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Original article

Influence of cattle grazing on the density of oak seedlings and saplings in a Tabor oak forest in Israel

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ARTICLE INFO

Article history:

Received 18 May 2005

Accepted 30 November 2006

Published online 4 January 2007

Keywords:

Quercus ithaburensis subsp.*ithaburensis*

Eastern Mediterranean

Israel

Management measures

Mediterranean deciduous oak forest

ABSTRACT

The effects of cattle grazing on the density of seedlings and saplings in a Tabor oak forest (*Quercus ithaburensis* subsp. *ithaburensis*) are investigated. The Tabor oak forest studied is located in a Nature Reserve in the Mediterranean region of Israel. Cattle graze at a stocking density of 0.71 head/ha for 6 months a year. The cattle grazing in the Nature Reserve is a beneficial management measure because it enhances plant species richness and reduces shrub encroachment.

The impact of grazing on the densities of seedlings and young saplings was quantified in 46 large sampling plots (333 m² each) distributed over two experimental sites; the first being used as a rangeland for decades while the second is a forest patch totally free from grazing. The density and the height of Tabor oak individuals in each sampling plot were recorded. Four height categories were distinguished with a special focus on young seedlings (<0.15 m), established seedlings and young saplings (0.15 m–1 m).

The density of seedlings and young sapling in the grazed Tabor oak forest were, respectively, 61% to 67% lower than in the ungrazed treatment. Implications on the continuity of the entire Tabor oak forest ecosystem are discussed. Three management measures that enable to prevent a decrease in young oak densities are proposed – reduction of stocking rate, deferment of the commencement of grazing, and fencing young seedlings.

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1. Introduction

Once considered a major threat to Mediterranean-type ecosystems (Thirgood, 1981), livestock grazing has been progressively promoted since the 1980's, as an efficient management measure in Mediterranean forests that enhances plant biodiversity (Naveh and Whittaker, 1979; Blondel and Aronson,

1995; Verdu et al., 2000; Noy-Meir and Oron, 2001) and helps to reduce fire hazards (Gutman et al., 1991; Le Houérou, 1993; Perevolotsky and Seligman, 1998). However, several studies carried out in various forest types within the Mediterranean basin over the past twenty years have shown, or at least mentioned, that extensive, moderate grazing, may also cause severe damage to forest ecosystems, as it prevents the

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doi:10.1016/j.actao.2006.11.003

development of tree seedlings and therefore threatens the continuity of entire forest ecosystems (Quézel, 1998; Quézel and Barbero, 1990; Pinto-Correia, 1993; Fraval and Villemant, 1997; Montero and Cañellas, 1999; Pulido et al., 2001; Mountford and Peterken, 2003; Plieninger et al., 2004). Surprisingly, although many authors highlight a possible negative effect of extensive grazing on the dynamics of forest stands in the Mediterranean few attempts (e.g. Plieninger et al., 2004) have been made to quantify the impact of grazing on the regeneration and the sustainable development of Mediterranean forests and, more particularly, on the establishment and the development of tree seedlings.

The central aim of this study is therefore to quantify the effects of cattle grazing on seedling and sapling abundance of a Tabor oak forest that has been used as grazing area for decades and where cattle grazing has been promoted by the Nature Reserve Authority as a desirable management measure in terms of plant species richness and fire mitigation. The main question addressed in this paper is: Does cattle grazing affect the presence of tree seedlings and saplings in the Tabor oak forest? The implications of the current livestock grazing on the general sustainability of the Tabor oak forests in Israel are also briefly discussed.

