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Livestock grazing and biodiversity conservation in Mediterranean environments: The Israeli experience

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SUMMARY – Livestock grazing has been considered for many years a source of ecological disturbance to natural ecosystems. Consequently, grazing has been excluded from protected areas such as nature reserves. However, livestock grazing is one of the few available tools for the management of dense woody vegetation stands such as those characterising the Mediterranean landscape. Recently, a more active mode of management has been proposed for biodiversity conservation in Mediterranean environments and livestock grazing should become part of it. This paper reviews research findings from Israel, concerning the relationships between livestock grazing and ecological parameters – genetic diversity, species richness and composition, and landscape structure – relevant for the conservation of biodiversity. The conclusion is that in most cases, livestock grazing can help achieve the conservation goals. However, a clear definition of operative conservation goals is a prerequisite for a successful management that optimises the benefits provided by the grazing livestock.

Key words: Mediterranean ecosystem, grazing impact, nature conservation, biodiversity, range management.

RESUME – "Pâturage du bétail et conservation de la biodiversité dans les environnements méditerranéens : L'expérience israélienne". Les animaux sur parcours ont été considérés longtemps comme une cause d'altération écologique et ont été exclus des zones protégées comme les réserves naturelles. Cependant, les animaux sur parcours sont un des rares outils disponibles pour gérer la végétation ligneuse dense qui caractérise certains paysages méditerranéens. Récemment, un mode de gestion plus actif, dont les animaux au parcours sont un élément, a été proposé pour conserver la biodiversité des milieux méditerranéens. Cet article fait le tour des résultats de la recherche en Israël sur les relations entre les animaux au parcours et les paramètres écologiques – diversité génétique, nombre d'espèces et leur composition, structure des paysages – impliqués dans la conservation de la biodiversité. La conclusion est que dans la majorité des cas, les animaux au parcours sont utiles pour atteindre les objectifs de conservation. Cependant, une définition claire des objectifs de la conservation est nécessaire pour le succès d'une gestion qui optimise les avantages qu'apportent les animaux sur parcours.

Mots-clés : Ecosystème méditerranéen, impact du pâturage, conservation de la nature, bio-diversité, gestion de l'espace.

Introduction

Conservation of natural values has become a major concern in the modern world. It does not merely deal with the preservation of endangered species of plants or animals but also with preventing drastic, sometimes irreversible, changes in landscape and ecosystems. The concept of nature conservation is not easily defined, probably due to its broad nature and the fact that it is strongly value-loaded. The task has become even more complex in recent years as the concept of biodiversity is gaining popularity and added to ecosystems as the principal conservation targets. The definition of biodiversity combines 3 ecological dimensions: genetic diversity within principal populations, community structure (species diversity and composition), and landscape heterogeneity. It should be realized that the biodiversity concept also includes the ecological processes occurring between the above-mentioned 3 dimensions (Shachak *et al.*, in press).

The common view considers livestock grazing as a disturbance factor to the natural ecosystem and, therefore, should not be practiced within reserves. Recently this common perception has been challenged in the Mediterranean environment and it was suggested that, since livestock grazing has been part of these system for millennia, it could serve as a legitimate tool for managing and conserving it (Perevolotsky and Seligman, 1998).

The Mediterranean environment supports various ecosystems depending on rock-soil type, site climatic conditions and land-use history. In general, plant communities of this region are composed of two dominant components: annual or perennial herbaceous plants and sclerophyllous, mostly evergreen, woody species (dwarf shrubs, shrubs and trees). Woodlands or shrublands composed of tall shrubs (3-5 m) or small trees, mostly dominated by *Quercus* species, are the common vegetation formations in the Mediterranean region. The succession of the vegetation in the Mediterranean region is well-documented: the woody species take over the open areas which are inhabited by diverse herbaceous community, while low shrubs are replaced by taller woody species. This process is interrupted occasionally by wild fires that consume the woody vegetation (Naveh, 1994). The Mediterranean ecosystem is, however, prone for rapid recovery and is considered very resilient (Perevolotsky and Seligman, 1998).

