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Livestock farming systems and conservation of Spanish Mediterranean mountain areas: The case of the “Sierra de Guara Natural Park”. 2. Effects of grazing on vegetation

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RESUME *– "Systèmes d'élevage et préservation des zones de montagne méditerranéennes. Cas du Parc Naturel de Sierra de Guara (Espagne). 2. Effets du pâturage sur la végétation". On a étudie l'évolution de la végétation herbacée et arbustive dans six parcours utilisés par des troupeaux de vaches et brebis dans le Parc Naturel de Sierra de Guara. On a fait une caractérisation préliminaire de la végétation arbustive dans la première année de l'étude, qui a montré une grande diversité même intra parcellaire dans quelques localisations. On a comparé cette évolution dans des zones pâturées et parcelles clôturés (non-pâturées) a coté des autres. Pendant une seule saison de pâturage, la quantité d'herbe des zones pâturés s'est réduite et la relation entre les fractions verte et morte s'est maintenue, tandis que dans les zones non-pâturées il y a eu une accumulation d'herbe avec une plus grande proportion de matériel morte, ce qui s'accompagnerait d'un moindre valeur nutritive pour le bétail et un risque de dégradation de l'environnement.*

Mots-clés : *Pâturage, végétation herbacée, végétation arbustive.*

Introduction

Preserving landscape diversity is a major goal in European countries, specifically in those areas which have been protected due to their high ecological value. Many Protected Natural Areas are based on ecosystems which are the result of the interaction of man, domestic animals and environment throughout centuries. Recent changes in rural activities, animal densities and management are endangering the fragile equilibrium which has taken so long to reach.

In the particular case of Sierra de Guara Natural Park (SGNP), located in a typical Mediterranean mountain area (430-2077 m, 850 mm annual rainfall with summer drought) the sharp decrease in livestock number in the last fifty years has led to very reduced use or even abandonment of most of the area of the park. The traditional mosaic landscape is quickly following its natural succession towards the climatic forest, which in preliminary stages is characterised by abundant bush proliferation. In fact, the surface of SGNP is dominated by shrubland (40%), while the rest of the grazed land are forest clearings (30%) or grazed forests (20%), all of them highly susceptible of fire hazard.

Several studies have been conducted in Spain to evaluate the impact of livestock grazing on vegetation dynamics in different Protected Natural Areas, however none had yet been developed in this Park. The preliminary results of a research carried out for three years (2001-2003) will be given in this paper.

Material and methods

Six beef cattle herds and sheep flocks grazing on rangeland were studied. The grazed lands are representative of the farming systems present at SGNP and the vegetation was grazed mainly in spring, summer and autumn, and were characterised by a high density of bushes of different species. The characteristics of the farms and pasture sites are shown in Table 1.

Twelve experimental plots (2 per farm) were located in areas reported to be frequently grazed by livestock. In each of them, a representative area of 10x10 m was fenced in early spring 2001 in order to prevent them from animal grazing thereafter. Different measurements of herbaceous and bushy vegetation were recorded outside (Grazed area) and inside the plots (Not Grazed area) in 2001, and will be repeated on a yearly basis.

Table 1. Characterisation of animals and pasture sites in the six farms involved in the study

Farm n.	Livestock number	Pasture size (ha)	Altitude of experimental Plots (m)
1	600 sheep	600	1062
2	1150 sheep	3000	1043
3	700 sheep	140	845
4	700 sheep	280	715
5	80 cows	800	1220
6	300 cows	227	1418

Herbage, bush and tree cover were estimated visually inside and outside the fenced areas at the start of the study. Botanical composition was analysed in each plot. Sward height was measured with a HFRO sward-stick on 60 points at random in the paddocks, both in spring and autumn. The relationship between herbage height and biomass was estimated in three 0.25 m^2 quadrates randomly located in each of the twelve plots. This was done by measuring herbage height with the sward-stick, and by harvesting the biomass with an electric mower at 2 cm above ground level inside the quadrates. A general equation was derived for all plots. Green and dead herbage fractions were separated in samples taken in the spring and in the autumn. Both fractions oven-dried at 60 C^o and stored for further analyses.

For the study of woody vegetation, a fixed transect of 10 x 1 m was delimitated with four iron sticks inside and outside the fenced areas. All bush individuals in the transect were identified to calculate species contribution, and numbered for tracking their individual changes in the following years. Bush biomass has frequently been related to its volume, and thus height, length and width were measured in order to calculate bush volume, assuming an elliptic-based cylindrical shape (volume = (π/4) x height x length x width), which was later related to bush biomass using the equations obtained by Torrano (2001). Only preliminary results describing the shrub vegetation at the start of the study will be presented in this paper, because shrub measures are only taken once per year in the spring.

Data were analysed using SAS Statistical Package. The relationships between variables were measured with Pearson correlation coefficient. Predictive models were obtained by linear regression (step-wise method). Analyses of variance were performed by using a General Linear Models procedure, considering Grazing (Grazed vs. Non-Grazed Areas) as a fixed effect.

Results and discussion

Except for two plots in which bushes had been mechanically removed by the farmers in the previous year, all the studied areas showed an important shrub cover (32% on average).

The flora and phytosociological communities most representative of the park had been widely described by Montserrat (1986), revealing a great contrast between the Northern and Southern versants. Botanical inventories conducted in the experimental plots revealed a high species diversity; 85 herbaceous and 25 shrub species were identified.

Herbaceous vegetation

Herbage cover did not differ between the Grazed and Not-Grazed areas at the start of the study (71.3 vs. 62.5%, respectively), proving that the fenced areas were representative of the site.

