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Goat grazing silviculture for the prevention of forest fires in Doñana Natural Park

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Abstract. The effects of goat grazing in the understory of a pine forest in the Doñana Natural Park were assessed over a 24 month period employing non-destructive methods. After the two year period, biovolume had undergone a significant decrease of 28%. Floristic composition (biodiversity) did not show a difference between grazed and ungrazed areas, but the relative abundance of species (diversity) was affected. The species of the family Cistaceae (*Cistus salvifolius, Halimium halimifolium, H. calycinum* and *Cistus monpeliensis)* experienced the greatest reduction in biovolume. The different responses of scrub species to such grazing can be used as an effective tool to control scrub in forest areas, so the reduction of vegetation can contribute to the progressive reduction of fire risk.

Keywords. Grazing – Payoya goats – Doñana – Diet.

Sylviculture pour la prévention des incendies de forêt dans le Parc Naturel de Doñana

Résumé. *Pendant 24 mois on a évalué avec des mesures non-destructives le pâturage des chèvres dans une pinède du Parc Naturel de Doñana. Après deux ans, le biovolume de la végétation a montré une diminution significative de 28%. La composition floristique (diversité biologique) n'a été pas différent entre zones broutées et non broutées, mais l'abondance relative des espèces (diversité) a été touchée. Les espèces de la famille des Cistaceae (*Cistus salvifolius, Halimium halimifolium, H. calycinum *et* Cistus monpeliensis*) ont eu la réduction plus importante du biovolume. Le comportement différent des espèces arbustives peut être utilisé comme un outil efficace pour le contrôle de la végétation des zones forestières. En outre, cette réduction peut aider à la réduction progressive des risques d'incendie.*

Mots-clés. *Pâturage – Chèvres – Doñana – Régime alimentaire.*

I – Introduction

Silvopastoral systems are complex agrarian systems that combine the use of woody plants with that of herbaceous plants and animals (Nair, 1991). At present, these systems attempt to reconcile the use of the products and services of the natural environment with a guarantee of permanence, or similarly attempt to pursue ecological, economic and social stability through the diversification of structures and products with an efficiency of use (San Miguel, 2005).

Due to its physiological characteristics, the goat is the animal best adapted to the consumption of the scrub found in the Mediterranean forest understory: it is able to incorporate a greater variety of scrub species into its diet than other domestic ruminants, and to choose different plants or groups of plants according to the time of year, therefore consuming virtually everything that grows within the Mediterranean forests (Hoffman, 1989, Liacos *et al*., 1980). Furthermore, grazing improves pasture, with a consequent increase in food available to wild herbivores.

The objective of this study is to determine, through non-destructive measures, the capacity for the elimination of potentially combustible plant biomass of the undergrowth, through forest grazing by the goats and to determine the effect of such grazing on the diversity and biodiversity of the vegetation.

II – Materials and methods

The experiment was conducted in a 100 ha pine forest situated within the Doñana Natural Park (37º14'52''N, 6º20'35''O, SO Spain) an area from which all large herbivores were excluded in 2002. The pine forest is composed mainly of *Pinus pinea* (with an average density of 217 trees/ha and an average diameter at breast height dbh of 26.92 cm) and is complemented in some areas by a small presence of Cork Oak (*Quercus suber*) and Holm Oak (*Quercus ilex* subsp. *ballota*). The climate is Mediterranean, and the winter is wet with mild temperatures (monthly average temperature is 10 ºC in December and January), and the summer is long and dry, with a mean temperature of 25 ºC in July and August. Minimum winter temperature drops to between –2 and –4 ºC. Mean annual rainfall is around 540 mm (with 80% of precipitation occurring from October to March). Summer drought is severe, with no precipitation from July to August.

Nine fixed grazing exclusion plots (0.25 ha each) were installed in the pine forest prior to the introduction of the goats. Within the fenced-off exclusion plots, a fixed linear transect was delimited and all species on it were identified. In the vicinity of each of these plots (at the cardinal points N, S, E and W), four transects were similarly established, containing the same species as those found within the enclosures. These transects, of 25 m in length, provided a permanent and repeatable point for successive samplings. Vegetation was sampled using the point-intercept method (Daget and Poissonet, 1971), scoring the points of contact with scrub vegetation every 10 cm along a transect. In addition, the height of the scrub was recorded, and this data used to determine total vegetation cover, frequency of different species and the biovolume (average height of each species x number of contacts in every metre of transect (Frandsen, 1983). Seven sets of measurements were taken: one before allowing the goats to enter the pine forest (April 2007), and another every six months over a 24 month period of grazing (October 2007, April and October 2008, April and October 2009 and April 2010).