The human impact on the Mediterranean ecosystem has been rather intensive and long-standing (e.g., Naveh and Dan, 1973). Livestock grazing and wood-cutting are two of the principal activities by which humans have affected the Mediterranean landscape. We believe that these traditional Mediterranean activities should be part of the manager or conservationist management arsenal. The paper discusses the ecological outcome of using these management options under various conditions in the Israeli Mediterranean region.

Review of relevant field-work

Genetic diversity

The genetic diversity is part of the biodiversity concept. Genetic diversity is usually strongly correlated with ecological heterogeneity or with certain level of disturbance. There is little empirical evidence to the relations between livestock grazing and genetic diversity. The study of wild progenitors of cereals in the Middle East is one of the exceptions (Noy-Meir, 1990). These native tall grasses (*Triticum dicoccoides*, *Hordeum spontaneum* and *Avena sterilis*), found in restricted habitats in northern Israel, are a conservation target on a species level since they are close relatives of the domesticated wheat, barley and oat. The cover of these tall grasses is negatively correlated with grazing pressure. However, grazing seems crucial for maintaining the grasses distribution and the high genetic variation within their populations. Among the features conserved under grazing is the tolerance of grazing itself. Therefore, when management for conservation of these species is considered, livestock grazing is strongly recommended (Noy-Meir, 1990).

Species richness and composition

Already 25 years ago Naveh and Whittaker showed that heavy grazing generates the richest plant community (in terms of species richness) in the Mediterranean woodland and shrublands of northern Israel (Naveh and Whittaker, 1979). Naveh and Whittaker noted that within dense stands of woodland dominated by *Quercus calliprinos*, species richness was reduced by 75%. They reported on a similar decrease in abundance of birds, rodents, reptiles and insects.

Noy-Meir and his colleagues investigated the response of Mediterranean grassland to grazing in northern Israel. When grazing is excluded these grasslands are dominated by tall perennial and annual grasses (60-80% cover). But, under light to moderate grazing, they become more diverse due to a wide range of plants established in open patches. Heavy grazing has provided adequate conditions for yet another group of species, mostly small and prostrate ones, to become abundant (Noy-Meir, *et al.*, 1989).

A set of fire breaks was established at the Ramat Hanadiv Park in a Mediterranean calcareous rocky shrubland (600 mm), for preventing the spread of fire. Its management is based on one-time removal of the woody vegetation and an annual very heavy grazing pressure by beef cattle for a short duration at the peak of the productive (green) season (Perevolotsky *et al.*, 2002). The local herbaceous community is rather rich (more than 400 species). Contrary to expectations, the high grazing pressure had a limited negative impact on species richness of the herbaceous community (a decrease of 10-26%). This impact decreased as the spatial scale, at which richness was measured, increased. In general, the magnitude of the negative impact of grazing on plant diversity was lower

than the positive effect of shrub removal [an increase of 24-63% in species richness, also scale-dependent (Hadar *et al.*, 2000)]. However, it was noted that heavy grazing induced changes in the composition of the herbaceous community (small growth forms, geophytes and early flowering species were favoured). The density and diversity of flowering plants is significantly higher under these conditions as compared to grazing or clearing alone or to the control (untreated) plots (Hadar *et al.*, 1999).

Undergrazed Mediterranean grassland is prone to drastic structural changes in years of vole outbreak. The dominant tall grasses are replaced by annual forbs, many of them are ruderals. At the same time, adjacent moderately and heavily grazed areas preserve their diverse community structure (Noy-Meir, 1988).

In the case of the Mediterranean shrubland of Ramat Hanadiv it was also observed that cattle grazing generated an increase, over time, in the density of the attractive geophyte *Anemone coronaria*, in open patches within the shrubland. We believe that, here again, the ecological process involved is the release, by livestock grazing, of *Anemone* from competition for light imposed by the neighbouring dense herbaceous sward (Ne'eman *et al.*, 2003). The effect of different stocking rates and, in particular, very heavy grazing pressure on Mediterranean grassland was studied in the experimental farm of Karei Deshe in northern Israel. This area is dominated by Mediterranean basaltic grassland (600 mm), very rich in herbaceous species (more than 160). The impact of increasing stocking rates of beef cattle 2-4 times above the norm (1.8 ha/cow) was assessed. The study was based on a set of large exclosures (20-50 ha) and manipulations of stocking rates and/or timing/duration of the grazing period. The assumption was that species richness will decrease under either high grazing pressure, early grazing and/or a long grazing period (Sternberg *et al.*, 2000).

