



Foraging selectivity of three goat breeds in a Mediterranean shrubland

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ARTICLE INFO

Article history:

Received 19 April 2011

Received in revised form 20 August 2011

Accepted 2 September 2011

Available online 29 September 2011

Keywords:

Browse

Grazing

Diet selection

Pistacia lentiscus

Phillyrea latifolia

Near-infrared spectroscopy

ABSTRACT

Foraging behaviors of the Damascus, Mamber and Boer goat breeds were compared on shrublands of the South Carmel mountain ridge of Israel. Dietary choice was determined for a group of yearling animals of each breed ($n = 11$ or 12), housed and grazed separately to prevent social facilitation, during a total of 4 (Mamber) or 5 (Damascus and Boer) sessions of four days each in fall 2004 and spring 2005. The proportions in the diet (including concentrate feed) of three main dietary components – *Pistacia lentiscus* L. (20% tannins), *Phillyrea latifolia* L. (3% tannins) and herbaceous vegetation – were determined by application of near-infrared reflectance spectroscopy to faecal samples ($n = 147$). On average, *P. lentiscus* constituted 14.9% of the DM ingested by Damascus goats, but only 5.6 and 5.0% of that ingested by Mamber and Boer goats, respectively. In the fall season, Damascus goats ingested diets richer in tannins than did Mamber or Boer goats ($P < 0.001$). In the spring, the contribution of herbaceous vegetation to DM intake was higher in Mamber goats (38.5%) than in the other breeds (27.7%). Boer goats selected the most nutritious diets in terms of crude protein (CP) content and in vitro dry matter digestibility (IVDMD). Despite their differences in foraging selectivity, the local Damascus and Mamber goats selected similar diets in terms of CP and IVDMD. Our data suggests that, of the three breeds examined, the Damascus should provide the best control of *P. lentiscus* encroachment and the least competition with cattle for green grass in the spring. These findings may help to develop ecologically sound ways of controlling the spread of the tannin-rich shrub *P. lentiscus* L., which threatens rangeland biodiversity and amenity values in the Mediterranean climatic region of Israel.

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1. Introduction

It is well established that different livestock species exhibit differences in grazing behavior and will consume different plant species or plant groups when exploiting the same pastures (Abaye et al., 1994; Taylor, 1985). Domestic goats (*Capra hircus*) ingest browse even when more nutri-

tious food, such as alfalfa hay, is available (Landau et al., 2002). However, the propensity to browse may differ also among domestic goat breeds.

There are two key aspects related to foraging behavior differences among goat breeds. One is nutritional – the ability of the goat to collect sufficient nutrients to meet requirements for maintenance, growth, reproduction and lactation. The other is ecological – the impact of the goat on the plant community or other organisms that are part of the ecosystem. In a comparison of Spanish and Angora goats, Pritz et al. (1997) found that Spanish goats exhibited higher consumption of redberry juniper (*Juniperus*

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pinchotii Sudw.) than Angora goats, but that the digestibility of redberry juniper was higher in Angora than Spanish goats. In a comparison of Boer and Mamber goats, Aharon et al. (2007) found that Boer goats spent less time grazing herbaceous species than did Mamber goats (22 vs. 44%, respectively) and would therefore be less competitive to cattle in a mixed grazing system. Grazing behavior differences between breeds may also be related to sensitivity to gastro-intestinal nematode (GIN) burdens. Hoste et al. (2001) found that Saanen goats behaved more like browsers than did Angora goats when kept in heterogeneous environments. Lower faecal egg counts were found in the Saanen goats, possibly due to the anthelmintic properties of browse tannins (Min and Hart, 2003).

A major managerial issue of Mediterranean rangelands is related to brush encroachment. Most brush species are evergreen and have developed various strategies to cope with herbivory. Some species, such as *Phillyrea latifolia* L. a small tree approximately 4 m in height, exhibit vigorous regrowth when browsed but have low tannin content. Others, like the tall shrub *Pistacia lentiscus* L., a strongly encroaching species, synthesize secondary compounds, especially tannins (which can reach 20% of dry matter in *P. lentiscus*; Landau et al., 2004a), which deter browsing (Decandia et al., 2000; Landau et al., 2002).

Three goat breeds – two indigenous and one recently imported – are potential candidates to combat *P. lentiscus* encroachment in Israel. The local, small-framed Mamber goat thrives on Mediterranean brushland (Aharon et al., 2007) and has developed complex feeding behaviors to regulate its dietary concentration of tannins (Kababya et al., 1998), but it ingests *P. lentiscus* in small amounts when given as the sole feed source (Silanikove et al., 1996). The large-framed Damascus goat can ingest large amounts of *P. lentiscus* (Landau et al., 2002). Little is known of the dietary preferences of the recently introduced, large-framed Boer goat in this environment (Aharon et al., 2007). The foraging behavior of these three breeds has never been compared in an area subject to *P. lentiscus* encroachment.

A methodology based on the spectral characteristics of faeces in the near infra-red region has recently been shown to reliably predict botanical and nutrient composition of the diets of goats fed Mediterranean browse (Landau et al., 2004a). This methodology has been extended to free-ranging goats by constructing calibration equations in which intake is based on species-specific bite counts and mass of simulated bites (Glasser et al., 2008). The aim of the present study was to apply this new approach to compare the foraging selectivity (botanical and nutritional) of Mamber, Damascus and Boer goats in a landscape dominated by *P. latifolia* and encroached by tannin-rich *P. lentiscus*.

