephala,* two giant columnar cacti which comprise the dominant elements of the vegetation, together with other cacti such as *Opuntia* spp. and globose cacti (i.e. *Mammillaria* sp., *Echinocactus* sp., *Ferocactus* sp.), trees (*Pseudosmodingium multifolium, Mimosa lacerata, Acacia* spp.), scrubs (*Lippia graveolens, Euphorbia antisyphilitica*) and rosette-like plants (*Yucca periculosa*, *Beaucarnea gracilis*, *Agave* spp., *Hechtia podantha*) (Valiente-Banuet et al., 2000). Many of these species are endemic to the Tehuacán Valley and present conservation problems due to low rates of regeneration: several species of *Beaucarnea* (Cardel et al., 1997) and cacti (Esparza-Olguín et al., 2002; Hernández and Godínez, 1994; Carrillo-Angeles et al., 2005) are particularly affected. Few of these, however, are protected by any category of conservation.

2.2. Animals and treatments

The study was conducted with 16 non-pregnant adult female “*criolla*” goats from the same herd. All animals were weighed at the beginning and end of the study (see results). Goats were randomly allocated to two groups, which were balanced for live weight. Individuals from one group were supplemented daily with 500 g of commercial animal feed (15–20% protein; 2.51–5% fat; 59.95% free nitrogen extract; 3.63–5% fiber; 6.45–7% ash, with a water content of 12–14%, and including minerals and vitamins; Forrajera Acatepectc®) while isolated in individual enclosures for 2.5 h (from 7.00 to 9.30 a.m.) prior to foraging. The other group was kept without food supplementation in order to act as a control. Supplementation was administrated daily from January 20th to May 20th. One goat repeatedly refused more than 50% of the offered food, so it was necessary to eliminate this individual from the study. All animals were individually identified by a colored number written on both flanks.

2.3. Behavioral recording

Goats from both groups were taken by a herder to forage from 09.30–10.00 to 16.30–17.30 h, normally covering more than 6 km per day. They were first taken to the river for water and then on to the forage sites. We selected sites which were representative of the vegetation communities described above, and where the herder frequently took the goats. Two observers accompanied the herd during the morning and oral observations of individual goat behavior were recorded on portable tape-recorders. These observations included identification of plant species under consumption, and total foraging times spent on each different species. It was therefore possible to quantify total time of consumption for each individual element of the diet. One goat from each group was selected at random for each recording period, and these were observed simultaneously, one by each observer. Some plant species, such as leafless shrubs, proved impossible to identify and were classified as “dry shrubs”. Observations of foraging behavior were repeated during the dry season from February to May at 20-day intervals in 5 separate periods of study. During each period, each goat was observed over a time period of approximately 1 h, split into 9 separate time intervals of between 5 and 7 min each. Observations were made over 4 days with two–three time periods per goat per day.

Because the two groups of goats (supplemented and unsupplemented) forage together, they can exert an influence over each other, with a potential loss of independence between experimental units. However, this methodology ensured that control and supplemented animals were exposed to identical conditions in terms of plant species availability, time of day and environmental conditions.

2.4. Statistical analysis

Differences in weight between goats from each treatment were tested for significance with a one-way ANOVA. Dietary overlap between each pair of goats in each period was calculated using the Morisita–Horn similarity index (Beck et al., 2007), considering the proportion of time allocated to the consumption of each item as representative of its relative contribution to the overall diet. This index provides a value between 0 and 1, where 0 is no overlap and 1 is complete overlap between diets. Degree of overlap was considered to be small, medium or high when the Morisita-Horn similarity index is between 0 and 0·29, 0.3–0.59, and >0.60, respectively (Langton, 1982). The Morisita–Horn similarity index was computed by the program EstimateS (Colwell, 2006). Following angular transformation, differences between values of the Morisita–Horn similarity index in the comparison of goats from within the same treatment and from different treatments (type of comparison) were analyzed with a Generalized Least Squares (GLS) model, comprising type of comparison and period of study as fixed factors. A variance estimate for each period was included with