Applied Animal Behaviour Science 124 (2010) 35–44

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

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

Feeding behaviour of sheep on shrubs in response to contrasting herbaceous cover in rangelands dominated by *Cytisus scoparius* L.

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ARTICLE INFO

Article history:
Accepted 8 February 2010

Keywords:
Bite
Broom
Feeding choices
Grazing behaviour
Shrub encroachment
Shrubland

ABSTRACT

The foraging responses of ewes faced with a diversity of feed items and their effects on broom (*Cytisus scoparius* L.) consumption were examined. The experiment was conducted on a farm in the autumn with ewes ($n = 33$) grazing three small paddocks (0.44 ha on average, for at least 10 days each) located in broom shrubland. The effects of three different herbaceous covers on broom consumption were compared: 100% of paddock area previously grazed in summer; 50% of paddock area previously grazed in summer; and paddock area non-grazed during the year. The characteristics of herbaceous cover (availability and quality) and the ewes' diet selection were encoded as bite categories. Flock activities were recorded through scan sampling. We used logistic regression to assess the relationship between feeding behaviour of sheep on herbaceous vegetation and on broom species, and calculated selectivity indices for this shrub. We showed that the presence of high-quality bite categories in the herbaceous cover affected the way ewes integrated broom into their diet. At the start of each paddock use period, ewes favoured high-quality larger and medium bites of the herbaceous cover. They gradually included larger bites of broom and reduced their bite size, but continued to seek out higher quality herbaceous plants, a pattern which suggested a stabilisation of their daily average digestibility and bite mass over time. A negative relation was observed between the percentage of ewes taking large and medium bites on highly digestible plant parts and the percentage of ewes browsing broom. A maximum of 26% of the flock browsing broom was observed on any given day. Hence, ewes have a threshold for this target shrubby species that they do not exceed during any paddock utilisation period. This finding was interpreted as a mechanism to deal with post-ingestive consequences and complementary interactions between nutrients and toxins. When comparing broom selection between paddocks in autumn, we found an earlier and thus longer broom selection in areas with herbaceous cover that had not been grazed during the year (possibly because of a lower palatability). Our results provide new insights into ways to manipulate diet selection in order to stimulate the use of broom by ewes. Bite categories are proposed as functional feed indicators that facilitate prediction of the herbaceous cover state preliminary to initial broom integration in the sheep's diet.

1. Introduction

Shrubby rangelands in Europe are now considered of high interest for their ecological, landscape and agronomic value (Agreil et al., in press). Many aspects (e.g. biodiversity conservation, accessibility for herbivores, productive goals)

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doi:10.1016/j.applanim.2010.02.002

support the value of maintaining open pastures and a certain level of control of dominant shrub cover in these natural areas (Bossard and Rejmánek, 1994; Casasús et al., 2007). Grazing, especially with small ruminants (sheep and goats), has shown to be an economic way to integrate environmental goals into these production systems (Valderrábano and Torrano, 2000; Bellingham and Coomes, 2003; Frost and Launchbaugh, 2003). From a practical perspective, technical specifications need to be proposed in order to increase the potential use of grazing to control shrub population. However, very few studies have focused on how to graze flocks on highly diversified plant communities, such as shrublands (e.g. Agreil et al., 2005). Understanding the feeding behaviour of livestock faced with high plant diversity is a powerful tool available to managers to modify plant–herbivore interactions to achieve targeted shrub grazing levels (Launchbaugh, 2006).

In shrubby rangelands, it has been demonstrated that herbivores' diet selection is not simply geared to a satisfactory quantity–quality trade-off of food items (Kabaya et al., 1998; Agreil et al., 2005; Rogosic et al., 2007), as suggested by the forage maturation hypothesis (sensu Fryxell, 1991). Two important factors undermine this hypothesis in shrubby rangelands: a lack of correlation between bite masses and bite quality in the case of these vegetation types comprising several plant life forms and architecture (Van Soest, 1982; Agreil et al., 2006), and the necessity for herbivores to mix diets in order to meet their nutritional needs and, at the same time, avoid poisoning (Provenza et al., 2003; Villalba and Provenza, 2005; Rogosic et al., 2007). For the poisoning issue, a recent review (Rogosic et al., 2008) has highlighted the positive influence of biological diversity that, thanks to complementary chemical interactions, helps to prevent toxic effects and/or increase the efficiency of detoxification in small ruminants. Based on these findings, research has been done to identify the causes of foraging behaviour in response to variable ranges of edible items, such as in shrubby rangelands. Herbivores often consume plant species, or plant parts, with different nutritive values, without maximizing their intake rates (Kabaya et al., 1998; Papachristou et al., 2005). In shrubby rangelands, Agreil et al. (2005) have observed that a diversity of food sources enables small ruminants, in a reasonable length of time, to reach satiation by diversity of their instantaneous choices and by increasing their range of bite sizes. Unfortunately, the importance of the diversity of feed items in targeted grazing of dominant shrubs remains unclear.

