

## The Role of Black Oak Woodlands (*Quercus pyrenaica* Willd.) in Small Ruminant Production in Northeast Portugal

*Marina Castro, José Castro and Antonio Gómez Sal*

### Abstract

The use of black oak woodlands (*Quercus pyrenaica* Willd.) by small ruminant flocks was investigated in northeastern Portugal. In their daily grazing itineraries, the animals crossed a large and heterogeneous set of vegetation patches, returning to their corrals every night. Two goat flocks and two sheep flocks led by shepherds were surveyed monthly from May 1999 to May 2000. A hand rover Global Position System (GPS), recording time, geographical position and land cover, monitored shepherding paths every two minutes. The utilization of black oak woodlands was analyzed by three different approaches:

- 1) time spent by the flocks at black oak woodlands in relation to total time of itineraries,
- 2) relation of time spent at black oak woodlands and time spent crossing them, and
- 3) the contribution of black oak to flock diets.

GPS data revealed changes in black oak woodlands utilization among seasons and/or kind of flocks. Diet estimation indicated also differences in the intensity and sort of black oak woodlands consumption related to kind of animal and season over the course of the year.

**Keywords:** Black oak, range management, goats, sheep, Portugal

### Introduction

Small ruminant production is a very extensive activity in northeastern Portugal, mainly based on exploitation of spontaneous resources. Driven by shepherds, goat and sheep flocks use several daily itineraries, crossing over a highly diversified landscape. Among the main land uses, black oak woodlands (*Quercus pyrenaica* Willd.) have a special role due to their natural value, the large area they occupy, and their use for animal production (feed, rest, shelter, etc.).

For a long time, oak woodlands held a prominent place within the traditional economy of Mediterranean regions by providing firewood, charcoal, fuel for

glass making, by-products such as tannin and by offering a grazing area for livestock (Debussche et al., 2001). Black oak is one of the most abundant and characteristic oak species in the Iberian Peninsula (Calvo et al., 2003). In Portugal, the main areas covered by this species are found in the Bragança region (Franco, 1956), where they cover about 40% of the total rangeland area.

Black oak woodlands significantly improve local economic and social values when crossed by small ruminants' itineraries. As animals play an important role in soil fertilisation (Gómez Sal, 2000a) and shrub encroachment control (Delabrazze, 1987; Etienne et al., 1994; Etienne et al., 1991; Guitton et al., 1994; Hubert, 1991; Léouffre, 1991), however, these forests provide forage and welfare to small ruminant production systems (Castro et al., 2000a; Castro et al., 2003; Castro et al., 2000b). The black oak silvopastoral system produces firewood and high quality meat, while keeping a diverse landscape and an increased biodiversity. It is seen as a strategic ecosystem for nature conservation as it maintains resources in a sustainable and productive way (Gómez Sal, 2000b).

The present study concerns the role of black oak woodlands in the small ruminant production systems, analyzing their importance in daily flock itineraries as well as investigating their dietary significance as a forage resource for animals.

## Material and methods

The present study is part of a research project that deals with vegetation-herbivore interaction of black oak silvopastoral systems. Fieldwork was conducted over the territory of four villages located near Bragança, northeast Portugal (41°46'N latitude and 6°45'W longitude) at 700 to 1000 meters above sea level. The climate is humid Mediterranean with yearly mean temperatures of 11.6°C and precipitation of 972.1 mm, which occurs mainly from October until May (INMG, 1991). The dominant soils are umbric Leptosols and dystic Leptosols, depending on land use.

Black oak woodlands crossed by daily itineraries of sheep or goat flocks vary widely throughout the village territory. They can occur in small woods over agricultural fields (less than one hectare) or in large stands on rangeland areas (several hundreds of hectares), composing a traditional land mosaic (scrublands, meadows, arable lands, perennial crops) used differently depending on the kind of flock and season of the year. Trees density varies from 400 to 1800 per ha, of 9 to 17 meters in height and 18 to 30 cm tree diameter at a height of 1.3 meters.

The flocks of local breeds ("Serrana" goat and "Churra" sheep) have a variable size (100 to 200 individual each) and they are raised for meat production. Two goat and two sheep flocks were selected and followed monthly with a hand rover GPS (Global Position System), accompanying their shepherd. Data from May 1999 to May 2000 consists of time, geographical position and land cover of 52 flocks' itineraries (13 by flock) that cross black oak woodlands. The whole shepherding journey varies between 6 and 16 hours as a function of season and animal.

Each monthly itinerary represents a sample that was used to calculate the time and space of the flock at black oak woodlands. Samples were analyzed by

computing percentages of “staying time” and “crossing length” used by flocks. This information was grouped by season and type of animal (sheep or goats); winter time was considered when animals do not rest at midday (“siesta”), normally from October until April; summer time was considered the remaining months, May to September. The percentages of “staying time” determined for each itinerary were compared by two-factor analysis of variance (kind of animal and season).

