Short communication
Grazing alone is not enough to maintain landscape diversity in the Montseny Biosphere Reserve

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Abstract

Conservative land-use over the past few decades has converted the Montseny Biosphere Reserve (Spain) from the original open, patchy landscape to almost continuous woodland. Small ruminant grazing is virtually the only major remaining utilisation activity yet little is known about its role in the changing vegetation of the Reserve. This study was undertaken to determine the effects of current grazing practice on its main vegetation components. Three flocks, composed of sheep and goats, that graze yearlong on three separate ranges in the Reserve were selected for study. The ranges represent the wooded slopes and the shrubby upland (altiplano) in the area. Biomass consumption by the flocks was estimated by calculation of normative requirements for observed production and the botanical composition of the livestock diets over a whole annual cycle was determined by micro-histological analysis of the faeces. Production of herbaceous vegetation was determined by clipping sample quadrats, the production of the woody vegetation was derived from previous work in the Reserve. It was found that grazing removed a very small proportion of the dominant Holm oak (Quercus ilex) on the slopes, and a moderate fraction of the shrubby and herbaceous vegetation on the altiplano. Only the heath tree (Erica arborea), an edible shrub in the woodlands, was relatively heavily grazed. It is concluded that grazing alone is not enough to maintain the open, diverse landscape with its many natural values. As in other northern Mediterranean countries, under-utilisation of these woodlands is becoming a serious problem that is also increasing the fire hazard. Maintaining landscape diversity in the region is a complex challenge that land managers should recognise. ©2000 Elsevier Science B.V. All rights reserved.

Keywords: Quercus ilex; Erica arborea; Calluna vulgaris; Small ruminants; Mediterranean rangeland

1. Introduction

Most landscapes in the Mediterranean Basin are the product of human activities including forest clearing, cropping, wood-cutting, grazing and fire (Naveh and Dan, 1973). Over the years, these traditional practices have created a high degree of both landscape and biological heterogeneity, much of it of great natural interest. In recent years, many traditional practices have diminished and some have ceased completely. Certain areas, like the Montseny mountain in Spain that was heavily exploited for wood and charcoal until the
1950’s (Folch, 1986), have become protected conservation areas, resulting in large changes in the landscape and greater homogenisation. The environmental consequences of these changes are not all favourable in terms of diversity and fire hazard.

In the past, many small flocks composed mainly of sheep and goats, grazed on Montseny. Today, there are fewer but larger flocks and the total number of animals is about the same (Llobet, 1947; Bartolomé, 1995), approximately 13,000 head of small livestock, about 0.4 small ruminants per hectare. These are still managed more or less in the traditional manner.

Grazing can be a major factor in determining the nature of vegetation change and a tool for land management. Grazing can control shrub encroachment (Sharrock, 1989) and increase grass cover and forage production (Fierro et al., 1984). Livestock operators are encouraged to herd their animals in British woodlands to promote greater landscape and biological diversity (Mitchell and Kirby, 1990). Heavy grazing by domestic ruminants has apparently converted grasslands to shrublands (Milchunas and Lauenroth, 1993; Archer, 1996).

The present study was conducted to determine the effect of traditional sheep and goat grazing on the main vegetation components of a Holm oak woodland, typical of large areas in the north-western Mediterranean region. The study has special relevance to woodland management because even though the Montseny Biosphere Reserve has been the subject of much ecological research during the past (Ferrés et al., 1984; Rodà et al., 1990) the role of grazing on the vegetation dynamics has not received adequate attention. With the rapidly changing land-use in most Mediterranean countries, such information is essential for rational planning of future management.

2. Materials and methods

2.1. Study area

The study was conducted on the ‘la Calma’ upland (altiplano) and its associated slopes in the Montseny Biosphere Reserve and Nature Park in Catalunya, Spain (Fig. 1). The altitude ranges between 700 and 1300 m a.s.l. The climate is humid Mediterranean with average rainfall varying between 800 and 1000 mm. Three farms in this area (Boscàs, Cortada, and Molar) were selected for the study, each with its own separate rangeland unit characterised by varying proportions of grassland, heath and woodland. Each farm had a flock composed of sheep and goats (Table 1) that grazed their own rangeland units throughout the year.

