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Shrub vegetation consumption by goats in the southwestern Iberian Peninsula

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ABSTRACT

Domestic ruminants grazing behavior on natural vegetation suggests a potential balance between the development of extensive farming systems, and environmental conservation. The preference of domestic goats (Payoya Goat) for the shrub understory of a pine forest in Doñana Natural Park was analyzed over the course of a year, using a multinomial logistic regression model. Results show selective and seasonal grazing which varies throughout the year. The model explained 42.2% of the experimental variability with a Cox and Snell pseudo-R^2 coefficient of 0.407. These are acceptable values given the complexity of the model. Two species subject to high levels of consumption, *Myrtus communis* and *Cistus salvifolius*, presented excellent predictions (69.2% and 68.2% respectively). Seasonal variations found in grazing preferences suggest the potential utility of the goat as an instrument with which to control woody vegetation without loss of biodiversity. In this way, it is possible to very accurately control the final results, facilitating the establishment of a vegetation management plan.

1. Introduction

Domestic herbivores in Europe, particularly ruminants, have played an important role in the genesis and maintenance of landscapes (Emanuelsson, 2009). Goats are among the first ruminants to be domesticated (10000-7000 years ago; Mason, 1984; Clutton-Brock, 1999) and have grazed in Mediterranean shrublands for millennia (Esteban Muñoz, 2009). The feeding habits and forage preferences of domestic and wild goats are similar (Garcia-Gonzalez and Cuartas, 1989), but in recent years, extensive livestock production has undergone a sharp decline in Europe and is now restricted to very marginal areas. Due to their marginality, these areas are often very well conserved and have been undergoing a gradual conversion into areas of very high conservation status, which can complicate the management of pastoral activities. The benefits offered by goat production, such as their survival ability in marginal areas, are recognized by broad sectors at international level (Gall, 1991; Devendra, 1987). Until relatively recently, however, goat production in forest areas has been subject to controversy (Tejón et al., 1997).

The goat is undoubtedly the most specialized domestic ruminant in pruning and therefore, under appropriate management, could become a very valuable instrument in the conservation of woodlands and Mediterranean forests (Hofmann, 1989; Torrano and Valderrabano, 2005). An understanding of the relationships that exists between such phytophagous organisms and the vegetation is essential for the sound management of the natural environment and conservation of biodiversity and landscapes (Anderson et al., 2000; Vera, 2000; Pedroli et al., 2007). An important factor to consider in the management of silvopastoral systems is selective consumption of plants. It is an extremely variable factor depending on

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seasonal changes (Barroso et al., 1995; Dannel and Bergström, 2002; Dziba et al., 2003), heterogeneity of vegetation (Hooper, 1960; Rogosic et al., 2006), availability of food (Genina and Pijoanb, 1993; Freeland et al., 1985; Rogosic et al., 2003), learned behavior of the animals (Galef and Giraldeau, 2001; Lesley et al., 1994) and the biochemical composition of plants (Baraza et al., 2008; Dannel and Bergström, 2002; Garín et al., 1996; Provenza et al., 2003; Rogosic et al. 2006). Understanding the reasons why animals prefer certain shrubs and not others is important for many reasons; particularly for managing livestock and wildlife with regard to sustaining the shrublands they occupy. In this way, the objectives of this experiment are: (1) To analyze the temporal variations in the preferences of the goats for scrub vegetation over a year using a multinomial logistic regression model (Agresti, 2002); (2) To evaluate the potential utility of the domestic goat in the conservation management of areas dominated by woody vegetation.

The relative preference of an animal for a particular plant species is closely related to the nature and availability of other species in its environment (Hein and Miller, 1992). In dietary studies, the use of complex probabilistic analysis is relatively uncommon and consideration is normally given only to the use of a particular resource alongside with its availability in the environment. In addition, such analyses are largely conducted in relative rather than absolute terms; i.e. through comparison of relative use and availability (Fernández-Olalla and San Miguel, 2008).

2. Material and methods

2.1. Research area

The experiment was conducted in a 100 ha pine forest situated in Doñana Natural Park (37° 14′N, 6° 20′W, SW Spain), an area from which all large herbivores were excluded in 2002. The pine forest is composed mainly of *Pinus pinea* (with an average density of 217 trees/ha and an average dbh of 26.92 cm) and is complemented in some areas by a small presence of Cork Oak (*Quercus suber*) and Holm Oak (*Quercus ilex* subsp. *ballota*). The climate is Mediterranean. The winter is wet with mild temperatures (monthly average temperature is 10 °C in December and January), and the summer is long and dry, with a mean temperature of 25 °C in July and August. Minimum winter temperature drops between −2 and −4 °C. Mean annual rainfall is around 540 mm (with 80% of precipitation occurring from October to March). Summer drought is severe, with no precipitation from July to August.

2.2. Data compilation

In order to determine the abundance of shrub species, prior to the introduction of goats, 36 fixed transects of 25 m in length were established. Likewise, nine fixed grazing exclusion plots (0.25 ha each) were installed to test the evolution of the vegetation in the absence of grazing. Vegetation was sampled along these transects using the point-intercept method of scoring the points of contact with scrub vegetation every 10 cm (Mancilla-Leytón et al. 2012a). Cover of each species in each plot and date was calculated as the percentage of points occupied by the species. Total shrub cover was calculated as percentage of points with shrub. Biovolume (m^3/ha) of each species and of the shrub was calculated as the percentage of cover by mean height. The vegetation was sampled three times: before grazing, after six months of grazing and at the end of the study (after one year of grazing).

A herd of 350 adult female *Payoya* goats (average weight of 45 ± 5.3 kg, 2.9 ± 1.4 years) was introduced into the study area at a stocking rate of 2.7 goats/ha/yr. These goats browsed the entire area over three consecutive days and the fourth day was spent grazing outside the area (280 days/yr). The management may be considered to be semi-extensive, although in order to exploit the 100 ha in a uniform manner, the goats are closely controlled and herded by a shepherd.

In order to determine which shrub species are preferred by goats, a method of direct observation was used. This technique is very efficient for determining the shrub species consumed the most desired parts, and the relative preferences and variation throughout the year. Although modified, the procedure described by Meuret et al., 1985 was followed. In this experiment, surveys were performed from the beginning to the end of the grazing day, during three consecutive days per month, with 10 min monitoring period per goat, in the understory of the forest. Every day, 10–15 goats were observed (30–45 goats/month). Goats were chosen at random, without repeatedly observing any individual in the same sample (see Mancilla-Leytón et al., 2012b).

2.3. Analysis

With data obtained through monthly monitoring (number of bites per species and goat), the probability of choice for each species in each month can be calculated, considering the probability of consumption of each plant species independently. However, to achieve a more realistic approach, a model which allowed the calculation of the probability of choice of each plant species was built. Both the number of bites and the time devoted by each goat to each different species was taken into account. This type of model has a descriptive rather than a predictive character, but represents a useful tool for the subsequent development of a management plan.

The model used was built with the multinomial logistic regression method (Agresti, 2002), and the variables used were: plant species consumed (target variable), number of bites and the month (predictor variables). The multinomial logistic regression model (MLR) is a simple extension of the binomial logistic regression model. It is used when the dependent variable has more than two nominal or unordered categories, and it is based on k-1 binary logistic regression models when there are k categories in the dependent variable. Tabachnick et al. (2001) argued that multinomial logistic regression technique has a number of major advantages,