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Abstract. The habitat use of non-shepherded and mixed grazing livestock in grassland-heathland mosaics occurring in the Atlantic Mountains of Northern Spain was studied. Plant communities included grasslands, open heathlands, dense heathlands, forests and rocky pastures. Average stocking rate was 0.83 ± 0.52 LU/ha. Grassland was the most commonly grazed community (1.81 ± 0.45 LU/ha), followed by open heathland (1.60 ± 0.4 LU/ha) and significantly more ranged than dense heathland (0.36 ± 0.40 LU/ha). This fact points out the potential interest of open heathlands for livestock production. Finally, rocky and forest areas had the lowest livestock presence (0.21 ± 0.39 and 0.14 ± 0.38 LU/ha, respectively). Sheep mainly ranged on grasslands while large animal species, such as cattle and horses mainly grazed on heathlands. These differences in habitat use by each livestock species are necessary to be considered when managing these rangelands, as they could be translated into different impacts on vegetation. In this sense, it is important to consider the different use of open heathlands by small and large animal species for maintaining their important ecological value (Habitats Directive 97/62/EU) and stopping wood invasion that may convert them into dense heathlands.

Keywords. Free ranging livestock – Mountain pastures – Stocking rate – Habitat utilisation – Geographic information system.

Utilisation de l'habitat du cheptel en pâturage libre et mixte dans des parcours en mosaïque (herbacées et bruyère) des montagnes atlantiques

Résumé. *L'utilisation de l'habitat par des troupeaux mixtes, non gardés par des bergers et placés sur des parcours en mosaïque à base d'herbacées et de bruyère dans les montagnes atlantiques du Nord de l'Espagne a été étudiée. L'espace pastoral est composé de parcours à base d'herbacées, de parcours à base de bruyère à faible et à forte densité, des forêts et des parcours sur des croûtes calcaires. La charge animale moyenne a été de 0,83 ± 0,52 LU/ha. Les parcours à base d'herbacées ont été les plus utilisés par les animaux (1,81 ± 0,45 LU/ha), suivis par les parcours de bruyère à faible densité (1,60 ± 0,40 LU/ha). Les parcours de bruyère à densité élevée ont été moins exploités par les animaux (0,36 ± 0,40 LU/ha) que ceux à faible densité de bruyère. Ces résultats dénotent l'intérêt des parcours à base de bruyère à faible densité dans la production animale. Les parcours sur des croûtes calcaires et les forêts ont été les moins utilisés par les animaux (respectivement, 0,21 ± 0,39 et 0,14 ± 0,38 LU/ha). Les moutons ont pâturé plus dans les parcours à base d'herbacées alors que les vaches et les chevaux ont pâturé plus dans les parcours à base de bruyère. Ces différents modes d'exploitation de l'habitat par les espèces animales doivent être considérés dans les stratégies de gestion des espaces pastoraux, puisqu'ils peuvent agir sur la végétation. Ainsi, il est nécessaire d'envisager l'exploitation des parcours à base de bruyère par les petits et les gros animaux pour préserver la valeur écologique (97/62/EU) et arrêter l'invasion des ligneux qui peuvent rendre ces parcours de bruyère excessivement denses.*

Mots-clés. *Pâturage sans gardiennage – Parcours montagneux – Charge animale – Utilisation de l'espace pastoral – GIS.*

I – Introduction

In extensive grazing systems on heterogeneous natural pastures, livestock tend to use the available feed resources in a very heterogeneous pattern, which is dictated by both biotic and abiotic factors. A considerable number of studies have been carried out to determine habitat use patterns of livestock and its constraints (Senft *et al.*, 1985; Warren and Mysterud, 1991; Howery *et al.*, 1998; Baumount *et al.*, 2000; Bailey, 2005). As far as the biotic factors are concerned, forage quality and quantity influence a great deal the spatial distribution of grazing livestock.

A significant proportion of dairy sheep and goat flocks, as well as beef cattle and horse herds of the Basque Country traditionally use mountain pastures in a non-shepherded and mixed grazing system from late spring to autumn (Mandaluniz *et al.*, 2005a). Grasslands are characterized by the presence of various shrub species at different cover as a result of the pastoral activity carried out through centuries. Over the last decades, however, these grazing areas have experienced some remarkable changes in livestock utilisation due to the increase of beef cattle and the reduction of sheep census. Moreover, a general tendency of abandonment of large grazing areas is observed in many of these Atlantic pastures at the same period. As a result, woody invasion is occurring (Flamant *et al.*, 1999; Bartolome *et al.*, 2000; Plaixat and Bartolome, 2001; Amezaga *et al*., 2004; Courtois *et al*., 2004; Bernués *et al.*, 2005).

