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Small ruminants as manipulators of brown hare (*Lepus europaeus*) habitat in kermes oak rangelands

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Abstract. Livestock grazing affects habitat structure and forage resources, thus it often influences the abundance and dispersion of wild fauna's populations. The aim of this study was to assign the usefulness of small ruminants as habitat manipulators for brown hare in a mosaic landscape (kermes oak stands intermingled with grasslands). The importance of kermes oak as a food resource for goats and sheep in spring was estimated with the microhistological analysis of faeces. We also tested the hypothesis that different levels of livestock grazing intensity influence the use of kermes oak stands by hare; and the type of habitat (kermes oak stands or grasslands), which is used more intensively by hares, using the pellet counts method. Kermes oak was a primary food resource for goats and a secondary one for sheep. Different levels of livestock grazing intensity did not affect the use of kermes oak stands by hare. Grasslands constituted the main feeding habitat for hare, while kermes oak stands were used mainly for shelter. Reducing the scrubland area and creating various shaped and sized openings (grasslands) could benefit brown hares. However, available cover and food must both be considered in conservation plans. Manipulation of kermes oak stands can be based mainly on goats and secondarily on sheep. Grazing strategies may be used to increase forage availability for hare, to improve its quality and to provide adequate cover, so as to attract hares to desired areas. Thus, under appropriate grazing management brown hare habitat values could be enhanced.

Keywords. Plant-animal interactions – Livestock diet – Grazing management – Habitat use – Wildlife.

Les petits ruminants comme manipulateurs de l'habitat du lièvre marron (*Lepus europaeaus*) dans des parcours à base de chêne kermès

Résumé. *Le pâturage affecte la structure de l'habitat et les ressources fourragères ; ce qui influence l'abondance et la dispersion des populations de la faune sauvage. L'objectif de cette étude est de démontrer l'utilité des petits ruminants comme manipulateurs de l'habitat du lièvre marron dans un paysage en mosaïque (association de chêne kermès et d'herbacées). L'importance du chêne kermès comme aliment pour les caprins et les ovins au printemps a été estimée par analyse micro-histologique des fèces. On a aussi testé l'hypothèse selon laquelle différents niveaux d'intensité de pâturage affectent l'utilisation du chêne kermès par le lièvre, et le type d'habitat (bosquets de chêne kermès ou de prairie), qui est utilisé plus intensivement par les lièvres, en utilisant la méthode de comptage des crottes. Le chêne kermès représente le principal aliment chez les caprins et l'aliment secondaire pour les ovins. Les différents niveaux d'intensité de pâturage n'ont pas affecté l'utilisation des bosquets de chêne kermès par le lièvre. La végétation herbacée constitue la principale source d'alimentation du lièvre, alors que le chêne kermès a été utilisé par cet animal comme abri. La réduction de la superficie du maquis et la création de différentes formes et d'ouvertures dimensionnées (prairies) pourraient être avantageuses pour le lièvre marron. Néanmoins, la couverture et l'alimentation disponible doivent être considérées dans les programmes de conservation. La manipulation des bosquets de chêne kermès pourrait être basée sur les caprins et en second lieu sur les ovins. Les stratégies de pâturage peuvent être utilisées pour augmenter la disponibilité fourragère pour le lièvre, pour améliorer sa qualité et pour assurer une meilleure couverture permettant d'attirer les lièvres dans des endroits ciblés. Par conséquent, moyennant une gestion des parcours appropriée, la valeur de l'habitat du lièvre marron peut être améliorée.*

Mots-clés. *Interactions plante-animal – Alimentation du bétail – Gestion des parcours – Exploitation de l'habitat – Faune.*

I – Introduction

The interactions between grazing animals and their food resources is one of the insights of ecology. Nowadays, these interactions receive increasing interest since they play a major role in range and wildlife conservational strategies. Livestock grazing reduces plant height and above ground biomass, alters plant diversity and curtails the natural vegetation succession processes (Davidson, 1993). The most consistent effect of grazing is the reduction in aboveground biomass, which can be used for the management of wildlife species inhibited by tall and dense vegetation. It is well documented that declining of range condition or lowering the successional status benefits lower-seral wildlife species and adversely affects upper-seral ones. Range and wildlife managers may always consider this fundamental rule in decision making. Variables that can be easily modified are livestock stocking rate, type of livestock species and grazing duration, distribution, season and system (Holechek *et al.*, 1989). Thus, a grazing scheme can be designed to maintain or enhance habitat values for a particular (or a group of) wildlife species, but invariably, some other species will be negatively affected. The gravity of developing an appropriate grazing scheme is a thorough understanding of wildlife species' habitat needs (food, shelter, nesting, etc.) and limiting factors (predators, diseases, urbanization, etc.).