The livestock were commercial cross-bred small ruminants, mainly Ripollesa sheep and Murciana goats. They were always herded by a shepherd and were returned to home corrals every evening except during the summer months (July to mid-October) when they were corralled on the altiplano. As a rule, the flocks were taken through the woodlands up to the altiplano in the morning and down again in the afternoon. During the winter months they would be allowed to graze sown pastures for up to 1 h (Bartolomé and Franch, 1992).

Fig. 1. Montseny Biosphere Reserve location in SW Europe.

2.2. Vegetation types and production

The slopes are covered by woodland and the altiplano by heath and grassland. The dominant species are Quercus ilex in the woodland, Agrostis capillaris and Festuca spp. in the grassland, Calluna vulgaris in the heathland, and Erica arborea in the ecotone between the woodland and altiplano and interspersed in the woodland. The area of each habitat was determined from aerial photos corrected for angular distortion.

Biomass production of the herbaceous vegetation was measured in fenced exclosures by harvesting the herbage at the end of the spring and autumn growth
<table>
<thead>
<tr>
<th>Animal numbers</th>
<th>Range</th>
<th>Boscás</th>
<th>Cortada</th>
<th>Molar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep</td>
<td>head</td>
<td>160</td>
<td>200</td>
<td>160</td>
</tr>
<tr>
<td>Goats</td>
<td></td>
<td>50</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Total small ruminants (SR)</td>
<td></td>
<td>210</td>
<td>270</td>
<td>260</td>
</tr>
<tr>
<td>Overall stocking ratea (SR per hectare)</td>
<td></td>
<td>0.86</td>
<td>0.47</td>
<td>0.40</td>
</tr>
<tr>
<td>Habitat</td>
<td>Main species</td>
<td>hectare</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holm oak woodland</td>
<td>Q. ilex, E. arborea</td>
<td>144</td>
<td>468</td>
<td>465</td>
</tr>
<tr>
<td>Heathland</td>
<td>C. vulgaris, herbaceous spp.</td>
<td>52</td>
<td>34</td>
<td>109</td>
</tr>
<tr>
<td>Woodland-heath ecotone</td>
<td>E. arborea, herbaceous spp.</td>
<td>3</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Grassland</td>
<td>Herbaceous spp.</td>
<td>11</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Sown pasture</td>
<td>Grasses, legumes</td>
<td>3</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Other habitats</td>
<td>F. sylvatica</td>
<td>32</td>
<td>18.5</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>245</td>
<td>570</td>
<td>643</td>
</tr>
</tbody>
</table>

a Stocking rate (small ruminants per hectare).

Phases (Bartolomé et al., 1998). Cover of *E. arborea* was measured by the line-interception method (Eberhardt, 1978; Hanley, 1978). For estimates of biomass production of *Q. ilex* leaves, *C. vulgaris* and *E. arborea*, data was used from previous studies in the area. The average annual biomass production values, *B*, for these three dominant woody species were: *Q. ilex* (leaves) $1.5 \pm 0.29 \text{ Mg ha}^{-1}$ (Mayor, 1990) *C. vulgaris* $2.6 \pm 0.72 \text{ Mg ha}^{-1}$ (Ferrinet, 1988) *E. arborea* $1.9 \pm 0.23 \text{ Mg ha}^{-1}$ (Riba, 1991)

Dry matter requirements of the grazing animals Annual DM requirements (*Q*) of the flocks of sheep and goats was estimated by assuming normative requirements for maintenance, pregnancy, and weaning of a lamb or kid (Van Soest, 1982):

\[
Q = (NM_aC_a)
\]  

where *N* is the number of animals in the flock, *M*a (*W*a = 0.75) the metabolic weight of a ruminant (kilogram), *W*a the average liveweight of a mature sheep or goat (kilogram), *C*a the annual DM requirement per unit of metabolic weight (kg DM kg\(^{-1}\)).

The average weight of the sheep and goats was determined by weighing a number of animals in each flock periodically during the 3 years of the experiment. Representative weights for sheep and goats were 60 and 45 kg, respectively. Daily sheep feed intake varies between 50–100 g DM Ma\(^{-1}\) (Van Soest, 1982).

