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Land use changes and ground dwelling beetle conservation in extensive grazing dehesa systems of north-west Spain

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ABSTRACT

Traditional management practiced over centuries in Mediterranean cultural landscapes has led to singular agrosilvopastoral ecosystems such as dehesas. Recent abandonment of dehesa management has resulted in shrub encroachment, habitat homogenisation and increased fire risk. Mechanical shrub cutting to decrease biomass load creates novel cleared dehesas with yet unknown consequences for the ecosystem function. We investigated the effects of these land use changes on ground dwelling beetles (carabids and staphylinids) as model organisms by comparing traditionally grazed, long-time abandoned and newly cleared dehesas. Land use changes affected beetle species composition by altering habitat structure (e.g., litter layer) and the availability of feeding resources. Grazed dehesas held the highest number of exclusive species and particular functional guilds of carabid seed eaters and staphylinid coprophiles, utilizing food resources related to the presence of grazing livestock (annual herbs and coprophagous insects). Beetle assemblages of abandoned dehesas, resembling those known from surrounding human disturbed oak forests, exhibited the lowest abundance and greatly differed from beetle assemblages of grazed dehesas. Shrub clearance after dehesa abandonment benefited opportunistic beetle predators feeding on decomposers associated with cutting slash left on the ground. The habitat structure and beetle species composition of cleared dehesas slightly approached those of grazed dehesas, therefore suggesting shrub cutting as a first step towards restoration of abandoned dehesas. However, since livestock grazing is an essential driver of ground dwelling beetle composition, it should be promoted after shrub cutting in cleared dehesas to restore the characteristic assemblages, species interactions and ecosystem function of grazed dehesas.

1. Introduction

In the Mediterranean region, characterised by unique cultural landscapes and outstanding biodiversity, many species are strongly adapted to the recurrent disturbances caused by traditional management practiced through millennia (Blondel et al., 2010). Recent land use changes resulting in the abandonment of non-competitive Mediterranean traditional systems can then be detrimental for biodiversity and threaten the preservation of singular ecosystems (Blondel et al., 2010; Stoate et al., 2001) in which resource exploitation and nature conservation are achieved together (see Gómez-Limón and de Lucío Fernández, 1999). This is the case of the Spanish *dehesa* (and its Portuguese counterpart *montado*), a traditional agro-forestry system that simultaneously supports extensive livestock grazing, forestry and even agricultural production while maintaining high values of biodiversity, and that is strongly affected by the land use changes determined by national and EU agricultural policies (Gómez-Limón and de Lucío Fernández, 1999; Plieninger, 2006). The distinct habitat structure of the dehesa system, with mature trees scattered in a continuum of grasslands, depends entirely on traditional management practices and is created by the combination of tree thinning and pruning, shrub cutting and domestic livestock grazing. Dehesas also provide additional ecosystem services economically valuable such as beekeeping, game hunting, ecotourism and even carbon sequestration (Bugalho et al., 2011).

In north-west Spain, dehesas are scarce, mainly constituted by *Quercus pyrenaica* trees, and embedded in a mosaic of forests with different habitat structures shaped by a variety of human uses and disturbances (Tárrega et al., 2006, 2007). Contrary to the large dehesa systems of southern Spain that are privately owned, the small dehesas in north-west Spain function as public renting systems, typically shared by the livestock holders of neighbouring locations.

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Uniqueness of these dehesa systems is supported by their peculiar spatial arrangement (Taboada et al., 2006a; Tárrega et al., 2006) and great diversity in microhabitats (i.e., old-growth trees, pasture grassland, clusters of tree saplings, isolated shrubs, piles of pruning debris, etc.) which enhances biodiversity at the local and regional scales (Taboada et al., 2006a, 2011; Tárrega et al., 2006). In these dehesas, the maintenance of large mature trees, uncommon in the surrounding highly modified *Q. pyrenaica* landscape (Robles et al., 2011), is essential for the conservation of endangered species such as the Middle Spotted Woodpecker (Robles et al., 2007), as well as for the persistence of other adapted species like secondary cavity nesting birds (Robles et al., 2011). The singularity of these dehesa sites is reinforced by their cultural and historical values as being part of the traditional transhumance routes used for centuries to shepherd livestock between summer highland and winter lowland pasturelands.

During the last decades a progressive depopulation of the rural areas is threatening the conservation of dehesas (Gómez-Limón and de Lucío Fernández, 1999). The abandonment of dehesa management results in shrub encroachment which increases the risk of fire (Pinto-Correia and Mascarenhas, 1999), may decrease biodiversity (Bugalho et al., 2011) and may lead to habitat loss and reduction of the carrying capacity for livestock (Moreno and Pulido, 2009). To counteract these negative effects and preserve the pasturelands, shrub cutting with heavy machinery has been recently implemented in many places (Canteiro et al., 2011; Pinto-Correia and Mascarenhas, 1999). Mechanical shrub cutting may be detrimental to tree regeneration (Pinto-Correia and Mascarenhas, 1999) and may have negative effects on plant (Tárrega et al., 2009; but see Canteiro et al., 2011) and bird diversity (Camprodon and Brotons, 2006). In those dehesa systems of north-west Spain where grazing activities have become uneconomical, mechanical shrub cutting is a presently applied management practice whose effects on living organisms remain poorly known (Tárrega et al., 2009). As a consequence of the abandonment of traditional land uses and the implementation of new management activities, three types of dehesas currently exist in this region (Fig. 1): (1) traditionally managed dehesas where the extensive grazing system (generally, sheep and goats) is maintained, (2) long-time (more than 20 years) abandoned dehesas, and (3) cleared dehesas where mechanical shrub cutting is carried out by the regional administration to reduce the biomass load after grazing abandonment. The three dehesa management types differ in habitat structure, topsoil conditions and vegetation (Tárrega et al., 2009), which may in turn affect fauna diversity and composition.