Brown hare (*Lepus europaeus*) is considered that evolved from the mountain form of the desert hare (*Lepus capensis*), in Middle East. The clearance of forests for agricultural purposes, which occurred after the end of the glacial period in Europe, resulted in hare geographic range expansion from Middle East throughout lowland Europe (Tapper, 1987). Hare thrives on a variety of open country habitats including grassland, scrubland, clearings in scrub and forest, farmland and pastures (Knip, 1990). Recent studies revealed that hares used more intensively the grazed grasslands than the ungrazed ones (Karmiris and Nastis, 2007; Kuijper *et al.*, 2008). In addition, small ruminants and hares relied upon different food resources when grazing in common in a mosaic landscape constituted by kermes oak stands and grasslands (Karmiris, 2006). In this study, it was documented that shrubs constitute the main food for goats and a substantial food resource for sheep. It was also found that shrub proportions in diet composition of small ruminants were lower in spring than any other season and this was attributed to the elevated availability and quality of herbage during this season. These findings give insight for the rangeland management strategy enhancement to a more holistic conservational approach, integrating livestock and hare needs. To ensure this, it is of vital importance to broaden the scientific knowledge about the use of kermes oak stands by hares in relation to grasslands and also to quantify the importance of kermes oak as a food resource for goats and sheep.

The aims of this study were: (i) to evaluate the significance of kermes oak as a food resource for goats and sheep in spring; (ii) to assess whether different levels of grazing intensity by livestock influences the use of kermes oak stands by hare; (iii) to define what kind of habitat (scrublands or grasslands) is used more often by hares; and (iv) to integrate these results in order to direct livestock management for the benefit of hare populations.

II – Materials and methods

The study area was a 100 ha rangeland (360-520 m altitude), north of the city of Thessaloniki in central Macedonia, Greece. This area was dominated by kermes oak (*Quercus coccifera*) stands of 1 to 2 m height, intermingled with scattered grassland patches (0.3-3 ha). Total size of kermes oak stands and grasslands were about the same in our study area. Other scrubs, such as Jerusalem thorn (*Paliurus spina cristi*), dog rose (*Rosa canina*), hawthorn (*Crataegus monogyna*) and phryganic plants, such as pink rockrose (*Cistus incanus*), and asparagus (*Asparagus acutifolius*) also coexist in these grasslands solitary. The main herbaceous species in the study area are brusch grass (*Chrysopogon gryllus*), yellow bluestem (*Dichanthium ischaemum*), sheep's fescue (*Festuca valesiaca*), Bermuda grass (*Cynodon dactylon*), drooping brome (*Bromus tectorum*), ovate goatgrass (*Aegilops ovata*), cocksfoot (*Dactylis glomerata*), starry clover (*Trifolium stellatum*), burr

medic (*Medicago polymorpha*), haresfoot clover (*Trifolium arvense*) and hop trefoil (*Trifolium campestre*).

This area was grazed by sheep and goats in common for several decades, following a traditional continuous grazing system, all year long. A gradient of utilisation intensities from moderate to almost ungrazed, according to distance from the entrance point in the study area to the most distant ones, was observed. Three discrete pastures (2-2.5 ha) with different grazing intensity (moderate, light and ungrazed) were selected. These were considered as treatments. The average stocking rate for the moderate, light and ungrazed pastures was 0.70, 0.36 and 0 small ruminants/ha/year, respectively.

The main wild mammal species in the study area are brown hare, fox (*Vulpes vulpes*), beech marten (*Martes foina*), weasel (*Mustela nivalis*) and badger (*Meles meles*). There is no farmland in the vicinity and hunting is not practiced. The climate is semiarid (average annual precipitation 416 mm), with cold winters and hot dry summers. The soil is shallow of low productivity and partially degraded.

In order to evaluate the diet composition of goats and sheep in the whole grazed study area, fresh faecal samples were collected in 4 sites (regardless of grazing intensity) in the middle of every month from March 2005 to May 2005. About 100 pellets of the tested herbivores were collected in each site every month. We tried to collect fresh pellets by following the grazed animals while differences in pellet morphology were used for the distinction of pellets of goats and sheep. In any case however, where distinguish of pellets either between goats and sheep or fresh and old was in doubt, we avoid collecting them. Samples were oven-dried at 105°C for 24 hours and then ground through a 1-mm screen. Each ground sample was mixed thoroughly to ensure particle uniformity. Microscope slides were prepared of identified reference plants and fecal samples as described by Litvaitis *et al.* (1996). Diet composition was determined using the method of microhistological analysis. The frequency of each species was converted into relative density as an estimate of the percent composition by dry weight with the frequency addition procedure (Holechek and Gross, 1982). The relative percentages of kermes oak, other shrubs, grasses and forbs in the diet composition of goats and sheep were evaluated. Plant species were identified by comparing their epidermal characteristics with the reference slides.