A value of 100 g Ma\(^{-1}\) per day was assumed because of the extra energy expense involved in grazing the heavy slopes on the range and walking large distances each day. Annual normative requirement of forage and browse dry matter, *C*a, was therefore 36.5 kg Ma\(^{-1}\) per year or 787 kg per year dry matter intake for sheep and 634 kg for goats.

2.3. Forage sources and estimation of species utilisation

Supplementary pastures were sown to either *Lolium multiflorum*, *Vicia sativa*, *Hordeum distichum*, or *Secale cereale*. Herbage production of supplementary pastures was estimated by harvesting 1 m\(^2\) quadrats in six representative fields just before they were ready for grazing in winter. Total annual feed intake (*R*) from the rangeland was estimated as:

\[
R = Q - (S_pB_p)
\]

where *S*p is area of sown pastures (hectare), *B*p annual DM production of sown pasture (kg ha\(^{-1}\) per year).

Diet composition was estimated by determining the species composition of the epidermal fragments in the faeces (Bartolomé et al., 1998). The amount of biomass of the respective vegetation types consumed by the livestock was estimated as the fraction of each type in their diets and the annual dry matter requirement of the respective livestock species.
The degree of utilisation \( U_i \) of each species or group of species was estimated as:

\[
U_i = \frac{Rd_i}{S_iB_i}
\]

where \( d_i \) is the proportion of component \( i \) in the flock diet, \( S_i \) the area covered by component \( i \) in each range (hectare), \( B_i \) the annual biomass. DM production of component \( i \) (kg ha\(^{-1}\) per year). Values for \( B_i \) were derived as described above.

### 3. Results and discussion

#### 3.1. Herd size, range characteristics and feed balance

The herd size on each of the three ranges was similar, but the proportion of goats was higher on Molar range than on the other two (Table 1). Stocking rate varied between 0.40 small ruminants per hectare on the Molar range and 0.86 on the Boscás range. This compares with 0.37 sheep per hectare on blanket bog heathland in the UK where it is considered a light stocking rate (Rawes and Hobbs, 1979).

Sheep accounted for 67% of the feed consumption in the Molar flock and 78–80% in the other two. The rangeland provided 87% of the feed requirement of the Boscás flock and 95–97% in the other flocks (Table 2). The difference was made up by a larger area of sown pastures on the Boscás farm (Table 1).

#### 3.2. Production of the herbaceous component and the sown pastures

The total annual production of herbaceous forage (Bh) on the upland (Table 3) was of the same order of magnitude as the production of the shrubs (1.9 and 2.6 Mg ha\(^{-1}\)) and the oak leaves (1.5 Mg ha\(^{-1}\)). Total production from the two phases of grazing on the sown pastures was much greater (6.5 Mg ha\(^{-1}\)) per year), so that even though their area was small, their contribution to the feed balance was considerable.

#### 3.3. Composition of the forage consumed by the animals

The sheep diets contained a much higher proportion of herbaceous forage and a much lower proportion of *Q. ilex* than did the goat diets (Table 4). *E. arborea* was favoured by the goats and *C. vulgaris* by the sheep. The item ‘Others’ includes about 15 species, most of which contributed less than 1% to the diet.

*C. vulgaris* was a relatively constant proportion of the goat diets, even in the Boscás range where the area of Calluna was much smaller than in the other ranges. *E. arborea* in the goat diets was inversely proportional to its availability on the different ranges (Table 1); it was a relatively constant component of the sheep diets, despite differences in availability among ranges.

#### 3.4. Effect of grazing on the vegetation

Because of their higher numbers and higher annual feed requirement, sheep consumed more of all vegetation components (except *Q. ilex*) than the goats (Table 5). The total consumption by each of the three flocks was fairly similar, with differences smaller than the differences in total animal numbers because of differences in flock composition (Table 1).