Under local conditions, excluding grazing for long periods results in low species richness (~30 spp.) and the community becomes dominated by tall plants. Continuous grazing, under the recommended regime, maintained species richness around 60 species (range 55-65). Doubling the grazing pressure generated no change in species richness. A change of the grazing regime into a more concentrated and seasonal, lowered species richness to 47 in early grazing and 36 in the late treatment. Doubling grazing pressure had no additional effect (41 species for both seasons). The pattern of change in species richness in all treatments seemed to follow strongly the specific year conditions and no trend of change over the study period was observed. Timing of grazing appears to affect community structure, most likely through the removal of tall species, thus enabling short species to become established. Actual grazing pressure appears to be of little significance in determining grassland diversity (Sternberg *et al.*, 2000).

Despite very significant manipulations in the grazing regime, the herbaceous community in Karei Deshe has demonstrated a remarkable resilience in terms of species richness and ground cover of the various life forms. The mechanisms supporting such resilience are not fully understood. Heavy grazing pressure reduced seed bank densities of many species and in other species the seed bank was not persistent (Sternberg *et al.*, 2003).

In another case study, the impact of heavy grazing by traditional Bedouin sheep herd on patches of herbaceous vegetation, within a dry Mediterranean (or semi-arid) dwarf shrubland, was assessed. Traditional Bedouin sheep husbandry involves continuous grazing starting very early in the growing season. In this region habitats with low productivity (hilltop, south-facing slopes) are dominated by low stature species while those with high productivity (wadi shoulders) were dominated by tall species. Grazing reduces the competitive effect of tall species in the dense stands of the productive sites and provides space for more species to become established, while causing no significant impact on the herbaceous community in the less productive habitats (Osem *et al.*, 2002).

Landscape structure

As stated above, the direction of the successional process in most Mediterranean ecosystem is towards closer and denser woody stands. Moreover, this ecosystem is notorious for its rapid recovery from perturbation. For example, dominant dwarf shrubs return to their original size within 2-4 years from either fire or mechanical removal (Perevolotsky *et al.*, 2001). Developed woodlands return to the original state within 20-30 years after fire.

There is wide evidence that the process of landscape closing generates a decrease in plant and wildlife diversity (e.g. Naveh and Whittaker, 1979). Hence, it is commonly agreed today that biodiversity will be conserved best if open patches will remain in the closing woody matrix (Perevolotsky and Seligman, 1998). Heavy grazing pressure by livestock may be one of the most efficient and cheaper tools for keeping the woodlands heterogeneous in structure.

The impact of severe intervening management on a Mediterranean shrubland has already been presented in the case of Ramat Hanadiv fire breaks. The recovery of this shrubland is very fast: shrubs returned to the same cover as before removal in 6 years. Heavy cattle grazing delayed the recovery in one year only, but a combined management – shrub removal and heavy grazing – slowed down significantly the full recovery and delayed it to approximately 20 years (Perevolotsky *et al.*, 2002). In this case, maximal floral richness of annual plants was also recorded in the combined shrub clearing-grazing treatment (Hadar *et al.*, 2000). The landscape manipulations – cattle grazing alone and combined with shrub removal – also increased the richness of invertebrate species by 50% and 175%, respectively (Ben Mayor *et al.*, n.d.).

The outcome of tree removal and goat grazing, as a tool for opening-up the Mediterranean woodland, was quantitatively assessed by remote sensing and GIS methods (Svoray *et al.*, 2003). It was demonstrated that such management has created new and more heterogeneous spatial pattern of the landscape and the overall cover of open patches increased. Figure 1 summarises various effects of livestock grazing on ecological parameters of different levels of ecological organisation: population, community and landscape.

