Ecological Indicators 49 (2014) 76–82

Contents lists available at ScienceDirect

Ecological Indicators

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

Carabid beetles as indicators for shrub encroachment in dry grasslands

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ARTICLE INFO

Article history:
Received 16 May 2014
Received in revised form 1 September 2014
Accepted 30 September 2014

Keywords:
Biomass
Cytisus scoparius
Fourth-corner-analysis
Functional traits
Habitat heterogeneity
Succession

ABSTRACT

Semi-natural grasslands are key habitats for biodiversity conservation in Central Europe. Shrub encroachment is one of the most threatening drivers of grassland degradation and affects soil properties, microclimate, and vegetation with possible impacts on higher trophic levels. We aimed to analyse the impact of shrub encroachment with broom (*Cytisus scoparius*) on carabid beetle diversity, species composition, and functional traits. In a field study on dry grasslands on the island of Hiddensee (Germany) we studied 15 sites along a gradient of increasing broom encroachment and classified them into three dry grassland types with low, medium, and high shrub cover. Our results provide evidence that shrub encroachment initially has positive effects on species richness and activity densities of dry grassland carabids. Carabid species composition differed among differently shrub-covered dry grassland types, and sites with low and high shrub cover were each characterised by unique carabid assemblages. The species composition of sites with a medium shrub biomass had a transitional character and contained species which are typical for open dry grassland, but also shared species with sites with a high shrub cover. Among functional trait parameters investigated, especially the body size of carabid beetles was related to environmental parameters associated with shrub encroachment. Body size was positively correlated to shrub biomass and soil humidity, but negatively to temperature. Eurytopy values of carabids were related to high litter cover, i.e. habitat generalist (eurytopic) species mainly occurred in densely shrub-encroached sites. In order to preserve unique carabid assemblages of open dry grasslands with stenotopic and smaller species, it is most important to prevent a shrub encroachment higher than about 60% cover. For management we suggest extensive grazing (by cattle, sheep or horses) to prevent shrub encroachment on dry grasslands. In areas with high shrub cover additionally the use of goats or mechanical removal of shrubs might be necessary.

1. Introduction

The traditional management over centuries and associated regular disturbances have favoured the occurrence of diverse assemblages of semi-natural grasslands, which have become a key habitat for biodiversity conservation in Central Europe (Baur et al., 2006; Duelli and Obrist, 2003; Poschlod and WallisDeVries, 2002). During recent decades European semi-natural grassland areas have dramatically declined, and further declines to less than 50% of the current area are predicted (Beaufoy et al., 1994; Rounsevell et al., 2005; Strijker, 2005). Major causes are land-use changes with agricultural intensification of some of these grasslands and an abandonment of traditional management procedures such as mowing and grazing in other grasslands. Successional processes including shrub encroachment have become a serious problem in semi-natural grasslands in many parts of Europe (Olsson et al., 2000; Parr et al., 2009; Prevosto et al., 2011; Tasser et al., 2007).

Shrub encroachment is considered to be one of the most threatening drivers of grassland degradation (Blaum et al., 2009; Moleele and Perkins 1998). Local effects of shrub encroachment include changes in soil properties such as decreasing pH, increasing nitrogen content, and higher amounts of soil organic matter. These effects are particularly strong with nitrogen-fixating shrubs, such as broom *Cytisus scoparius* (Valles et al., 2011). Moreover, shrub encroachment affects microclimate by balancing temperature extremes and increasing air humidity (Mantilla-Contreras et al., 2012; Valles et al., 2011). This induces changes in vegetation composition and structure with possible impact on higher trophic levels (Caldwell, 2006; Isermann et al., 2007). At larger scales, shrub encroachment may lead to habitat fragmentation of semi-natural grassland with consequences for typical

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http://dx.doi.org/10.1016/j.ecolind.2014.09.041
1470-160X/

grassland plant and animal populations (Blaum and Wichmann, 2007; Herremans, 1998; Meik et al., 2002).

Dry and nutrient-poor semi-natural grasslands often harbour a high diversity particularly of invertebrates (Riksen et al., 2006 Van Swaay, 2002). In such ecosystems, shrub encroachment is a threat especially for open-habitat specialists, mainly due to the loss of disturbance and dynamic effects (Bonte et al., 2006; Schirmel and Buchholz, 2011). Studies examining the impact of succession and shrub encroachment on grassland invertebrates include positive (e.g. butterflies: Balmer and Erhardt, 2000), negative (e.g. Orthoptera: Marini et al., 2009) or none (e.g. carabids: Schirmel and Buchholz, 2011) effects on diversity. However, even if diversity does not change along successional gradients, community composition might due to the replacement of one specialist by another (Buchholz, 2010). In line with this change also shifts in species functional traits could be assumed along successional gradients. Integrating functional traits are of growing interest in conservation biology, because they represent an additional aspect of biodiversity and supplement results of taxonomy-based analyses. For example, Schirmel et al. (2012) showed that body size and the number of non-flying carabids increased towards older stages in heath succession, while species richness remained unaffected.