The proportion of vegetation grazed was highly variable between species (Table 5). Over the years, increasing density of the oak canopy has reduced the cover of shrubs inside the forest. This has led to higher grazing pressure on *E. arborea*, the dominant palatable shrub in the oak woodland especially on the Boscás range where 84% of the annual above-ground biomass production was utilised. On the other hand, only about 2–3% of the estimated annual leaf pro-
Table 3
Average annual forage dry matter production of the herbaceous vegetation components in uplands of the Montseny Biosphere Reserve

<table>
<thead>
<tr>
<th>Component</th>
<th>Average production (g m(^{-2}) per year) (Mean ± SE)</th>
<th>Total production (Mega gram per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boscàs</td>
</tr>
<tr>
<td>Grassland</td>
<td>174 ± 9.0</td>
<td>19.4</td>
</tr>
<tr>
<td>Heathland</td>
<td>170 ± 46.3</td>
<td>91.9</td>
</tr>
<tr>
<td>Total</td>
<td>111.3</td>
<td>147.1</td>
</tr>
<tr>
<td>Sown pastures</td>
<td>650 ± 22.0</td>
<td>19.5</td>
</tr>
</tbody>
</table>

Production of *Q. ilex* was grazed. Virtually unrestricted growth has put most of its canopy beyond the reach of the animals. The leaves below 1.6 m are utilised much more intensively but constitute a small part of the total production. In contrast, utilisation of *Q. ilex* in the Cazorla mountains (also a protected area in the Iberian Peninsula) was much greater (Cuartas and Garcia-Gonzalez, 1992). There, *Q. ilex* cover is much lower than on Montseny, stocking rates of domestic livestock are higher, and there is also considerable grazing pressure by the local fauna.

Grant et al. (1976) considered 0.55 sheep per hectare on blanket bog heathland to be a heavy stocking rate. Yet, despite heavier stocking rates on the la Calma heath (2.22 small ruminants per hectare), ingestion of Calluna was only 16–29% of biomass production compared with 28–49% reduction in green-shoot biomass obtained by Grant et al. (1985). The small effect of the heavy stocking rate on Calluna can be explained by the availability of alternative forage from woodland and sown pastures and by possibly higher productivity of Calluna in the more

Table 5
Annual production and consumption (\(C_i\)) of vegetation components (dry matter)

<table>
<thead>
<tr>
<th>Rangeland</th>
<th>Production (Mega gram)</th>
<th>Consumption (Mega gram)</th>
<th>Proportion consumed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sheep</td>
<td>Goats</td>
</tr>
<tr>
<td>Boscàs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. vulgaris</em></td>
<td>91</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td><em>E. arborea</em></td>
<td>20</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td><em>Q. ilex</em></td>
<td>216</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>111</td>
<td>49</td>
<td>4</td>
</tr>
<tr>
<td>Cortada</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. vulgaris</em></td>
<td>166</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td><em>E. arborea</em></td>
<td>70</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td><em>Q. ilex</em></td>
<td>702</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>147</td>
<td>57</td>
<td>3</td>
</tr>
<tr>
<td>Molar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. vulgaris</em></td>
<td>172</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td><em>E. arborea</em></td>
<td>149</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td><em>Q. ilex</em></td>
<td>698</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>283</td>
<td>54</td>
<td>7</td>
</tr>
</tbody>
</table>
temperate Mediterranean environment. The effect of grazing on Calluna was probably negligible because it regrows vigorously even at much higher utilisation rates (Armstrong et al., 1997).

Herbaceous dry biomass production varied between 111 and 283 g m⁻², of which 22 and 48% was consumed by the domestic flocks, similar to the values obtained in UK by Job and Taylor (1978) and Armstrong et al. (1997). The herbaceous species were grazed mainly in the spring (Bartolomé et al., 1998) and as their biomass declined, the proportion of Calluna in the diet increased (Milne, 1994).

According to criteria proposed by Milchunas and Lauenroth (1993), the estimated consumption in the Montseny area varied from light to very heavy for E. arborea, light to moderate for C. vulgaris and the herbaceous component, and light for Q. ilex.

4. Conclusion

There has been a gradual closure of the landscape in the Montseny Reserve and Nature Park by woodland on the slopes and by shrubs on the heath. The accumulation of combustible dry organic matter also presents an increasingly serious fire hazard. The Reserve was created to preserve a diverse and partly open landscape that had developed as a result of human activities. In order to achieve this goal, more intensive pastoral activities and forestry interventions will have to be given greater attention so as to maintain grazing pressures and biomass utilisation at considerably higher levels than at present (Begon et al., 1998). This is an issue that must be faced by the management of the Reserve if it is to achieve the goals that led to its establishment. With the rapidly changing land-use in the region this situation has become common on many woodlands in the northern Mediterranean countries. It calls for an appropriate response, not only in declared conservation areas.

References


