Effects of several plant species on the spatial distribution of the European hare (*Lepus europaeus*) at the microhabitat scale

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Abstract

The influence of three shrubby species (kermes oak – *Quercus coccifera*, Spanish broom – *Spartium junceum* and yellow kidney vetch – *Anthyllis hermanniae*) and three herbaceous (brusch grass – *Chrysopogon gryllus*, pineleaf pink – *Dianthus pinifolius* and common chicory – *Cichorium intybus*) on the European hare's (*Lepus europaeus*) use of space at the microhabitat scale was investigated in a Mediterranean rangeland in northern Greece. The number of hares' pellets in 0.5 m radius plots around and in 2 m distance from 10 individuals of each plant species was counted. In addition, the number of twigs (shrubs) and shoots (herbs) per individual bitten by the hare was also counted. Surprisingly, Spanish broom (*Spartium junceum*), a shrubby species which is rarely consumed and it is considered as non-preferred for most of the herbivores, was the most often visited and browsed by the hare in relation to all the other plant species studied. These Spanish broom – hare interactions are innovative, and open new ways for a holistic rangeland management based on the regulation of hare's use of space at the microhabitat scale, through the spatially distribution of specific plant species that provide food and shelter against predators. The evaluation of the hare's grazing intensity and use of space could be based on the number of twigs/shoots bitten by this herbivore, which is a less laborious and time-consuming parameter to estimate in relation to the pellet-count one.

Keywords: plant-herbivore interactions, vegetation composition, animal behavior, rangeland management, wildlife management.

Introduction

Understanding the principles shaping spatial distribution patterns of herbivores constitutes one of the insights of ecology. Abiotic (e.g. slope, distance to water, physical barriers etc.) and biotic (e.g. vegetation composition, productivity and quality of forage, etc.) components of habitats have been well documented as critical factors influencing the use of space by herbivores (Senft et al. 1987, Smith 1988). In most cases however, the availability of forage resources plays crucial role as herbivores spend more time in areas where the resource levels are high (Senft et al. 1987). Several management practices (water development, placement of salt and supplement, fencing, grazing systems, etc.) have been implemented to modify and control grazing distribution of domestic and wild herbivores (Bailey et al. 1996). Investigating the interactions between

plants and herbivores, indubitably, will contribute to a more sustainable and profitable use of the valuable natural resources in Mediterranean rangelands. Nowadays, these ecological interactions receive increasing interest since they play a major role in range and wildlife conservational strategies (Holechek et al. 2001).

European hare (*Lepus europaeus* – hereafter hare) uses more intensively habitats with increased heterogeneity, especially at the within- habitat scale (Vaughan et al. 2003, Smith et al. 2004). Hare's use of space is also influenced by the structure of the vegetation, i.e. it uses more intensively the grazed sites with a sparse and short vegetation height (Karmiris and Nastis 2007, Karmiris et al. 2010). However, for vulnerable species, such as the hare, availability both of forage and cover (shelter against predators) have been reported as critical factors affecting the use of space (Kuijper and Bakker 2008, Karmiris and Nastis 2009). Under this perspective, the presence of specific plant species which constitute the bulk of the diet of the hare and/or provide shelter against predators might influence the spatial distribution of the hare at the microhabitat scale.

The aim of this study was to investigate: (i) the effects of the presence of six shrubby and herbaceous species, known to provide food and/or cover for wild herbivores, on the European hare's spatial distribution at the microhabitat scale in a typical Mediterranean rangeland in northern Greece and (ii) the potential to use the parameter 'number of twigs and shoots' to evaluate the hare's grazing intensity and the use of space at the microhabitat level.

Material and Methods

The study was conducted in a 600 ha rangeland, located about 1-2 km north of the city of Thessaloniki in central Macedonia, Greece. The climate is semiarid (average annual precipitation 416 mm), with cold winters and hot dry summers. The soil, formed mainly by limestone and gneiss, is shallow of low productivity and partially degraded.

All study area is a part of the suburban forest of Thessaloniki (Kedrinos Lofos). Several measures have been applied in order to protect this area from development and to maintain its protective and aesthetic role, such as hunting banning and limitations to livestock grazing. The suburban forest was once dominated by the Calabria pine (*Pinus brutia*). About three-quarters of the total study area were burned by a wild fire in the summer of 1997. The experimental area was affected heavily by the fire (more than 90% was burned). As a consequence, the study area is now a mosaic of patches consisting of the remnant Calabria pine forest (approximately 5%),

regenerated pine forest (20%), kermes oak (*Quercus coccifera*) shrubland (50%) and grassland (25%).

The major plant species that constitute the bulk of the diet of the hare and/or provide shelter against predators in this area are the kermes oak, Spanish broom (*Spartium junceum*), yellow kidney vetch (*Anthyllis hermanniae*), brusch grass (*Chrysopogon gryllus*), pineleaf pink (*Dianthus pinifolius*) and common chicory (*Cichorium intybus*) (Karmiris and Nastis 2009, Karmiris and Nastis 2010). Ten individual plants of each of the aforementioned species were randomly selected and the number of hares' pellets in 0.5 m radius experimental plots around each individual was counted. Control plots of the same size and similar vegetation structure which however did not contain the targeted plant species were also established at within 2 m distance from the experimental plots. Faecal pellets were counted every 30 days and subsequently removed from each plot. In addition, the number of twigs (shrubs) and shoots (herbs) bitten by the hare per individual plant was also counted in the experimental plots. Hare's bite marks are easily recognizable especially when other domestic and wild herbivores do not graze in common (Bang and Dalstrøm 2004).

