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The function of goat grazing in Doñana Natural Park

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Abstract. From 2007, a project was carried out concerning the use of goat grazing to improve the understory shrub vegetation of the Doñana pine forest. To understand this plant-animal interaction, the evolution of the vegetation and the nature of the grazing were studied. This grazing, in addition to significantly reducing the shrub biomass with a consequent reduction in the risk of forest fire, has resulted in the improvement of pastures and an increase in the food available to wild herbivores. In this case, these herbivores include the rabbit, which is in turn prey for the Iberian lynx (*Lynx pardinus*), the Iberian imperial eagle (*Aquila adalberti*) and the Eurasian eagle-owl (*Bubo bubo*), all of which breed within the study area. Moreover, grazing has contributed to the conservation of certain plant species, such as *Thymus albicans*, that are in danger of extinction.

Keywords. Goats – Rabbits – Shrub Vegetation – Doñana – Iberian lynx.

Le rôle de chèvres paissant dans le Parc National de Doñana

Résumé. *Un projet d'amélioration de la végétation du maquis d'une pinède (Parc Naturel de Doñana) par le pâturage des chèvres est en cours depuis 2007. Pour comprendre cette interaction "plantes-animaux" on a suivi l'évolution de la végétation et le pâturage du bétail étudié. Le pâturage a non seulement réduit considérablement la biomasse des arbustes avec une réduction conséquente du risque d'incendies, mais a aussi entraîné l'amélioration des pâturages avec une augmentation de la nourriture disponible pour les lapins, qui dans ce cas, est l'espèce plus importante pour la nourriture du lynx ibérique (*Lynx pardinus*), l'aigle impérial (*Aquila adalberti*) et le Hibou grand-duc (*Bubo bubo*), qui se reproduisent dans la zone d'étude. Aussi le pâturage a contribué à la conservation d'espèces végétales menacées d'extinction telles que* Thymus albicans.

Mots-clés. *Chèvres – Lapins – Maquis – Doñana- Lynx ibérique.*

I – Introduction

For its size, structural and productive characteristics, and its role within terrestrial ecosystems, shrub vegetation is of special interest in media with difficult climatic and soil conditions, and in those which have endured more intense anthropic action.

While it is acknowledged that the Mediterranean forest has the highest biodiversity in Europe thanks to its ecological and economic richness (Charco, 2002), we must not forget that the intimate interrelationship between ecological and cultural processes has created a landscape characterized by high dynamics of vegetation, with spatial and temporal degradation and regeneration patterns produced by clearing, burning, fallow, pasture, etc. (González Bernáldez, 1990; Naveh, 1994).

Decades ago, changing economic directions and technology (industrialization) led to a sharp drop in rural populations with massive migration to the cities and the consequent abandonment of large areas of crops and pastures (Martín, 2004). This together with the low levels of extensive livestock farming has led to increased shrub biomass, thereby increasing the risk of spread of wildfires.

In this regard, livestock production constitutes a limit on plant growth and the formation of dense and closed patches (Fernández Santos *et al.*, 1994). Goat herding currently plays a very interesting role in landscape conservation, as the goat is the ruminant most suitable in combating the spread of shrub vegetation in the pastures and reforested areas. This is due to the goat having the ability to incorporate a greater variety of shrub species into its diet than other domestic ruminants, and makes the goat a potential tool to help prevent forest fires.

A four year study, funded by the Ministry of Environment of the Junta de Andalucía (FEADER), began in 2007 and examines the role of goats in the conservation of Mediterranean forest. The main objective of the project is to understand the role of grazing goats in shrubland vegetation in order to optimize their management in terms of pasture improvement and control of combustible biomass in a plantation of *Pinus pinea* in the Doñana Natural Park. It is intended to use these data to develop a model that is exportable in order to manage forests with the intention of minimizing the risk of fire. Furthermore, grazing can lead to improved pastures with a consequent increase in food available to wild herbivores. In this case the most important of these is the rabbit, which is in turn prey for many important species which breed in the area, such as the Iberian lynx (*Lynx pardinus*), Iberian imperial eagle (*Aquila adalberti*) and the Eurasian eagle-owl (*Bubo bubo*).

II – Materials and methods

The experiment was conducted in a 600 ha pine forest (*Pinus pinea*) situated in the Doñana Natural Park in SW Spain (37º14'52''N, 6º20'35''O, SO Spain). This pine forest has a shrub understory where *Cistus salvifolius, Halimium halimifolium, Halimium calycinum, Rosmarinus officinalis, Pistacia lentiscus, Myrtus communis* and *Phillyrea angustifolia* are the most common species. The climate is Mediterranean: winter is wet and mild, while summer is long and dry.