1.1. Grazing in Mediterranean forests: a background

Various types of forests, needle-leaved and broad-leaved, are used for livestock grazing (cattle, sheep and goats) throughout the Mediterranean. In terms of area, the main types of forest that have been used for grazing are oak forests (*Quercus* spp.). Deciduous or semi-deciduous oak forests seem to have been particularly used for stock grazing as the soft and relatively large leaves of the oaks themselves carry a higher fodder value than the small and leathery leaves of sclerophyllous species (Blondel and Aronson, 1999). For example, forests with *Quercus pyrenaica* Willd. and *Quercus faginea* Lam. in Spain and Portugal are used as pasturelands (Joffre et al., 1999; Montero and Cañellas, 1999). In Algeria and Morocco, forests dominated by deciduous oak species such as *Quercus afares* Pomel and *Quercus canariensis* Willd. have been turned into grazing areas (Wojterski, 1990; Meddour, 1993). In Corsica, downy oak forests (*Quercus pubescens* Willd. subsp. *pubescens*) and sessile oak stands (*Quercus petraea* (Matt.) Liebl.) have been extensively grazed since the fourteenth century (Boyer et al., 1983). Similarly, in Turkey, the deciduous oak forests formed by *Quercus infectoria* subsp. *veneris* A. Kern., *Quercus cerris* L. and *Quercus pubescens* Willd. subsp. *crispata* Steven are used as grazing area, as well as the forest structures dominated by *Quercus brantii* (Lindley) in southeastern Anatolia and by *Quercus ithaburensis* subsp. *macrolepis* (Kotschy) Hedge & Yalt. in western and southern Anatolia (Davis, 1982). Finally, Tabor oak forests (*Quercus ithaburensis* Decne. subsp. *ithaburensis*) in Israel -my case study- are still used as grazing areas, mainly for cattle.

1.2. Types of impact

Grazing impacts on oak forest structures vary according to the life stages and the regeneration cycle of the oak population (see Pulido and Díaz, 2005): The 'pre-dispersal acorn

predation' (Ibid.) by livestock is limited to the browsing of the lower branches, generally up to 2.1 m height (Fraval and Villemant, 1997). The 'post-dispersal acorn predation' by cattle is considered one of the most severe types of damage in oak forests (Putman, 1996; Díaz et al., 1995; Santos and Telleria, 1997; Siscart et al., 1999; Pulido and Díaz, 2005). However, a recent study suggests that the extent of the destruction of the acorn bank by livestock may actually be much more limited than previously thought as the major acorn loss is due to predation by rodents (Leiva and Fernandez-Ales, 2003).

It is generally agreed that the main direct damage through the regeneration cycle seems to occur at the 'seedling emergence and establishment stage' (Pulido and Díaz, 2005) when seedlings are browsed or trampled on by livestock: By affecting the development of seedlings and the recruitment of saplings, browsing may prevent numerous individuals from attaining canopy status (Hester et al., 2000). The continuous hampering of the regeneration process may then lead to the progressive decay of the forest cover (Fraval and Villemant, 1997; Quézel, 1998; Hester et al., 2000; Pulido et al., 2001; Leiva and Fernandez-Ales, 2003; Plieninger et al., 2004; Quézel and Médail, 2003). Saplings, unlike seedlings, are not killed outright when browsed. Yet, their defoliation by the herds can severely hamper their development as the plant is left with an insufficient leaf area of photosynthetic tissue to operate at maximum efficiency (Putman, 1996). Nonetheless, potential positive effects of grazing on the regeneration of oak seedlings have been mentioned in several studies, as the grazing of the herbaceous layer depletes surface soil water and therefore induces higher soil water potential for oak seedlings (Hall et al., 1992, and references therein). However, these benefits will only arise if the density of oak seedlings is not reduced, by grazing, to levels below which the forest stand cannot be maintained.

2. Materials and methods

2.1. Study area

2.1.1. General features

The study area is the Ramot-Menashe region (32°37' N–35°E), located at 30 km south-east of the city of Haifa, Israel (see Fig. 1). The topography is characterized by low hills (elevation <200 m a.s.l.) formed from Eocene chalk outcrops. The soils are mainly shallow Rendzina, light brown or grey (Singer and Ravikovitch, 1980). The climate is typically Mediterranean *sensu* Köppen (Csa). The annual rainfall average is 650 mm. The Mediterranean bioclimate in the region considered is "sub-humid and hot" (*sensu* Emberger), with a remarkably long dry season lasting 7 months (see Dufour-Dror and Ertas, 2004).

The vegetation of the study area is characterized by the Tabor oak 'park forest', which is distinguished by an open to scattered tree coverage, dominated by *Quercus ithaburensis* Decne. subsp. *ithaburensis*, an East-Mediterranean deciduous oak. Tabor oak 'park forests' in Israel are further characterized by the presence of medium or dwarf shrubs such as *Calycotome villosa* (Poiret) Link, *Rhamnus lycioides* L. subsp. *graeca* (Boiss. et Reuter) Tutin, *Sarcopoterium spinosum* (L.) Spach, *Majorana syriaca* (L.) Rafin., and by a significant herbaceous stratum, dominated chiefly by Poaceae, with *Avena sterilis* L., *Hordeum*

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