Relating time and length of shepherding activity assessed the functionality of black oak rangelands. Black oak crossing length and the time spent in it were related by three mathematic functions in order to achieve functional indicators of animal activities (grazing or browsing, resting and walking):

- $F1 = \text{crossing length} / \text{spent time (m.s}^{-1}\text{)}$ ;
- $F2 = \text{spent time (\%)} - \text{crossing length (\%)} \text{ (non-dimensional)}$ ;
- $F3 = [\text{spent time (\%)} - \text{crossing length (\%)}] / [\text{spent time (\%)} + \text{crossing length (\%)}] \text{ (non-dimensional)}$ .

These functions clarify the flock behaviour (walking, grazing/browsing or resting) based on their movement rate. F1 represents the flock speed crossing the black oak woodlands. During the shepherding journey, animal speed ranges from  $0.00 \text{ m.s}^{-1}$  when resting,  $0.14 \text{ m.s}^{-1}$  when grazing in meadows, up to over  $0.69 \text{ m.s}^{-1}$  when path walking (Castro, 2004); the flock speed is an average of the entire set of animals in different activities. When the flock stops, it could indicate either grazing or midday rest. The F2 function is the difference between the proportion of time spent by the flock in black oak woodlands in the total time of shepherding, and the proportion of the flock crossing length at black oak woodlands in the total length of shepherding. This function indicates the divergence of flock speed at black oak woodlands in relation to the average flock speed during the entire shepherding journey. Positive values represent a general trend of flock to grazing and/or resting, and negative values represent a general trend of flock to walking. F3 is the quotient of F2 by the sum of flock time spent and crossing length proportions at black oak woodlands in relation to the total time of shepherding. This function differentiates the importance of F2 information in relation to the participation of black oak stands in the grazing itineraries.

The black oak contribution for diets was computed for each sampled itinerary. The daily diet composition was assessed by data on feeding behavior and diet selection. The animals' activity - grazing, browsing, resting and trekking - and the grazed species were noted every 15 minutes by direct observation (instantly recorded). Ten animals in each flock were randomly chosen according to their geographic quadrant distribution (N, NE, E, SE, S, SW, W, NW) in a scan-sampling scheme (Altmann, 1974). The amount of browsed black oak was compared with the total number of feed species. This diet information allowed us to distinguish grazing activity from midday rest, when the functions values indicated journey break.

With ANOVA analysis we tested the effect of the kind of flock (sheep or goats) and itinerary season (winter or summer) over black oak woodlands utilization, which was derived from the time and length reports and diet contribution.

Logarithmic transformations and the *Bonferroni* test were used to detect any significant differences ( $P < 0.05$ ).

## Results and discussion

The staying time of the studied flocks at the black oak woodlands differs in terms of season and kind of animal (Table 1). Its percentage in itinerary total time was higher in summer than in winter, with 25.86% and 5.20%, respectively. Significant differences were also found between sheep and goat flocks; higher in the former than in the last.

The results show that black oak woodlands are mainly used during summer, apparently due to leaves (May to October) or fruit (September to October) availability. During the summer hot days, shelter is another important function of these woodlands.

Table 1: Staying time by season ( $P < 0.01$ ) for sheep or goat ( $P < 0.001$ ) flocks at black oak woodlands. Number of observations in brackets.

	Summer (24) (%)	Winter (28) (%)
Sheep (26)	20.21	0.83
Goats (26)	31.51	9.57

Table 2: F1, F2, F3 indicator functions of black oak woodlands by season and animal. Number of observations in brackets.

	Winter	Summer		Goats	Sheep
F1 ( $m.s^{-1}$ ) ( $P < 0.05$ )	0.311 (18)	0.248 (17)	F3 ( $P < 0.001$ )	0.230 (21)	- 0.154 (14)
F2 ( $P < 0.001$ )	1.353 (18)	15.685 (17)			

### Staying time vs. crossing length as a functional indicator

The importance of black oak woodlands to small ruminants itineraries was studied by three mathematic functions described previously, F1, F2 and F3 (Table 2). F1 varied from  $0.311 m.s^{-1}$  (winter) to  $0.248 m.s^{-1}$  (summer). F2 varied from 1.353 (winter) to 15.685 (summer). Positive values of F2 in winter itineraries can be interpreted as a moving indicator, since it was very low. These results (F1 and F2) suggested trekking in winter and resting in summer. F3 differs in sheep and goats flocks: positive F3 for the goat flocks (0.230) indicates resting or grazing, while negative F3 values for the sheep flocks (-0.154) indicates trekking.

Results reveal the general tendency of flocks to use black oak woodlands in winter for trekking, and as resting sites in summer. In addition, the flocks use

these sites with different objectives. More information is required to precisely determine flock requirements from these woodlands. Browsing and the midday resting activities cannot be distinguished with the functions used because they detect only a staying stage.

Across their daily itinerary, the flocks can use woodlands for different purposes. Meuret (1995) reported the following: "overt appetite", "moderation", "first course", "glance", "second course" and "dessert". In the present case, these surfaces could have other functions than browsing and grazing, such as resting, sheltering, etc. The results confirm those found by Castro and Castro (2003) with different methodologies; in this case, using the "ecological profile indices" by Gauthier et al. (1977), woodlands represent reposing sites for goat and sheep, but also forage sites for goats.