The aim of our study was to analyse the effects of shrub encroachment on dry grassland carabid beetles (Coleoptera: Carabidae). Carabid beetles are suitable ecological indicators for shifts in terrestrial ecosystems (Koivula, 2011; Kotze et al., 2011; Schirmel and Buchholz, 2011). They are rich in both individuals and species, have high reproduction rates, include several stenotopic species, have a well known ecology, and sampling is easy and cost-effective (Lövei and Sunderland, 1996; Rainio and Niemelä, 2003). We were especially interested how the biomass of shrubs correlates with carabid diversity and species composition. Moreover we aimed to identify functional traits of carabids responding to shrub encroachment. To do so we conducted a field study on dry grasslands on the island of Hiddensee, NE Germany, during the vegetation period of 2010. We studied 15 sites along a gradient of increasing encroachment with broom (*C. scoparius*) and classified them into three dry grassland types with low, medium, and high shrub cover. We addressed the following research questions: (i) Does shrub encroachment (measured by shrub biomass) affect carabid species richness, activity density and species composition? (ii) Which functional traits of carabid beetles are related to the environmental parameters associated with shrub encroachment? (iii) What can be concluded for dry grassland management?

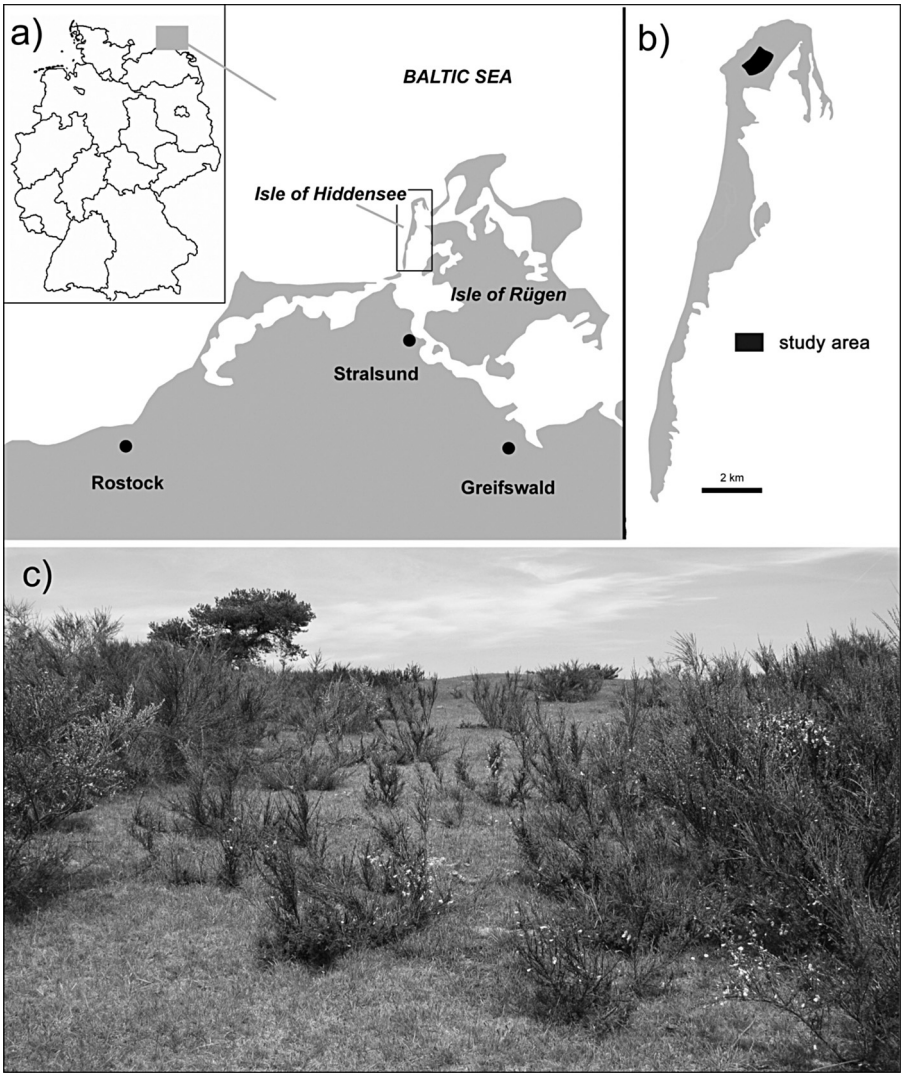

Fig. 1. The position of (a) the island of Hiddensee in NE Germany and in the Baltic Sea and (b) the study area on the island. (c) The dry grasslands in the northern part of the island are traditionally used for grazing and mowing, but in recent years the abandonment of land use led to an increasing shrub encroachment, mainly of broom *Cytisus scoparius*.