The knowledge of habitat use by livestock in these heterogeneous rangelands could help to develop appropriate utilisation guidelines aimed at contributing to their sustainability. Therefore, the main objective of this paper was to determine habitat utilisation of the non-shepherded and mixed grazing system (beef cattle, horses, sheep and goats) along the grazing season in the Gorbeia Natural Park of northern Spain.

II – Materials and methods

1. Study area

The study of habitat use by livestock was carried out on the pastures located in the Gorbeia Natural Park (43°02.06' N and 02°48.205' W) of northern Spain. Geologically, sedimentary rocks dominate and round siliceous hills and abrupt limestone areas are combined over the Park. The mean annual rainfall ranges between 1000 and 1300 mm and the mean annual air temperature between 8 and 12°C. The E-W orientation of the massif separates the Park into the wet and warmer northern watershed and the drier and sunnier southern one. Based on this heterogeneity, 4 representative grazing areas were selected, which occupied 10% of the pastures of the Park. They ranged from 700 to 1200 m a.s.l., belonged to different watersheds and had different soil characteristics. Beef cattle, horses, sheep and goats roamed non-shepherded from the end of May to November.

2. Data collection

Five plant communities were identified and geo-referenced: grasslands (GR), open heathlands (OH), dense heathlands (DH), forest areas (FA) and rocky scarce pasture (RO).

Stocking rate was estimated monthly (from June to October of the years 2002-2004) at fixed transects previously defined in each management unit (Casasús *et al.*, 2005). Transects were monitored during the day at hours of maximum grazing activity (about 7.00-10.00 and 17.00-20.00) and two observers. Livestock were located with a geographic position system (GPS) and information about animal species and number of animals was collected at each position. These values were converted into livestock units (LU) (Mandaluniz *et al.*, 2006) and stocking rate (LU/ha) was estimated at each location taking into account the number of animals and the surface of plant communities in each area.

3. Data analysis

Average stocking rate was analysed by a general lineal model (SAS, 2001) taking into account plant community (GR, OH, DH, FA and RO), animal species (cattle, mare, sheep and goats) and their interaction as fixed effects.

III – Results

Average stocking rate was 0.83 ± 1.82 LU/ha (n = 951). Predominant livestock was beef cattle

(0.34 ± 0.31 LU/ha), followed by mares and sheep (0.23 ± 0.19 and 0.24 ± 0.27 LU/ha, respectively), whereas goats' presence was low (0.02 ± 0.05 LU/ha). Stocking rate had fluctuations throughout the grazing season due to the different management imposed by the production system to each animal species (Casasús *et al.*, 2005). In relation to physical parameters there was a higher stocking rate in northern watershed, areas with slopes lower than 12% and SE, N and E aspects (Casasús *et al*., 2005).

Referring to biotic factors, there were found significant differences in the average stocking rate per plant community ($P < 0.01$) and animal species ($P < 0.001$), but not for their interaction, ($P < 0.05$) (Fig. 1). According to plant community, the presence of livestock was significantly higher in grasslands and open heathlands (1.81 ± 0.45 and 1.60 ± 0.40 LU/ha respectively) and lower in rocky and grove areas (0.21 ± 0.39 and 0.14 ± 0.38 LU/ha respectively). Dense heathlands had an intermediate pressure (0.36 ± 0.41 LU/ha), not statistically different ($P > 0.05$) from the other communities.

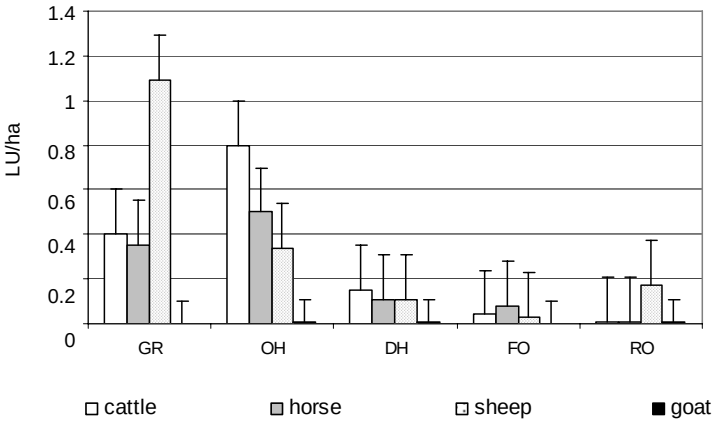

Fig. 1. Observed stocking rate (LU/ha) of different animal species grazing different plant communities in the Gorbeia Natural Park (northern Spain).