2. Materials and methods

2.1. Study site and vegetation

The study was conducted at the Ramat Hanadiv nature park, which is located on the southern tip of the Carmel mountain ridge, Israel (32°33'N, 34°56'E). Average annual rainfall is 600 mm, which falls between October and April. The ecosystem is a disturbed Mediterranean woodland (garigue) featuring steep rocky slopes with patches of shallow soil. The vegetation is dominated by low trees (mainly *P. latifolia* L.) and tall shrubs (mainly *P. lentiscus* L. and *Calicotome villosa* L.) that form coppice islets

and represent 46.7, 20.9 and 16.7% of the cover, respectively, and are sometimes covered with climbing *Rubia tenuifolia* Dum.-Urville, *Clematis cirrhosa* L. and *Smilax aspera* L. Isolated Kermes (*Quercus calliprinos* Webb) and Tabor (*Q. ithaburensis* Decaisne) oak trees, as well as carob (*Ceratonia siliqua* L.) and buckthorn (*Rhamnus alaternus* L.) trees can also be found. Occasional bushes of *Ephedra foemina* Forsk., *Asparagus stipularis* Forsk. and *Sarcopoterium spinosum* L. Spach are located between the coppices.

From January to mid-May, green annual herbaceous vegetation covers the soil patches. *P. lentiscus* and *P. latifolia* are evergreen and are available for foraging all year round whereas *C. villosa* foliage appears after the first rains and is consumed between December through May. During June through November twigs of *C. villosa* are consumed by the goats in very small amounts. Herbaceous vegetation germinates in the months October–December (depending on timing and amount of the rainfall) and dries up in May–June, when it becomes of low nutritive quality. Around 500 herbaceous species are found in the Park. In a recent survey, the most common herbaceous species were *Cyclamen persicum* (36.8%), *Brachypodium distachyon* (27.3%), *Urospermum picroides* (24%), *Asphodelus ramosus* (23.9%), *Anagallis arvensis* (23.4%) and *Convolvulus pentapetaloides* (23.3%). Many other herbaceous species were found in occurrence frequencies lower than 20% (Hadar et al., 2009). In an earlier study we established that herbaceous species, *P. latifolia* and *P. lentiscus* are the major dietary components selected by goats in this foraging environment (Landau et al., 2005). The nutritional quality of the herbaceous species plummets between spring and summer, with crude protein (CP) concentration and in vitro dry matter digestibility (IVDMD); determined according to Tilley and Terry (1963) values of 11.6 and 74.8% during spring vs. 7.1 and 44% during summer, respectively. The nutritional quality of ligneous vegetation is more stable (Zohar, 2008).

2.2. Animals and grazing management

Groups of 11 Damascus, 12 Boer and 11 Mamber yearling goats were purchased in August 2004. All goats were bought from farms where goats grazed daily. The breeds were housed and grazed separately in order to prevent social facilitation among them, and were kept according to the Israel Council on Animal Care Guidelines (ICACC, 1994). During these years goats were not exposed to bucks. They were still in growth stages and were regularly weighed.

Goats were housed at night, led out in the mornings to forage, and were returned to the group pens after approximately 4 h. The animals received a daily ration of 138 g dry matter (DM) of a commercial concentrate (Ambar Feed Mills, Hadera, Israel) containing 18% CP on a DM basis. Boer, Mamber, and Damascus goats weighed (mean $\pm$ SE; kg) 21 ± 1.1 , 18.1 ± 0.7 and 31.8 ± 0.5 , respectively, in the fall of 2004, and 31.6 ± 1.7 , 26.7 ± 0.5 and 36.4 ± 0.7 , respectively, in the spring of 2005. Over the course of the fall 2004 and spring 2005 seasons, foraging was rotated among seven 0.1-ha paddocks, according to vegetation availability, so as to expose each breed to each paddock.

2.3. Collection of faecal samples

Botanical composition and quality of the diets selected by goats were determined by analysis of faecal samples in two contrasting seasons of the year: fall and spring. The fall observation period extended from 2 to 19 November 2004, during which the Boer, Mamber and Damascus groups were sampled 2, 2 and 3 times, respectively. The spring observation period extended from 15 March to 11 May 2005, during which the Boer, Mamber and Damascus groups were sampled 3, 2 and 2 times, respectively. At each sampling, faecal samples were grab-collected individually from all the animals of each group.

2.4. Application of FNIRS

The botanical composition and nutritional quality of forage selected by goats were determined by faecal near-infrared reflectance spectroscopy (FNIRS). The faecal samples were dried, ground and packed into a sample cell with a NIR-transparent quartz cover-glass. Reflected energy represented as $\log(1/R)$ in the range 1104–2492 nm was collected in 2-nm increments, with a Foss NIRSystems 5000 NIR reflectance monochromator spectrometer (Foss Tecator, Hoganas, Sweden). Raw spectral data was transformed with the standard normal variance (SNV) and de-trend procedures to remove the non-linearity that results from light scattering (Barnes et al., 1989).

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