The Shannon-Wiener diversity index was applied to determine the diversity index (*H*) (Magurran, 1988), and was calculated by the following equation:

$$H' = -\sum p_i \ln p_i ,$$

where: H' = diversity index; $p_i = n_i / N$; n_i = number of individuals of the species *I*; and $N = \sum n_i$ total of individuals in all the species.

The data were analyzed with an analysis of variance using SPSS v 17.0.

III – Results and discussion

The grazing of goats exerted a remarkable effect on the forest architecture although the response of each group of species differed according to individual survival strategy. The decrease in biovolume was progressive, with a significant decrease in biovolume of 28.1% and 27.8%, at 18 and 24 months grazing, relative to the initial measurements (t (18 months) = 2.88; t (24 months) = 2.69 $p < 0.05$). In contrast, the total biovolume of the species within the exclusion plots increased significantly, relative to the initial value, by 12.31%, 31.74%, 20.79% and 28.09% at 6, 12, 18 and 24 months, respectively (t (6 months) = –3.37; t (12 months) = –5.20; t (18 months) = –3.05; t (24 months) = –3.53; $p <0.05$).

The variation of biovolume over time differed among species (Figure 1A).There is a maximum limit of consumable plant biomass which is determined by the availability and palatability of plant production. This limit is theoretical and cannot be reached, as it is virtually impossible for animals to locate all new plant material produced annually. Within the grazed area after 24 months, thirteen of the seventeen species studied showed a decrease in biovolume. This loss was statistically significant for *Halimium halimifolium* (–88.99 %) y *Cistus salvifolius* (–60.69 %) (t = 2.387 y t = 2.489 $p< 0.05$, respectively). However, other species experienced an increase in

biovolume due to vegetable production exceeding consumption (*Pistacia lentiscus*, *Genista* spp., *Quercus coccifera*) or to plants which were not grazed (Thymus) (Mancilla-Leytón *et al.* 2008). Species of the family Lamiaceae showed increasing biovolume: these species are not consumed or consumed sparingly during flowering, because they have high oil content (Guillen and Cabo, 1996). This was significant in *Rosmarinus officinalis* (+67%) ($t = –2.405$ $p< 0.05$) and *Thymus mastichina* (+89.72%) ($t = –2.601$ $p< 0.05$). Within the fenced-off exclosures, we found a progressive increase in the total live biovolume of the species reflecting the time of exclosure. After 24 months, almost all species had increased in biovolume, significantly so for the species of the family Fabaceae (*Genista* spp. and *Ulex* spp.) (+79.44%) and *Rosmarinus officinalis* (+ 56.66 %) ($t = –2.494$ y $t = –3.104$ $p< 0.05$, respectively). Moreover, within the exclusion plots, the biovolume of some species of the family Cistaceae (*Halimium halimifolium*, *H. calicinum*, *Cistus salvifolius* and *C. libanotis*) decreased, although not significantly, due to the death of some individuals during the summer drought (Fig. 1A).

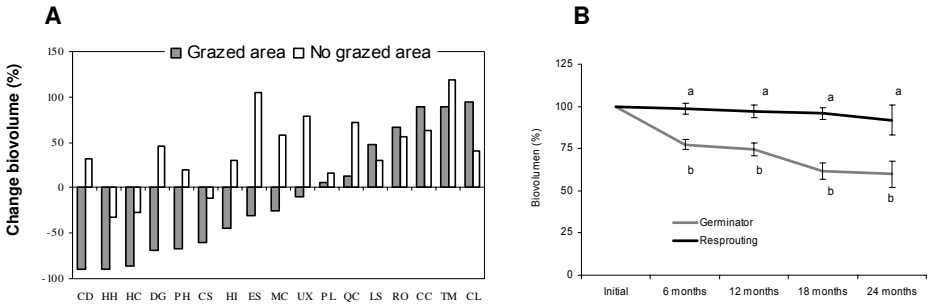

Fig. 1. A-Change in biovolume/species as a percentage of initial biovolume in the grazing and excluded areas at 24 months of study (gray grazed area and white no grazed area). B-Change in biovolume of species grouped into their particular regenerative strategies, whether resprouting or seed germination. Abbreviations: *Cistus crispus* (CC), *Cistus ladanifer* (CD), *Cistus libanotis* (CL), *Cistus salvifolius* (CS), *Daphne gnidium* (DG), *Erica scoparia* (ES), *Halimium calycinum* (HC), *Halimium halimifolium* (HH), *Helichrysum italicum* (HI), *Lavandula stoechas* subsp *pedunculata* (LS), *Myrtus communis* (MC), *Phillyrea angustifolia* (PH), *Pistacia lentiscus* (PL), *Quercus coccifera* (QC), *Rosmarinus oficinales* (RO), *Thymus mastichina* (TM), *Genista* sp. + *Ulex* sp. (UX).