Herbage height was highly related to available herbage biomass (r = 0.86), and therefore the predictive equation derived was accurate enough to allow for estimating the biomass by only measuring sward height:

Biomass (kg DM/ha) = 86.59 $_{(s.e.\ 10.30)}$ x height (cm) + 531.12 $_{(s.e.\ 137.20)}$ $\quad R^2 = 0.75$

The evolution of herbage height and biomass from early spring to late autumn 2001 is presented in

table 2. No differences were observed in the spring in terms of sward height or biomass between the Grazed and Non-Grazed areas, confirming the homogeneity of the areas selected for comparison at the start of the study. However, there were clear differences already in the autumn, after one single grazing season. Sward height and biomass had decreased in Grazed areas (-2.28 cm and –260 kg DM/ha, respectively), as a result of herbage removal by herbivores, and it had increased in Non-Grazed areas (4.24 cm and 231 kg DM/ha, respectively) due to herbage natural growth.

Table 2. Changes in sward height and biomass during the 2001 grazing season

	Non-Grazed Areas	Grazed Areas	*s.e.d.*	Significance
Sward height (cm), spring	10.93	9.14	*4.65*	NS
Sward height (cm), autumn	16.60	8.08	*3.32*	*
Biomass (kg DM/ha), spring	1208	999	*445.7*	NS
Biomass (kg DM/ha), autumn	1583	884	*341.7*	*

The separation of the available herbage mass in its green and dead fractions revealed a similar tendency (Fig. 1). In the Grazed areas the ratio green:dead material did not differ between samples taken in the spring and autumn, whereas in Non-Grazed areas the green fraction was significantly reduced at the end of the autumn, as the dead fraction increased.

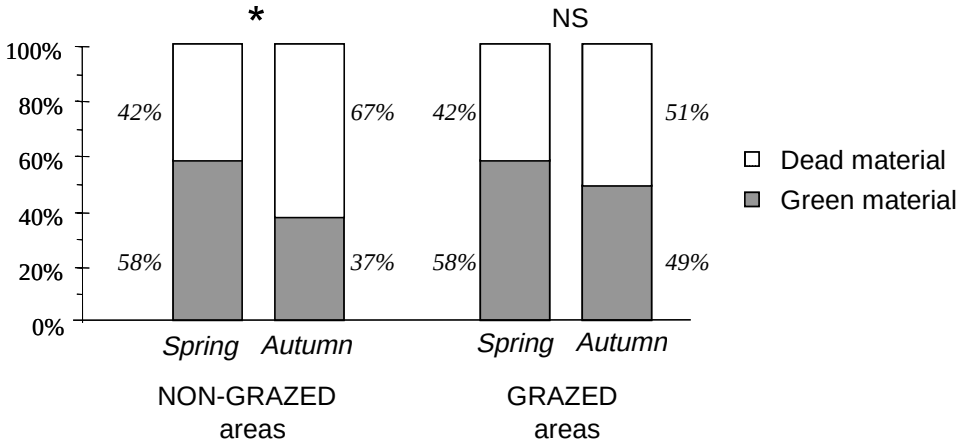

Fig. 1. Green and dead fractions of herbaceous samples in Grazed and Not-Grazed areas in the spring and autumn.

These results show that livestock grazing contributes to the control of herbage biomass on rangelands, which is kept short throughout the grazing season and, moreover, it keeps a higher proportion of green plant tissues. This is due to the compensatory vegetative growth that occurs in grazed plants. Growth can also be enhanced by a higher soil fertility, due both to animal faeces and urine, and to soil incorporation of dead material as a consequence of trampling. On the opposite, herbage biomass accumulates through the grazing season when animals are not present, and the dead fraction increases due to natural senescence. This is associated to increase in fibre content and decrease in protein content and forage digestibility, so that the nutritive value of forage can be significantly lower.

These results agree with those reported in other Natural Protected Areas with traditional farming activities (Aldezábal, 2001; Torrano, 2001). These authors also observed that in Not-Grazed areas floristic diversity could be reduced, as dominant species not consumed by herbivores became invasive, while grazing permitted to keep or increase specific diversity.

Shrub vegetation

Five hundred and forty-eight different shrub individuals were identified and measured in the

Grazed and Not-grazed transects of the twelve experimental plots. The most abundant was *Genista scorpius* (Table 3), which reached as much as 73% of the total species in farm 1.

Table 3. Relative proportion of different shrub species

Species	%	Species	%
Genista scorpius	27.0	*Crataegus monogyna*	4.7
Echinospartum horridum	13.3	*Juniperus communis*	4.7
Thymus sp.	12.2	*Lavandula* sp.	4.6
Prunus spinosa	6.4	*Rosa* sp.	3.8
Ononis sp.	5.7	*Buxus sempervirens*	2.9
		Others	14.6

At the start of the study (spring 2001) there was no difference in shrub size or density in the Grazed and Non-Grazed areas (19 *vs.* 22 individuals per 10-m^2-transect, NS). The continuation of the study in the following years will provide valuable information on how shrub vegetation is influenced by livestock in SGNP. In other similar and close areas of the Pyrenees, and even at the low stocking rates these pastures can support, grazing has been proved to maintain or decrease shrub density and volume, either by consumption or by trampling. On the opposite, when they were not grazed shrubs became invasive, and shrub biomass increased as much as 3200 kg DM/ha in six years (Casasús *et al*., 2002). Shrub survival, flowering and new growth can also be affected by herbivores, as Valderrabano and Torrano (2000) observed in *Genista scorpius*, the most abundant species in the Park.

Apart from the high risks of environmental hazard (forest fire) which can be derived from the lack of grazing activities, the decrease in herbage nutritive value and the increase in shrub density and size, closing pathways and impairing animal transit, can result in an irreversible decrease of the potential value of these pastures for livestock farming, which nowadays is the most important economic activity that can be sustained on these high-ecological value areas.

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