Biological Conservation 159 (2013) 240–247

Contents lists available at SciVerse ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Assessing the effects of seasonal grazing on holm oak regeneration: Implications for the conservation of Mediterranean dehesas

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ARTICLE INFO

Article history:
Received 8 July 2012
Received in revised form 7 November 2012
Accepted 15 November 2012
Available online 23 January 2013

Keywords:
Agricultural intensification
Agroforestry
Browsing
Quercus ilex
Transhumance

ABSTRACT

Scattered trees in agricultural landscapes are globally declining due to the intensification of agricultural practices. Dehesas, highly species-diverse Mediterranean open woodlands, are seriously affected by this decline, because of a generalized regeneration failure of oak, which compromise their long-term stability. Traditionally, *dehesas* were the wintering areas for transhumant herds, but transhumance is disappearing in the Mediterranean, due to multiple causes. Reductions in grazing intensity or grazing abandonment have been proposed to improve oak regeneration in dehesas, but the effect of the recovery of non-continuous grazing practices such as transhumance has not been tested to date. We measured different indicators of holm oak regeneration and condition in dehesas under transhumant grazing and in dehesas under permanent grazing in southern Spain. Oak juveniles were remarkably less browsed and their canopies covered a much higher area in transhumant estates. As a consequence, the median density of saplings was more than four times higher in transhumant than in permanently-grazed estates. Although transhumant grazing is necessarily associated with a reduction in the stocking rate across the year, the timing of grazing was always included as a predictor in the best models to explain the condition and density of holm oak. Our results suggest that the lack of oak regeneration in dehesas can be caused not only by the increases in stocking rates, but also by the recent abandonment of traditional grazing practices like transhumance. We propose the recovery of seasonal grazing regimes based on transhumant pastoralism as a measure to improve the conservation status of dehesas.

1. Introduction

Scattered trees in agricultural landscapes are widely recognized as keystone structures because of the large number of ecological functions that depend upon their presence (Fischer et al., 2010; Manning et al., 2006), but they are globally declining due to the intensification of agricultural practices (Gibbons et al., 2008). Among these landscapes, *dehesas*, Mediterranean open woodlands resulting from the clearing of original evergreen oak woodland and shrubland areas (Plieninger, 2007), also known as *montados* in Portugal, constitute an example of agrosilvopastoral ecosystems with a high biodiversity. *Dehesas*, when adequately managed, are considered as the epitome of a sustainable land-use (e.g. Pinto-Correia et al., 2011). These systems occupy a large area in the Iberian Peninsula and its conservation is considered very important for both environmental and socio-economic reasons (Moreno and Pulido, 2008). Many production activities take place in dehesas, livestock production being the most important in those dominated by holm oak (*Quercus ilex* subsp. *ballota;* Pinto-Correia and Mascarenhas, 1999; Pinto-Correia et al., 2011). Traditionally, dehesas have been grazed by sheep, the most suited species for most *dehesas*, at low stocking rates, with cattle restricted to the most humid ones (Peco et al., 2006; Moreno and Pulido, 2008). Also, pigs are introduced to many *dehesas* between October and January to take advantage of the abundant acorn production that takes place in autumn. Livestock feed on the acorns and grass under the tree canopy, which also provides firewood. Trees are therefore viewed as an integrated part of the system, and as a result are managed and regularly pruned (Blondel, 2006).

Mediterranean climate is characterized by marked differences between wet winters and dry summers and great inter-annual variability in rainfall. These temporal changes in water availability generate remarkable variations in the productivity of Mediterranean grasslands. Transhumance practices consist in a regular and periodic movement of livestock from winter pastures (valley bottoms and/or southern latitudes) to summer pastures (mountains and/or northern latitudes; Weber and Horst, 2011). These practices optimize the use of the existing resources by matching the presence of animals in a given zone with the annual peak in productivity (Ruíz and Ruíz, 1986). This, along with the high variability in topographic conditions, makes transhumance a successful grazing

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0006-3207/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biocon.2012.11.015

management practice in these environments (Manzano and Casas, 2010; Niamir-Fuller and Turner, 1999; Weber and Horst, 2011). Because of its size, climate, topography and anthropological characteristics, transhumance systems have historically had a great importance in the Iberian Peninsula. In Spain, transhumance reached its peak in the Middle Ages, when up to 4 million sheep were involved in transhumant practices and an extensive network of protected drove roads was created (Manzano and Casas, 2010; Oteros-Rozas et al., 2012a; Ruíz and Ruíz, 1986). However, the breakdown of the Merino breed monopoly during the 19th century began a continuous decline of transhumance in Spain, aggravated in the 20th century by the use of rail and truck transport as alternatives to the movement of herds along drove roads (Oteros-Rozas et al., 2012a). As a consequence, the number of transhumant sheep has been reduced to ca. 250,000, of which only a 10% are moved by foot (MARM, 2011; Oteros-Rozas et al., 2012a). Simultaneously, the intensification of agricultural practices that European agricultural systems have been facing for more than a century (Ostermann, 1998; Stoate et al., 2009), have caused a drastic decline of traditional extensive grazing management practices. Extensive practices, which are characterized by low grazing intensities with traditional livestock races like the merino sheep, are being substituted by more intensive regimes that include the preference for large-scale free range grazing over traditional shepherding, increases in stocking rates and the use of heavier breeds of cattle (Pinto-Correia and Mascarenhas, 1999; Peco et al., 2001).