In this situation, with a high variability in the diversity of edible items, there is also growing evidence that the probability of a target plant being grazed is largely conditioned by management factors, rather than by the plant's intrinsic properties (Baraza et al., 2005; Launchbaugh, 2006). Some of these management factors can directly affect the feeding behaviour, e.g. feed additives (Rogosic et al., 2008), stocking density (Provenza et al., 1983; Mellado et al., 2003; Shaw et al., 2006), grazing route (Meuret, 1996) and even the animal's earlier experiences (Provenza, 1995; Provenza et al., 2003; Villalba et al., 2004). Some other management factors affect the feeding behaviour indirectly by having animals cope with changes in resource availability as a result of changes in the grazing season (Valderrábano and Torrano, 2000; Dumont et al., 2005), the spatial distribution of vegetation (Hester and Baillie, 1998; Holst et al., 2004; Oom et al., 2004) or the relative abundance of species, e.g. with ryegrass and clover associations (Parsons et al., 1994; Penning et al., 1997). However, little attention has been given to the effects of management factors on selectivity in target plants (e.g. shrubs) through the manipulation of resource availability, i.e. abundance, size and quality of alternative feed items in the heterogeneous vegetation community.

The objective of our study was to identify the role of feed item diversity in targeted grazing of a dominant shrub, namely, broom (*Cytisus scoparius*). We hypothesized that: (i) broom selection by ewes is influenced by the diversity of the feed items available; thus, factors other than the intrinsic properties of the dominant shrub influence the browsing habits; (ii) the diversity of the feed items available, associated with increasing resource heterogeneity in day-to-day grazing, promotes an increase in the range of bite sizes and nutritive qualities selected by the flock over time, thus modifying the browsing effect on the broom. Based on these hypotheses, we predicted that intake of broom would increase with depletion in the size, nutritive quality and structure of plant parts in herbaceous vegetation, rather than the animals selecting larger bites of mature herbaceous cover or increasing bite frequency on such cover.

We carried out a trial on heterogeneous vegetation, a natural broom shrubland located within a farm system. The effect of three contrasting herbaceous covers on broom consumption was compared by investigating and monitoring the adaptive feeding behaviour of the flock over time. Special emphasis was given to the condition of the herbaceous cover at the beginning of broom browsing in order to identify new qualitative indicators, coded as bite categories (Agreil and Meuret, 2004), to influence diet selection for shrub control. We aimed at answering the following questions: (1) How do small ruminants (sheep) select their diets when faced with shrubby rangelands which vary over time and in space? (2) How do abundance, size and quality of alternative herbaceous feed items affect the importance of broom consumption over time?

2. Materials and methods

2.1. Study site and treatments

The experiment was conducted on private property in the southwest of the Ariège-Pyrénées region (France) at a mean altitude of 900 m. The study area (1.3 ha) was composed of multi-stratified vegetation with a wide variety of grasses and forbs encroached with broom (*C. scoparius* L.). In summer, this area was divided by an electric fence into three paddocks of 0.44 ± 0.03 ha each on average. In order to create three future states of herbaceous vegetation for the autumn experiment, we manipulated it by having horses graze in the area from 12 June to 2 July 2008, thus creating differences in paddock characteristics: (1) P1 = 100% of paddock area grazed (3.731 kg LW/ha/day during 8 days); (2) P2 = 50% of paddock area grazed (3.261 kg LW/ha/day during 10 days); and (3) P3 = non-grazed paddock area.