A herd of around 600 Payoya goats (including milking, breeding and male individuals), with a ratio of 18 females per male, was utilized in the study. The fertility of the herd was 90% with an average litter of 1.5 offspring goat^{-1} year^{-1}. Average milk production is 1 litre per goat per day, with animals milked twice per day (until May when this is reduced to once daily). Due to management requirements (milking and supplementation), the herd does not enter the pine forest until the afternoon. Time of return to the fold is determined by day length, but grazing in the pine forest usually lasts between 4-7 hours. Prior to the introduction of grazing, nine fixed plots excluding cattle (0.25 ha each) were installed, enabling control of the grazing within these plots.

In order to better understand this plant-animal interaction, we examined the following features of the vegetation and grazing:

(i) Changes in the vegetation structure and biovolume: Inside and outside of the nine fenced-off exclusion plots, fixed linear transects were established where the vegetation was sampled by the point-intercept method every 10 cm, obtaining coverage and biovolume data from the scrub vegetation. This was done prior to the entry of goats into the pine forest and then twice annually thereafter for three years.

(ii) Food preferences: A total of 30 goats per month were observed at random for 10 minutes each, noting the time spent in movement; time of consumption/species; plant organ consumed; number of bites and number of plants consumed by species.

(iii) Phenological changes of the scrub: Changes of phenology experienced by the vegetation over the year can affect its palatability for the goat, so that monitoring may be essential to understand the diet of the goats. A total of 10 individuals per species were monitored monthly by recording the phenophases.

(iv) Dispersal and germination of seeds: Dry fruits (*Cistus salvifolius* and *Halimium halimifolium*) and fleshy fruits (*Myrtus communis* and *Pistacia lentiscus*) were fed to three

individually housed goats, in order to determine the percentage of seed loss, the distribution of recovery in terms of time after ingestion and the germination efficiency of the seeds following passage through the digestive tract.

(v) Biomass and inflammability of scrub: The reduction of plant biomass by grazing was evaluated, and changes in the inflammability of the study area were estimated.

III – Results and discussion

The reduction in biovolume of the grazed vegetation was progressive and increasing: after thirty-six months of grazing in the pasture area, the total biovolume of the grazed species decreased significantly by 33%, causing a significant increase in bare ground by 49% relative to the initial measurements. The goat grazing exerted a remarkable effect on the architecture of the scrub although the response of each group differed according to each particular species survival strategy. The loss of biovolume of the germinator species (*Cistus salvifolius*, *C. libanotis*, *Halimium halimifolium*, *H. calicynum*, etc.) was significantly greater than that of the resprouting species (*Myrtus communis*, *Quercus coccifera*, *Pistacia lentiscus*, ...) losing a great deal of its structure. However, other species experienced an increase in biovolume, because in some cases plant production exceeded consumption (*Pistacia lentiscus*, *Ulex* and *Genista* spp*., Quercus coccifera*), or they were scarcely (*Rosmarinus officinalis*, *Lavandula stoechas*, *Helicrisum italicum*) or not consumed (*Thymus* spp.) (Mancilla-Leytón *et al*., 2008) (Fig. 1). Despite the significant loss of biomass found in some species, grazing was insufficiently intense to eradicate these species in this time, no significant differences in vegetation composition were observed between the grazed and ungrazed treatments.

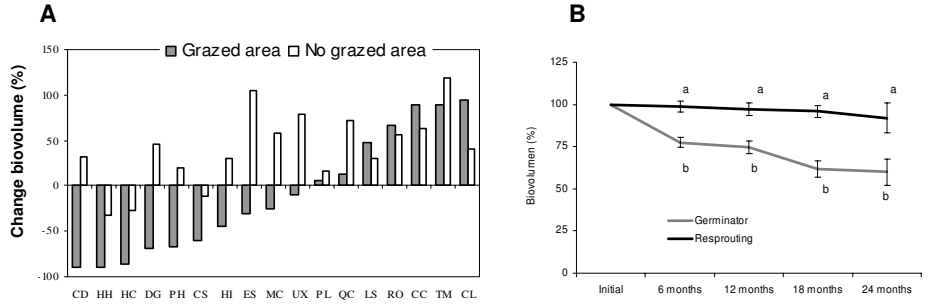

Fig. 1. A- Change in biovolume/species as a percentage of initial biovolume in the grazing and excluded areas at 24 months of study (gray grazed area and white no grazed area). B- Change in biovolume of species grouped into their particular regenerative strategies, whether resprouting or seed germination. 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).*

As an observational follow-up, and due to the characteristics of variety and breeding method (natural), the approach phase was very laborious. This approach required a period of adaptation of the animal to the presence of the observer. The pattern of selection did not follow a fixed pattern, consumption of shrub species varied throughout the year, but there was preferential consumption of certain species. *Myrtus communis*, *Halimium halimifolium* and *Cistus salvifolius* accounted for more than 70% of the diet. Goats tended to select the leaf and stem shoots in all species, as well as the fruits of *Cistus salvifolius*, *Halimium halimifolium*, *Myrtus communis*,

Pistacia lentiscus, *Olea europea*, *Pinus pinea*, *Quercus coccifera, Q. suber* and *Q. ilex* susp. *ballota* (Fig. 2A).