Dehesas, that have traditionally been the wintering areas for transhumant herds, are currently facing deterioration partly because of the overgrazing of estates, which is somewhat related with the sedentarization of previously transhumant herds. Similarly to other landscapes composed by scattered trees, the last decades have seen a remarkable decrease in the total area covered by dehesas as well as in the tree densities of the remaining ones (Moreno and Pulido, 2008). Studies on the tree size structure of dehesas have shown that these systems are characterized by over-aged oak stands, because of a disruption in the forest cycle characterized by an extensive lack of regeneration (Montoya, 1998; Plieninger et al., 2003; Plieninger, 2007). Whether the lack of regeneration of trees in dehesas is caused by the aforementioned shifts towards more intensive regimes or is an inherent feature of grazed dehesas independent of grazing intensity is a question that has not been definitely answered to date (Moreno and Pulido, 2008; Plieninger et al., 2011). Regardless of its causes, lack of regeneration of the tree layer is threatening the long-term stability of dehesas, because of the capital importance that oaks have on these systems (Joffre et al., 1999; Plieninger et al., 2003).

Consequently, there is an urgent need to develop measures that would improve the regeneration of oaks in dehesas (Gibbons et al., 2008; Pinto-Correia et al., 2011). Several options have been proposed to achieve this objective, such as reductions in grazing intensity, afforestation or temporary grazing abandonment (e.g. Plieninger et al., 2003; Ramírez and Díaz, 2008). However, the implementation of these options is not possible without severe ecological and socio-economic costs. For example, the drastic reductions in the stock capacity that would be necessary to achieve a carrying capacity compatible with the regeneration of holm oak would be associated with very high socio-economic costs for farmers (Plieninger, 2007). Furthermore, a total abandonment of grazing would reduce the soil's nutrient availability, and, more importantly, lead to shrub encroachment, with the subsequent accumulation of vegetation fuel on the ground that would increase the risk of severe wildfires compromising the sustainability of these systems (Joffre et al., 1999; Peco et al., 2006).

Among the proposed management options for the tree regeneration of dehesas, a spatially and temporally limited set-aside of grazing and cultivation by means of rotating fences is the one that has more often been preferred in both management and scientific literature (Gibbons et al., 2008; Montoya, 1998; Plieninger et al., 2003). In Mediterranean systems there is a very marked drought during summer, which results in reduction in the availability and quality of herbaceous vegetation. This is associated with a great increase in both the amount of supplementary feed needed by livestock during the summer (Gutman et al., 2000) and in the intensity of browsing in this season compared to spring, when there is a much higher availability of fodder (de Miguel et al., 1997). This fact has led to the proposal of the recovery of transhumance practices as a measure to solve the problem of the lack of regeneration of the tree layer in dehesas (Garzón-Heydt, 2004). In fact, the adoption of non-continuous grazing management schemes has been recently proposed as a measure to ensure the regeneration of scattered trees in Australian landscapes (Dorrough and Moxham, 2005; Fischer et al., 2010). Nevertheless, to date no study has tested the effects of seasonal grazing regimes on tree regeneration in dehesas.

In the present paper we analyze the effects of transhumant pastoralism on the regeneration of holm oak, by comparing several indicators of tree regeneration and condition in different dehesas with contrasting management regimes (transhumant seasonal grazing vs. permanent grazing). We hypothesize that the conservation and regeneration status of holm oak saplings and trees will be better in estates managed under transhumance regimes than in estates with permanent grazing regimes.

2. Materials and methods

2.1. Study area and sampling design

The study area is located in the municipalities of La Carolina, Vilches and Santa Elena (38°20′ N, 3°30′ W; 400–600 m.a.s.l.) in South-Central Spain (Fig. 1). The climate is typical Mediterranean, with very dry summers and rainfalls concentrated in spring and autumn. Annual rainfall is ca. 600 mm, and mean annual temperature ca. 17 °C. These dehesas are located in one of the wintering areas for transhumant livestock of the Conquense Drove Road, one of the major drove roads still in use on foot transhumance by sheep and cattle in Spain.

We selected 18 estates of two different types according to grazing seasonality: nine of them were grazed throughout the year ("Permanent"), while the other nine were managed by transhumant livestock raisers and grazed only for six months each year (between December and May; "Transhumant"). The estates were holm oak-dominated *dehesas*, which were selected in order to cover a large range of adult trees densities (20 to ca. 400 adult holm oaks ha^{-1}), always ensuring that this density was similar in transhumant (99.43 trees ha^{-1} ± 23.44) and permanent (98.64 ± 22.28) estates. We also made sure that we sampled a diversity of grazing alternatives: among the studied estates, some were grazed by sheep (9 estates), some by cattle (6) and some by both (3), with a balanced distribution of these alternatives between transhumant and permanent estates. Interviews with landowners and shepherds revealed that all the selected estates have maintained their current grazing seasonality and grazing pressure for at least the last 10 years and that, besides grazing, small game hunting is the only noteworthy practice that takes place both in transhumant and permanent estates. Interviews also showed that the estates, including the transhumant ones, are leased by herders throughout the year, independently of the time of permanence of livestock on the estates. The area of the states ranged between 20 and 480 ha, with no significant differences between transhumant (210.15 ha ± 25.82; mean ± SE) and permanent (193.91 ± 19.56) states.