In late February 2005, 25 permanent fecal-pellet count plots (0.5 m radius) were randomly established in each treatment with different grazing intensity on kermes oak stands and on grasslands (in total 150 plots). Hare pellets were counted in late May and late August and subsequently removed from each plot. For more details about the use of this method see Karmiris and Nastis (2007).

Two simple main effects analysis of variance (Steel and Torrie, 1980) was used in order to evaluate the differences between: (i) the proportions of kermes oak and the other forage classes consumed by goats and sheep in spring; and (ii) the number of hare pellets deposited on kermes oak stands with different grazing intensities. In the first case, main effects were the species of livestock (goats and sheep) and the four major food categories. In the second one, the treated factors were the grazing intensity (three levels) and the two seasons. Proportions in diet composition (first case) were analysed using the square root transformation, but for convenience, the discussion is based on the original data. Comparison of pellet counts data between total scrubland and grassland area was performed with analysis of variance. In this case, a log(x+1) transformation of the original data was used in order to homogenise the variance between treatments. Mean differences were evaluated with the LSD test and considered significant at $P \leq 0.05$.

III – Results and discussion

Proportions of kermes oak were significantly higher ($F = 529.179$, $P < 0.001$) than any other type of forage in goats' diet (Table 1). For goats, significant differences were also found between the remaining forage types with grasses to be the second in declining order resource and forbs the third

one. For sheep, the most important food resource was forbs, followed by grasses and kermes oak ($F = 1565.931$, $P < 0.001$). Gross comparison of the forage consumed by goats and sheep reveals that the former are much more dependent on browse than the latter (kermes oak: $F = 636.943$, $P < 0.001$; other shrubs: $F = 144.863$, $P < 0.001$). Forbs ($F = 148.999$, $P < 0.001$) and grasses ($F = 129.827$, $P < 0.001$) were a more substantial part of sheep's diets than goats.

Table 1. Diet composition (%) of goats and sheep grazing in a typical Mediterranean rangeland in spring

Forage type	Goats	Sheep
Kermes oak	40^{aA}	16.9^{bC}
Other shrubs	5.1^{aD}	2.1^{bD}
Grasses	25.9^{bB}	36^{aB}
Forbs	22.5^{bC}	39.5^{aA}

^{a,b,A,B,C,D}Different letters indicate significant differences ($P \leq 0.05$) within rows (small letters) or columns (capital letters).

Hare use of kermes oak stands was relatively low during the study (Table 2). No significant differences were found in the mean number of pellets deposited in these stands between different levels of grazing intensity ($F = 0.179$, $P = 0.836$) and seasons ($F = 0.052$, $P = 0.820$). A highly significant result ($F = 80.063$, $P < 0.001$) was obtained comparing the mean of pellets deposited in the total kermes oak area to the respective one in the total grassland area. No significant differences ($F = 0.158$, $P = 0.692$) were found between seasons (spring and summer) in both habitat types. These results confirm that the prime feeding places of hares in this mosaic landscape of Mediterranean rangelands were almost exclusively the grassland sites.

Table 2. Mean hare pellet number per m^2 deposited in kermes oak stands with different levels of grazing intensity and in total grassland area during spring and summer

Season	Grazing intensity in kermes oak stands			Total scrubland area	Total grassland area
	Moderate	Light	Ungrazed		
Spring	0.36	0.36	0.56	0.43^{b}	6.68^{a}
Summer	0.48	0.44	0.48	0.47^{b}	6.40^{a}

^{a,b}Different letters within rows indicate significant differences ($P \leq 0.05$).

Mediterranean rangelands have been grazed by small ruminants for many centuries. Varying levels of stocking rate can influence plant communities in different ways (van der Meijden *et al.*, 1988). It is well established that moderate grazing stimulates new plant growth resulting in prolonged growing season (Tsiouvaras, 1988), while plant diversity may also be increased (Milchunas *et al.*, 1988), strengthening and stabilizing therefore range ecosystems function (McNaughton, 1979). Grazing can also influence abundance and spacing of fauna populations (Bolen and Robinson, 1995), as well as their feeding strategies (Gordon, 1988). Survival and reproduction capability of lagomorphs is greatly influenced by habitat characteristics and vegetation structure, therefore grazing may influence population dynamics of lagomorphs as well (Katzner and Parker, 1997). Small ruminants (both goats and sheep) have been used successfully for the biological manipulation of weeds and the improvement of grazing capacity. Since kermes oak was the prime food for goats in spring, while sheep consumed its biomass in a less intensive manner than goats, control of kermes oak growth can be achieved mainly by goats and secondarily by sheep. Many