Despite the significant loss of biomass found in some species, it can be seen that grazing was not of sufficient intensity to eradicate these species over this period of time. After 24 months, the grazed vegetation composition was unaffected in terms of the number of species (biodiversity), which maintained a total of 17. However, significant differences in relative abundance of these species (diversity) were observed following the 24 months of grazing (H' (before grazing) = 1.51 ±0.12; H' (after 24 months of grazing) = 1.30 ±0.13). In terms of the non-grazed vegetation, there were no significant differences in diversity over the entire period.

Mediterranean vegetation is able to survive different disturbances (cutting, fire, grazing, etc.) due to the regeneration of lost organs in the case of resprouting species, and to the seed bank present in the soil that ensures the presence of the germinator species in the next generation (Keeley, 1986). Figure 1B shows the biovolume of species grouped into their particular regenerative strategies, whether resprouting or seed germination. The loss of biovolume was significantly higher in germinator species that in resprouting species, for the four periods ($P <0.01$, $Z = 0.00$) showing loss of size and structure. The resprouting capacity of many Mediterranean woody species has allowed them to withstand significant periodic disturbances, sprouting vigorously from roots, rhizomes or stocks, in which they conserve abundant carbohydrate reserves (e.g. *Erica scoparia*, *Myrtus* communis, *Pistacia lentiscus*) (Ojeda, 2001;

Vallejo and Alloza, 2004). The opposite is true of germinator plants, but they assume a very important role in the high density of seeds in the soil, which plays a major part in regeneration potential, a determinant factor for the conservation and restoration of natural areas (Marañón, 2001). The Cistaceae are a good example of this type.

IV – Conclusions

Monitoring of the scrub understory has shown the positive impact of grazing goats over 24 months, in terms of reducing the quantity of easily combustible material. The different responses of scrub species to such grazing can be used as an effective tool to manage scrub in forest areas, which can reduce the risk of fire without loss of biodiversity, and may also contribute to the ecological balance, given adequate monitoring and maintenance of responsibility.

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References

Daget P.H. and Poissonet J., 1971. Une méthode d'analyse phytologique des prairies, critères d'application. In: *Annales Agronomiques*, 22, pp. 5-41.

Frandsen W.H., 1983. Modeling big sagebrush as a fuel. In: *J. Range Manage.*, 36, pp. 596-600.

Guillen M.D. and Cabo N., 1996. Characterization of the essential oils of some cultivated aromatic plants of industrial interest. In: *Journal of Science Food and Agriculture,* 70, pp. 359-363.

Hofmann R.R., 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: comparative view of their digestive system. In: *Oecologia*, 78, pp. 443-457.

Keeley J.E., 1986. Resilence of Mediterranean shrub communities to fires. In: Dell B., Jopkins A.J. and lamont B. (eds), *Resilience in Mediterranean-type Ecosystems.* Dordrecht: Dr. W. Junk, pp. 95-112.

Liacos L., Papanastasis V. and Tsiouvaras K., 1980. Contribución a la conversión de los matorrales de la coscoja en prados y comparación de su producción con los matorrales mejorados en Grecia. In: *Forestry Research*, I(2), pp. 97-141.

Mancilla-Leytón J.M. and Martín Vicente A., 2008. Uso del sotobosque arbustivo de un pinar de *Pinus pinea* por el ganado caprino. In: *XII Jornadas Internacionales de Ovinotecnia y Caprinotecnia*, Almería, pp. 243-246.

Magurran A.E., 1988. *Ecological Diversity and its Measurement.* Princeton: Princeton University Press.

Marañon T., 2001. Ecología del banco de semillas y dinámica de comunidades mediterráneas. In: Zamora R. and Puignaire F.I. (eds), *Ecosistemas mediterráneos. Análisis funcional.* Granada: CSIC-AEET, pp. 319-349.

Nair P.K.R., 1991. State-of-the-art of agroforestry systems. In: Javis P.G. (ed.), *Agroforestry: Principles and practice*. Amsterdam: Elsevier, pp. 5-29.

Ojeda F., 2001. El fuego como factor clave en la evolución de las plantas mediterráneas. In: Zamora R. and Puignaire F.I. (eds), *Ecosistemas mediterráneos. Análisis funcional.* Granada: CSIC-AEET, pp. 319-349.

San Miguel A., 2003. Gestión silvopastoral y conservación de especies y espacios protegidos. In: *Pastos, Desarrollo y Conservación*, pp. 409-421.

Vallejo R. and Alloza J.A., 2004. La selección de especie en restauración forestal. In: Vallejo R. and Alloza J.A., *Avances en el estudio de la gestión del monte mediterráneo.* Valencia: CEAM, Fundación Centro de Estudios Ambientales del Mediterráneo y Conselleria de Territori i Habitatge, pp. 102-115.