### **Contribution of black oak to diets**

The black oak proportion in animal diets is quite interesting, since it is related with the repose or the feeding character of the rest activity ("siesta"). Black oak as forage is consumed by sheep, 0.5% in the winter and 2.5% in summer (Table 3), but this consummation is quite small, and is associated with flock trekking. This suggests that the long stay in black oak woodlands is associated with repose activity. In winter, sheep flock trekking in these woodlands is not meaningful (less than 1%). In contrast, black oak as forage is a basic resource of goat diet, representing 22.5 % of their summer diet it means that about a quarter of their summer diet consists of black oak (Table 3 and Fig. 1).

The results agree with those reported by authors that pointed out the different foraging styles and prehensile capabilities between sheep and goats (Bartolomé et al., 1998; Cuartas and García-González, 1992; Léouffre et al., 1989). Diet selection is likely to differ among them (Gordon and Iason, 1989; Gordon and Illius, 1988; Pfister et al., 1988). For example, Meuret (1994) pointed out that the goat diet in the Provence region of France could consist of 75% woody plants (shrubs and trees) during some periods of the year. On the other hand, the shepherds recognize these different habits and use them accordingly to manage their production systems (Baumont et al., 2000; Meuret, 1995, 1996).

The use of tree leaves to feed domestic animals is a very old tradition (Bourbouze and Donadieu, 1987; Ramana et al., 2000) and is very common within Mediterranean Europe (Papachristou and Nastis, 1996; Papachristou et al., 1999; Papanastasis and Nefzaoui, 2000; Sigaut, 1987). Nevertheless, in developed countries, modern agronomy tends to avoid the use of woody plants in sheep and goat diets. Despite this they are still very important in animal nutrition in extreme and unstable climatic regions (Ben Salem et al., 1994; Koukoura and Nastis, 1994; Stringi et al., 1994). Most recently, woody plants have been cultivated as animal forage in some Mediterranean countries (Papanastasis and Nefzaoui, 2000) and other regions of the world (Apori et al., 1998).

Table 3: Seasonal variation ( $P < 0.001$ ) of black oak consumed by sheep and goats ( $P < 0.001$ ). Number of observations in brackets.

	Summer (24) (%)	Winter (28) (%)
Sheep (26)	2.50	0.50
Goats (26)	22.50	4.10

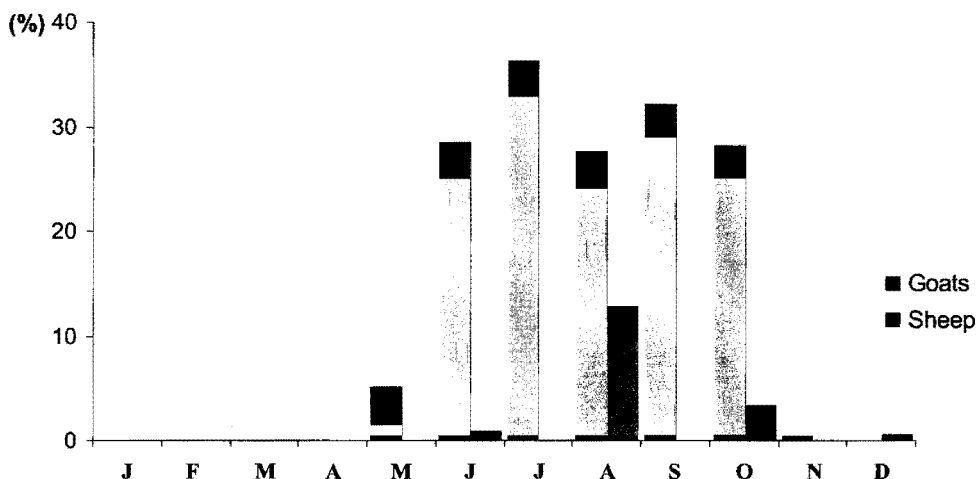


Fig. 1: Monthly variation of black oak consumed by goats and sheep.

## Conclusions

Black oak woodlands are used by small ruminants for different purposes (feeding, transit and resting), depending on animal species and season. Particularly in the summer, these woodlands are strongly used; resting time represents about 20 and 30% for sheep and goat flocks itinerary durations, respectively. During summer, sheep flocks cross black oak woodlands mainly in search of shelter to rest at midday; this oak species constitutes only about 2.5% of the sheep diet. In contrast, the use of black oak woodlands by goat flocks is longer. Their diet incorporates about 25% of this oak species. The winter use of black oak woodlands by sheep flocks is quite insignificant, less than 1%; these woodlands represent about 10% of goat flock itineraries duration.

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Addresses of authors:

**Marina Castro**

**José Castro**

Escola Superior Agrária de Bragança

Apartado 1172

5301-855 Bragança, Portugal

[mzecast@ipb.pt](mailto:mzecast@ipb.pt)

**Antonio Gómez Sal**

Universidad de Alcalá

Campus Universitario

Ctra. Madrid-Barcelona km. 33.600

28871 Alcalá de Henares (Madrid), España

[antonio.gomez@uah.es](mailto:antonio.gomez@uah.es)

Susanne Schnabel and Alfredo Ferreira (Editors)