EFFECT OF GRAZING AND SOILS ON THE STRUCTURE OF MOUNTAIN VEGETATION COMMUNITIES

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ABSTRACT
The range of life forms of four grassland communities in the Cantabrian mountains (N. Spain) was studied under grazing and when grazing was excluded in relation to soil characteristics. Hemicryptophytes were the most abundant life form in all communities and they increased their number when ungrazed. Diversity was bigger in the communities with shrubs, which presented a more heterogeneous structure. As a whole, grasslands on calcareous soils were more diverse than those on siliceous soils.

KEYWORDS
Life forms, soil type, grazing, diversity, mountain grasslands.

INTRODUCTION
The reduction in the number of livestock in recent decades has caused a change in vegetation structure due to an under-use of the high altitude pastures, whilst those grasslands in the valleys close to the villages are usually overgrazed. Seminatural mountain ecosystems, which need human management to persist (García et al., 1989), have suffered a shift of plant species, with a progressive dominance of shrubs, and consequent alterations in light competition at the herbaceous layer.

The effect of herbivores on species richness, and in vegetation structure in general, also seems to be related to soil characteristics (Canals and Sebastiá, 1996; Puerto et al., 1990; Tilman and Pacala, 1993).

The objective of this work was to evaluate the importance of the change in the botanical composition, and hence the vegetation structure, of mountain grasslands when grazing is excluded, and to relate this shift to environmental factors such as soil characteristics.

MATERIALS AND METHODS
Four grassland communities were studied in the Cantabrian mountains (Northern Spain) at 1500 m a.s.l.: two on siliceous soils (pastures with *Erica australis* and pastures with *Nardus stricta*) and two on calcareous and rocky soils (grasslands with *Genista occidentalis* and those with *Bromus erectus*). The mean annual temperature and precipitation are respectively, 5.5°C and 1319 mm. The first community of each series was characterised by the presence of shrubs, while the second presented a more homogeneous sward appearance. The area has been used traditionally by transhumant sheep, cattle and horses, but in the last decade the number of animals has decreased significantly.

40 inventories were performed in the grazed areas by means of a 0.25 m^2 quadrat and one exclosure cage of 1 m^2 was installed in each community. Each plant species found was allotted to one of the Raunkiaer's life forms (1937) following Ellenberg classification (1986).

20 soil samples of each community were also taken from the first 5-20 cm depth to determine the physical (texture) and chemical (pH in water, organic matter) characteristics and the mineral composition (N by Kjeldahl method; macronutrients by atomic absorption). Diversity was calculated by means of Shannon index.

RESULTS AND DISCUSSION
Soil quality, in terms of texture, was better in the siliceous soils (table 1), which were also more acid and homogeneous. Nevertheless, the distribution of the main macronutrients and the organic matter was uneven in the whole area, producing spatial heterogeneity. The presence of shrubs provides an additional source of heterogeneity which is beneficial for some species in terms of protection from herbivores under the shrub canopy. This fact caused a higher diversity in communities with a significant shrub cover (50-75%) (table 1).

Figure 1 represents the number of species of each biotype in each community when grazed and ungrazed. Only pastures with *E. australis* and *G. occidentalis* presented some species of phanerophytes which were, in the first community three heath species (*Erica australis, E. arborea* and *Calluna vulgaris*), and only *Genista occidentalis* in the second (this species did not appeared in the exclosure). Grasslands with *N. stricta* presented the lowest number of chamaephytes, just two, in the open areas. In this situation, the most common life form in all communities was hemicryptophyte, which can avoid consumption and damage in winter by having the reproductive buds at ground level. The number of geophytes was almost the same in the four communities (4-5), although the species were different in each soil type. The number of annual species or therophytes was higher in those communities on basic and rocky soils, which suggest that this biotype is more abundant in heterogeneous ground.

When grazed and ungrazed areas were compared for both soil types, there was a change in the mean number of species per sampling unit (from 14 to 17 in *E. australis*; from 12 to 21 in *N. stricta*; from 20 to 25 in *G. occidentalis* and from 17 to 13 in *B. erectus*). Considering that the total numbers were smaller in the exclosures, the percentage of phanerophytes and chamaephytes increased in siliceous soils (2.5 to 5.9% and 14.9 to 15.9%, respectively) and diminished or even disappear in calcareous soils (0.6 to 0% and 22 to 15.7% respectively). Hemicryptophyte percentage suffered few variations, with a slight increase in the exclosures. Geophyte proportion increased in the ungrazed areas, while therophyte percentage decreased for both soil types, presenting *E. australis* and *B. erectus* none species of this biotype.

These changes can be interpreted as a resilience of the species better adapted to the system (hemicryptophytes and geophytes) and disappearance of those with the highest light requirements (seedlings of phanerophytes and some therophytes). The result is a simplification of vegetation structure and an apparent homogenisation of the herbaceous layer.

The species richness seems to be more related to the heterogeneity of the habitat than to the physical and chemical characteristics of the soils.

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Table 1
Soil characteristics and diversity of the communities.

	E. australis	*N. stricta*	*G. occidentalis*	*B. erectus*
Soil texture	franc	franc-sandy	franc-sandy	sandy
pH	4.41 ± 0.3	4.69 ± 0.3	7.15 ± 0.4	6.23 ± 0.8
Organic matter %	16.70 ± 2.6	15.95 ± 1.1	14.44 ± 2.0	26.69 ± 8.1
N % (SEM 0.04)	0.62 [a]	0.70 [a]	0.59 [a]	1.10 [b]
K [1] (SEM 110)	1295 [a,b]	2150 [c]	1664 [a]	3361 [d]
Ca [1] (SEM 851)	517 [a]	749 [a]	8226 [b]	5481 [b]
Mg [1] (SEM 248)	3646 [a]	1823 [b,c]	6099 [d]	2394 [b]
Diversity	3.04	2.81	3.81	3.58

SEM = Standard error of the mean. n = 20.
[1] = p.p.m.
[a,b,c,d] = Values on the same line with different superscript are different, $P < 0.001$.

Figure 1
Number of species of each life form on the grasslands when grazed and ungrazed.