studies have confirmed that goats are browsers (Malechek and Provenza, 1983; Pfister *et al.*, 1988) and they consume higher proportions of browse when kermes oak cover is elevated (Papachristou and Nastis, 1993; Papachristou *et al*., 2005). Under moderate and heavy grazing conditions, small ruminants are able to maintain or even retard vegetation succession. This can be achieved more effectively when the mix of goats and sheep is in favour of goats. In our study area however, kermes oak stands have already been out of reach of small ruminants, thus these herbivores are not able to control and deteriorate the growth of this shrub. In order to use grazing as a manipulator tool, firstly their height has to be lowered by mechanical means, prescribed burning or some other management practice. Under the current grazing conditions in the study area and even more in the absence of grazing, kermes oak stands will grow taller and denser while the grassland area will be reduced, resulting in deterioration of hare's habitat.

The prime feeding places for hares were grasslands, while scrublands were avoided. Thus, creating various shaped and sized openings (grasslands) could attract more hares to the study area, without however increasing their vulnerability against predators. The limited number of hare pellets counted in kermes oak stands indicates that this kind of habitat is of lightly use by hares as feeding places. However, based upon personal observations, kermes oak stands had their own importance, since these sites were used by hares during daylight for shelter. In 27 morning visits in the study area during the span of the experiment, we encountered 31 adult hares flushing from their shelters, disturbed by our presence as we were approaching them. Hares were sitting motionless under kermes oak shrubs in 19 cases, while in 8 cases they were under isolated shrubs (kermes oak: 3; Jerusalem thorn: 3; hawthorn: 1; and dog rose: 1) occurring in grasslands solitary. As for the rest 4 cases hares were found in hollows or depressions on soil surface in grasslands. In 18 cases, where we had the chance to visually observe hares after flushing, they also took shelter under shrubs. In addition, newborns were also found in kermes oak stands exclusively (8 cases). Shrubs and forested areas are considered as of prime importance for hares in many studies conducted in central and northern Europe, mainly because these areas provide shelter to hares against predators (Tapper, 1987; Panek and Kamieniarz, 1999). These observations lead us to the conclusion that kermes oak stands are valuable for hare's survival and reproduction, but they are of secondary importance as feeding places for hare. For vulnerable herbivores therefore such as hares, both available cover and food must be considered in conservational plans.

Half a century ago, range management was focused on forage production for feeding domestic animals, while wildlife concerns were exceptional (Bolen and Robinson, 1995). Nowadays, wildlife has become of increasing importance to public and managers, while multiple use and sustainable production of range ecosystems are gaining interest around the world (Holechek *et al.*, 1989). The results of this study reveal that small ruminants are a potential tool for creating suitable habitats for hares. Although this could reduce the net profit derived by livestock in a specific time-place, this loss may be compensated by hunting, or other recreational activities, which usually emerge when wildlife is favoured. Mechanical (root plowing, reseeding, etc.) and chemical (fertilizers, herbicides, etc.) methods are both expensive management practices. Additionally, the latter usually generates adverse side-effects causing many environmental hazards. Prescribed burning is a useful tool, but application is limited by potential air pollution and also by the necessity for specific conditions. Livestock grazing would not be intended to replace any other method, it would have its own limitations, but it is an additional tool for this goal. In addition, grazing minimizes fire hazard in susceptible ecosystems, as are rangelands in Mediterranean area. Grazing strategies may be developed to increase forage availability, to improve its quality and to attract hares to specific areas. The key for a success conservation plan in our case seems to be the ceasing of succession progress, preventing advanced stages of vegetation to dominate the landscape. Thus, under appropriate grazing management hare habitat values could be enhanced.

IV – Conclusions

Small ruminants grazing influences hare's habitat by modifying plant biomass, forage quality, vegetation structure (height and cover) and plant species diversity. It affects the distribution of

hares while reduces the risk of intensive large-scale fires in susceptible ecosystems. Small ruminants can be used to drive plant succession for the benefit of animal species, which prefer early successional stages, such as the hare. Kermes oak constituted the main food resource for goats during spring even though during this season herbage quantity and quality are usually high in Mediterranean area. Kermes oak stands were used by hares primarily for shelter as opposed to grasslands, which constituted their prime feeding places. Properly planned grazing by small ruminants in combination with other management practices, such as prescribed burning and mechanical means, can suppress undesirable vegetation and control kermes oak expansion, creating and maintaining a mosaic landscape which will provide adequate food and cover for hares. This conservation approach merits serious consideration in the future.

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