Statistical differences in grazing intensity of hares between experimental and control plots were tested using paired samples-t-test. Simple linear regression was used in order to detect significant relationship between the number of twigs and shoots bitten by the hare and the number of pellets. All tests were considered significant at the $P < 0.05$ probability level (Zar 1984).

Results and Discussion

The number of hare's pellets accumulated per 30 days (Figure 1) in experimental plots (0.5 m radius) with Spanish broom (m = 12, SE = 3.3) was significant greater ($t_9 = 2.672$, P = 0.026) than that in control plots (m = 2.3, SE = 0.7). Since the 95% confidence interval of the mean differences was not containing the value (0), we reject the null hypothesis that hare's grazing intensity was not influenced by the presence of this species. Spanish broom was both visited and bitten, i.e. hare was attracted in order to feed for sure. Except food, this observed reaction of hares may also be the outcome of the hare's need to hide which, Spanish broom may provide due to its shrubby formation. Because, in the present study kermes oak and other shrub species as well as the regenerated pine stands which they still have a shrubby form provide numerous suitable shelters for hares, cover cannot be considered as a limited resource for hares in our case. Consequently, the hare's use of space at the microhabitat scale should be

mainly influenced by the availability and the spatial distribution of forage resources and less by the availability of shelters against natural enemies. These results are innovative and highly valuable seeing that the hare's use of space can be manipulated through the spatially distribution of Spanish broom, which is non-preferred by livestock and other wild herbivores. As our knowledge of the mechanisms regulating the interactions between plant and herbivores get enriched, the predictions we make on their moving and feeding behavior and consequently the holistic rangeland management are more realizable, which eventually may lead to the opening of innovating conservational avenues – worthwhile to walk.

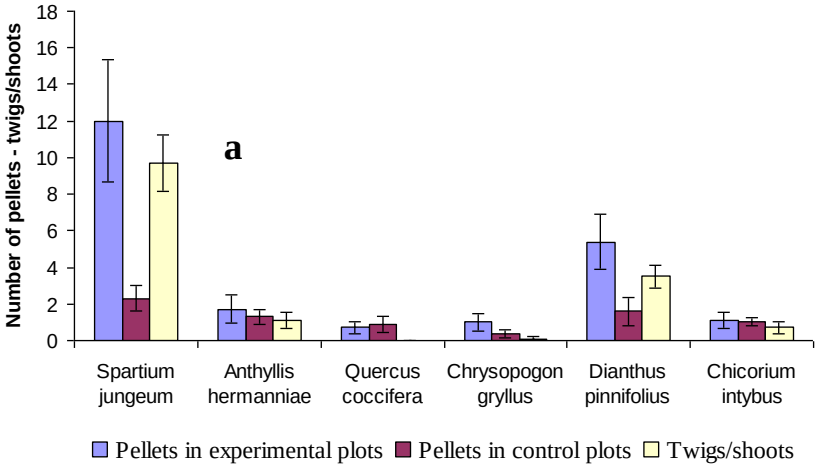

Figure 1. Number of hare's pellets (±SE) per 30 days in 0.5 m radius experimental and control paired plots around three shrub and three herb species and number of twigs/shoots bitten by the hare per species. Letters indicate significant differences in the mean number of pellets between experimental and control plots (paired-t-test, $P < 0.05$).

The estimated regression equation of number of pellets (Y) on number of bitten twigs and shoots (x) was found as $Y = 0.424 + 1.282x$, a significant linear relationship (d.f. = 58, $P < 0.001$) with a large effect size (adjusted $R^2 = 0.694$) (Cohen 1988). That means, the parameter 'number of twigs/shoots' can be used to evaluate the hare's grazing intensity and the use of space at the microhabitat level, as well as the parameter 'number of pellets'. The use of the former parameter is advantageous against the use of the latter one, as the

counting of bitten twigs/shoots is much quicker and accurate; especially in cases where dense and low height herbaceous vegetation covers the soil surface which obscures and makes the finding of the pellets a time-consuming procedure.

Conclusions

The hare's use of space at the microhabitat level depends on the spatial distribution of the Spanish broom, a shrubby species which provide both food and cover for this medium-sized wild herbivore and it is usually avoided by other wild and domestic herbivores. In Mediterranean rangelands where available cover for vulnerable prey species, such as the hare, is usually not limited due to the presence of many shrubby formations and solitary shrubs; the hare's use of space at the microhabitat scale should be mainly influenced by the availability and the spatial distribution of forage resources and less by the availability of shelters against natural enemies. In areas where the number of twigs/shoots bitten by the hare could be recognized without doubt, grazing intensity and use of space by hares at the microhabitat scale could be evaluated by counting the bitten twigs/shoots, a less laborious and time-consuming method than the pellet-count one.

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