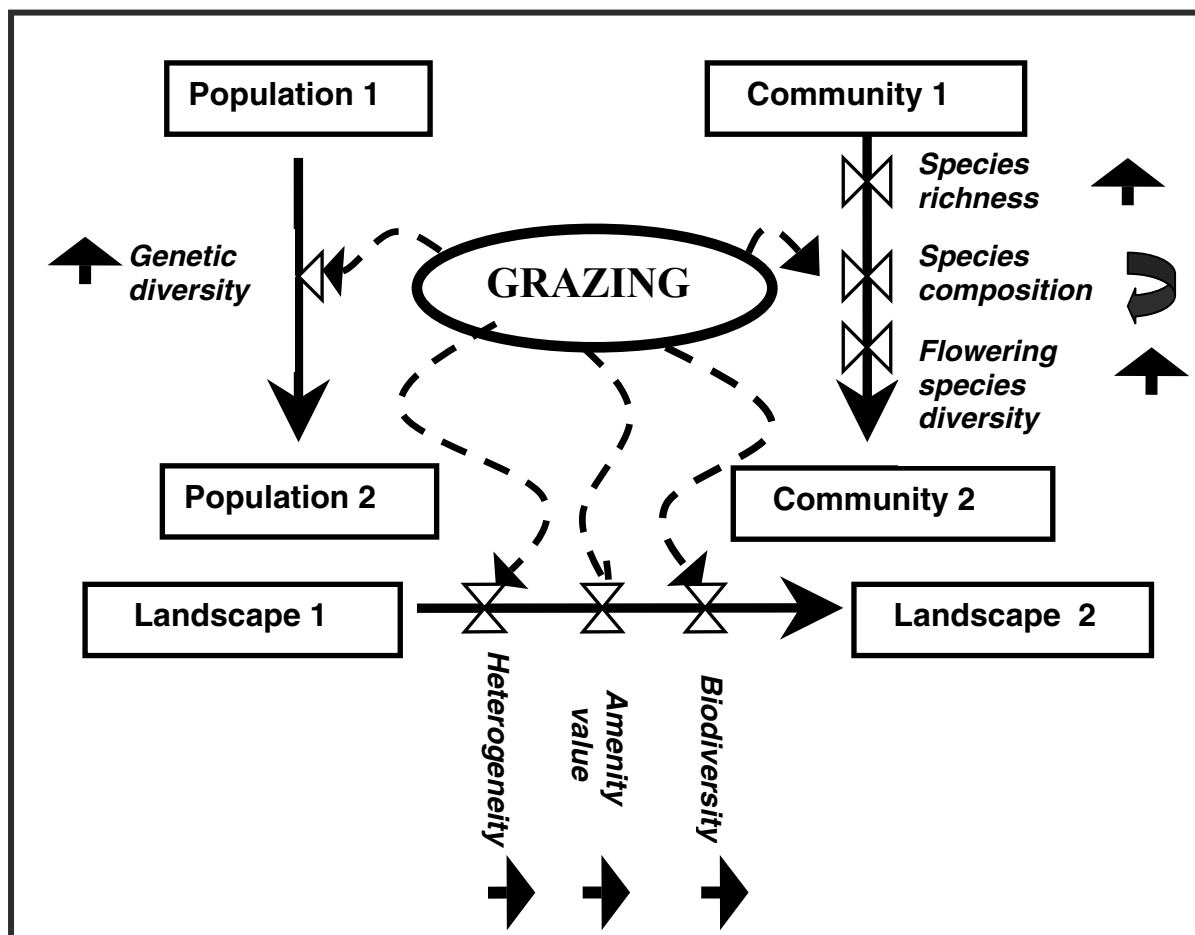


Fig. 1. A schematic over-view of the relations between livestock grazing and conservation parameters in the Mediterranean ecosystem.

Conclusions

(i) Livestock grazing has a significant effect on various ecological parameters of both the woody and the herbaceous components of the Mediterranean ecosystem.

(ii) Grazing may help in maintaining the genetic diversity within plant populations.

(iii) Grazing appears to be a very effective tool in releasing small, less aggressive herbaceous species, including geophytes, from competition, mostly for light, imposed by tall, aggressive plants. Consequently, grazing increases species richness and diversity of flowering species within the herbaceous community and may generate significant changes in species composition.

(iv) Livestock grazing, especially under heavy grazing pressure, may delay the successional process in which the landscape is closed-up by woody vegetation.

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