Soil arthropods, and among them ground dwelling beetles such as carabids and staphylinids (Coleoptera: Carabidae, Staphylinidae), are particularly sensitive to land use changes (Bohac, 1999; Rainio and Niemelä, 2003). In temperate regions, these beetles are plentiful and diverse and greatly contribute to ecosystem functioning mainly by pest predation (Bohac, 1999; Lövei and Sunderland, 1996; Rainio and Niemelä, 2003) and seed consumption (Honek et al., 2003). The majority of carabids are generalist predators though some complement their diet with seeds or are specialised granivores (Honek et al., 2003 and references therein). Similarly, although some staphylinid beetles feed on fungi or pollen, the majority are also predators (Bohac, 1999), many being adapted to ephemeral microhabitats such as carrion, dung, rotting plants and fungi, where they principally feed on fly larvae and other small arthropods (Muona and Rutanen, 1994). Since carabids and staphylinids belong to high trophic levels of the soil food web (Halaj and Wise, 2002) they may reflect changes at lower trophic levels caused by shifts in the nutrient input, plant production, habitat structure and arthropod abundance and composition (Lövei and Sunderland, 1996; Thiele, 1977). Previous studies have demonstrated that the dehesa systems of north-west Spain greatly contribute to regional biodiversity as they hold distinct carabid assemblages different from those of adjacent *Q. pyrenaica* ecosystems (Taboada et al., 2006b) and pasturelands (i.e., grasslands not surrounded by a forest matrix; Taboada et al., 2011). Within these dehesa ecosystems, carabid assemblages also differ between the forested habitat and the pasture grassland (Taboada et al., 2006b) rendering high diversity values at the local scale. However, there are no studies on the staphylinid assemblages of these dehesa systems to date. Although several authors have studied the effects of dehesa grazing abandonment and shrub encroachment on ground dwelling arthropods (Azcárate and Peco, 2012; Barriga et al., 2010; Martins da Silva et al., 2008, 2009), to our knowledge,

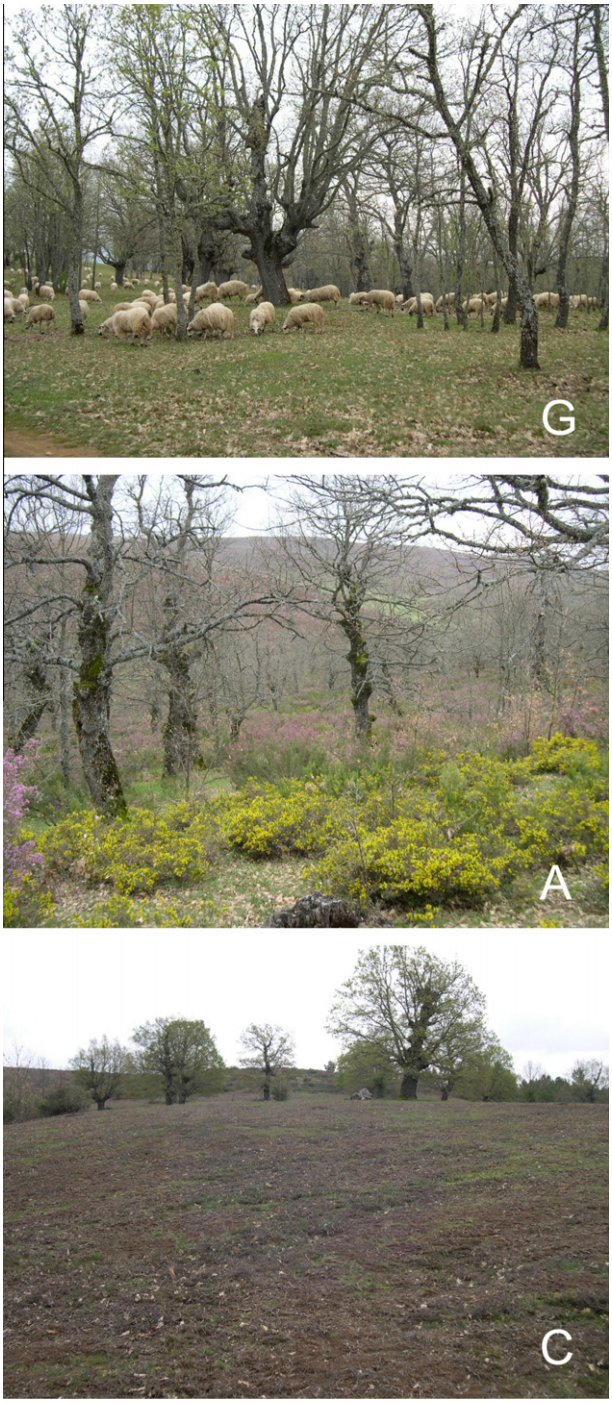

Fig. 1. The three types of dehesa systems, defined by the different management practices applied. G = grazed dehesas; A = abandoned dehesas; C = cleared dehesas.