In general, large animal species such as cattle and horses ranged on heathlands more intensively, mainly the open ones (0.77 LU/ha and 0.49 LU/ha respectively for the two kinds of animals). Sheep, on the other hand, made a higher pressure on grasslands than on heathlands (1.09 LU/ha and 0.34 LU/ha, respectively).

IV – Discussion

1. Habitat use by free and mixed livestock

Comparing with other Atlantic areas, animal pressure was similar to that found in Central Pyrenees (Aldezabal *et al.*, 1999; Marinas *et al.*, 2003) and higher than the one observed in the Prepyrenean pastures where abandonment of grazing areas has occurred over the last decades (Bernués *et al.*, 2005; Casasús *et al.*, 2005).

According to the "Use and Management Plan of Gorbeia Park" (Departamento de Agricultura y Pesca, Gobierno Vasco, 1994), observed stocking rate is similar to that estimated as potential. Nevertheless, there are important differences in habitat use due to different constraints, as stated by other authors (Senft *et al.*, 1985; Warren and Mysterud, 1991; Howery *et al.*, 1998; Aldezabal *et al.*, 1999; Marijuán *et al.*, 2004; Bernués *et al*., 2005; Mandaluniz *et al*., 2006).

The high stocking rate observed on grasslands for grazing could be due to their higher forage availability and nutritive value of its grass (Senft *et al.*, 1985; Baumont *et al.*, 2000; Bailey, 2005). Moreover, the higher sheep pressure on these pastures could be due to their positive selection of dicots and palatable graminoids.

Focusing on heathlands, livestock presence was higher on open than on dense ones (1.60 LU/ha *vs* 0.36 LU/ha, respectively). This could be due to the higher nutritive value (higher crude protein and digestibility values) of open heathlands (Mandaluniz *et al.*, 2005a). Moreover, according to the optimal foraging theory (Pyke, 1984), herbivores try to optimise ingested-spent energy ratio by selecting different plant communities. Lower use of dense heathlands could be related to a higher cover of shrubs, which make difficult their accessibility and finding herbaceous species.

When analysing the use of these heathlands by livestock species, there is a significant higher presence of large animal species, mainly by cattle. This higher presence of cattle could be due to the higher biomass content of heathlands (Mandaluniz *et al.*, 2005a), which is positively related with bite size (Laca *et al.,* 1992) and allows a greater intake rate (Distel *et al.*, 1995). In the case of mares, the use of open heathlands could be related to the ability of hing-gut fermenters to extract nutrients from high fibre and low quality forages (Duncan *et al.*, 1990).

Rocky pastures received less livestock than other communities, which could be due to their low herbage production. Anyway, sheep mainly grazed these pastures, probably due to their high dicot content (Mandaluniz *et al.*, 2007a, submitted). Finally, the use of forest areas was mainly during hot days when animals were looking for shelter (Bailey, 2005).

2. Effect of livestock presence on Atlantic mountain rangelands

As a consequence of the selective foraging pattern, overgrazing of preferred areas and undergrazing of that refused by livestock can be observed. This heterogeneity on habitat use is translated by different vegetation dynamics. According to Mandaluniz *et al.* (2007b), current stocking rate on open heathlands on the Park helps to maintain a sward/shrub balance avoiding shrub expansion. In the absence of livestock, these open heathlands will become denser through secondary vegetation succession, where livestock presence will be lower. Similar results were found by Bernués *et al.* (2005) in Prepyreneen mountain pastures.

According to Plaixat and Bartolome (2001), woody invasion has different succession stages, being in the first stage beneficial to both animal production and conservation, while in the later stages species richness is reduced, fire hazard risk is increased and access and grazing by livestock becomes difficult. Consequently, Atlantic mountain open heathlands could be at an early stage, while the dense ones at a later one. Under this situation, management of these communities should focus on using livestock as an important tool to control dense heatllands and maintain the open ones (Mandaluniz *et al.*, 2005b).

V – Conclusions

There are important differences in habitat use of rangelands by livestock depending on the particular plant community. Grasslands are the communities more grazed due to their higher grass availability and nutritive value. Focusing on heathlands, it seems that the relative abundance of grass-shrub components plays a crucial role in the use of shrubby communities. The results of this study point out the potential interest of open heathlands to livestock. Moreover, these communities need to be conserved due to their important ecological value (Habitats Directive 97/62/EU). Selective foraging pattern is translated into different vegetation dynamics. In the absence of livestock, open heathlands will be invaded by shrubs. The higher use of dense heathlands by cattle and their relatively higher distribution in the Park, show that livestock constitute a possible tool for their control, stopping wood invasion.

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