Phenological changes have influenced the consumption of some species, such as *Rosmarinus officinalis* with a winter usage which coincides with flowering and *Helichrysum italicum*, which is only consumed in summer. Only two species were not consumed: *Dafne gnidium*, due to its toxicity and *Thymus* spp., because of its high oil content (Guillén and Cabo, 1996) (Fig. 2B).

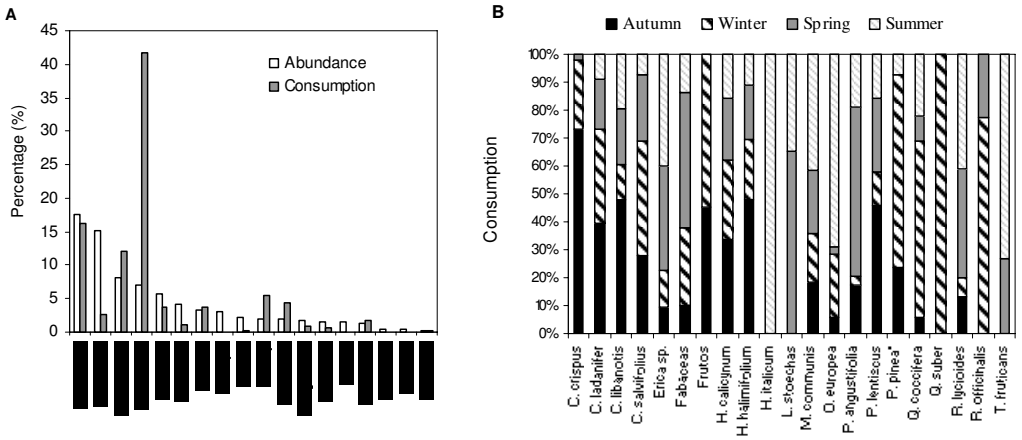

Fig. 2. A - comparison between the abundance (ordered from highest to lowest in percentage) and consumption (%) of the species; B - Percentages of the total bites/species/season produced by the direct observation of goats.

With regard to seed dispersal of scrub, the results suggest that goat grazing can be an effective disperser and germinator of Mediterranean scrub seed, particularly in the ungulate-Cistaceae interaction, where in addition to being good dispersers (dispersing 30% of seeds consumed), the goats facilitated germination (15-30% of ingested seeds compared to 2-5% in control seeds). The seeds of dry fruits resist the passage through the digestive tract of goats better than those of fleshy fruits. The low recovery rate of seeds of fleshy fruits must be related to their larger size since the percentage of seed destruction is directly proportional to seed size and inversely proportional to the hardness of the seed coats (Russi *et al.,* 1992) (Fig. 3).

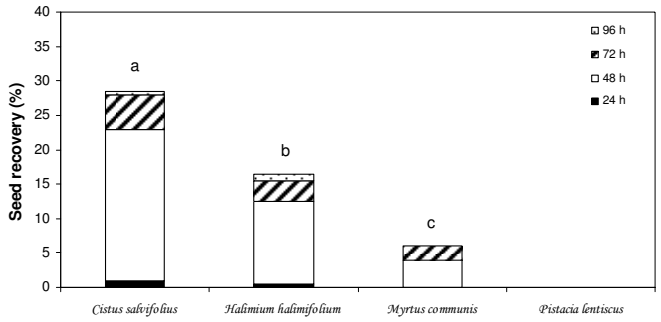

Fig. 3. Percentage of seed recovery, every 24 hours, of four species after seed consumption by goats. Different letters indicate treatment means for each species that are significantly different (Tukey test; $P < 0.01$).

Grazing resulted in a decrease in total biomass of 57% (31.13% for leaf biomass and 25.87% for wood biomass). The reduction of potentially combustible plant biomass of the understory observed in this study translates into a significant reduction in the inflammability of the species concerned (19%), and therefore a very significant reduction in the risk of fire since many of these species are highly inflammable, not only in the summer, but all year round (Elvira and Hernando, 1989; Vélez, 1990).

IV – Conclusions

Contrary to the general assumption that goats only cause degradation of vegetation, this evaluation of the goat-pasture interaction has shown a positive effect of goat grazing on scrub vegetation. The high selectivity of the goats and the different responses of plants to grazing suggests that the goat can be used as an effective tool for the control of shrubs in protected forest areas, allowing a reduction in the risk of fire without loss of biodiversity, and may help contribute to ecological balance, provided there is monitoring and maintenance of adequate responsibility. Further study is required to more fully understand the nature of the interactions involved this area, but this project can serve as a basis for future research.

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