Acta Oecologica 60 (2014) 7–16

Contents lists available at ScienceDirect

Acta Oecologica

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

Original article

The impact of grazing management on Orthoptera abundance varies over the season in Mediterranean steppe-like grassland

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ARTICLE INFO

Article history:
Received 20 March 2014
Accepted 11 July 2014
Available online 5 August 2014

Keywords:
Grasshopper
Sheep grazing
Vegetation structure
Biodiversity

ABSTRACT

As semi-natural grassland has a high level of biological diversity, understanding the effects of grazing and its variation over time is important in order to identify sustainable grazing practices. We measured temporal variation in Orthoptera abundance and spatial vegetation structure during seasonal grazing in an extensive sheep-farming system. We studied five grazed pasture areas (pre-grazing and post-grazing) and two adjacent ungrazed grasslands. We recorded the total abundance of Orthoptera and described the vegetation structure of 175 replicate plots (25 per pasture/grassland) during six field sampling sessions. We demonstrated that the impact of grazing on Orthoptera abundance is species-specific and greatly varies over the grazing season. The decrease of phytovolume is significant after 4–7 weeks of sheep grazing. Total Orthoptera abundance was higher in pre-grazed plots than in ungrazed plots, and higher in ungrazed plots than in post-grazed plots. These differences were particularly high during the peak of adult abundance. No difference in species richness was observed between grazing intensities. Total Orthoptera abundance positively correlated to phytovolume only when grazing pressure was high. However, the relationship between abundance and phytovolume differed between species. Extensive grazing by sheep tends to homogenize spatial vegetation structure and to temporarily reduce total Orthoptera abundance at pasture scale. However, rotational grazing allows spatial and temporal heterogeneity in vegetation structure to be maintained at farm scale, heterogeneity that is beneficial for Orthoptera. In contrast, absence of grazing has a negative impact on Orthoptera abundance as it favours the accumulation of litter, which is detrimental for a high proportion of xerothermophilic Orthoptera associated with bare ground and short vegetation.

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1. Introduction

Semi-natural grasslands are recognized in Europe for their ecological interest because of their high level of biological diversity of plant and invertebrate life, and notably as the habitat of several rare or threatened species (Báldi and Kisbenedek, 1997; Poschlod and WallisDeVries, 2002; Cremene et al., 2005). However, the ecological maintenance of semi-natural grassland is historically associated with or dependent on management, either by regular mowing or grazing by domesticated livestock. The feeding preferences and social behaviour of domestic livestock create sward heterogeneity under conditions of low-intensive grazing (Hofmann and Tallowin, 2004), which in turn largely influences the composition and abundance of invertebrate communities (Kruess and Tscharntke, 2002; Eschen et al., 2012).

Orthoptera are often an essential group of species among invertebrate communities in grassland ecosystems since they correspond to the largest biomass of arthropods (Little et al., 2013). As a result, they also represent a crucial prey source for many insectivorous invertebrate and vertebrate species such as spiders, birds and reptiles (Belovsky and Slade, 1995). Orthoptera are recognized as good indicators of modification in grassland ecosystems (Báldi and Kisbenedek, 1997; Bazelet and Samways, 2011), especially in relation to grazing management (Dolek and Geyer, 2002; Kruess and Tscharntke, 2002; Rook et al., 2004; Schirmel et al., 2010). Grazing can have different effects on Orthoptera species according to their ecological traits, by reducing food availability

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http://dx.doi.org/10.1016/j.actao.2014.07.001
1146-609X/Published by Elsevier Masson SAS.

and modifying the spatial vegetation structure and soil surface, thereby influencing microclimates and the availability of oviposition sites (Wettstein and Schmid, 1999; WallisDeVries and Raemakers, 2001; Kruess and Tscharntke, 2002). Studies have shown that the varying impact of livestock on Orthoptera is also dependent on parameters such as local grazing history (Quinn and Walgenbach, 1990), as well as the breed and grazing intensity of the livestock (Dolek and Geyer, 2002; Kruess and Tscharntke, 2002; Rook et al., 2004).

Many studies have shown that grazing is often followed by changes in Orthoptera abundance, with greater density in ungrazed grassland (or after low-intensity grazing) than in grazed grassland (Welch et al., 1991; Fielding and Brusven, 1995; O'Neill et al., 2003; Batáry et al., 2007). This effect may differ between species depending on their habitat requirements; in particular according to the species' optimal level of herbaceous density and canopy (Jepson-Innes and Bock, 1989; Batáry et al., 2007; Jauregui et al., 2008). Decreased grazing intensity has been proposed as a useful management method to preserve the diversity of invertebrate communities, including Orthoptera (Kruess and Tscharntke, 2002; Buckingham et al., 2006; Dumont et al., 2009; Eschen et al., 2012). However, few studies indicate what constitutes sustainable grazing for the maintenance or enhancement of biodiversity (Tallowin et al., 2005), notably in terms of grazing intensity and the optimal season for grazing. As the lifecycle stages of different Orthoptera species occur at different times over the summer (O'Neill et al., 2003), the grazing period is likely to influence the abundance of Orthoptera according to species, as has been suggested by studies conducted outside Europe (Onsager, 2000; Gebeyehu and Samways, 2003). However, studies on how grazing affects the Orthoptera community are often performed as a one-off snapshot or during only part of the season of Orthoptera presence, which significantly reduces the possibility of comparing studies, as well as their heuristic value. We felt it would be very valuable to record experimental data during a complete season of Orthoptera presence in order to define sustainable grazing conditions (in terms of intensity and period) in regard to the maintenance of this insect community.

In our study, we investigated an extensive sheep-grazing system to determine the effect of seasonal grazing on Orthoptera abundance on the largest steppe-like grassland area in the south of France. Many steppe-like grasslands in the Mediterranean area are managed by extensive sheep-grazing systems (Blondel et al., 2010), yet very few studies have been done on the relationship between grazing, vegetation and Orthoptera abundance in these systems. The aim of the study was to determine temporal variation in Orthoptera abundance, as well as variation in species richness and species' responses to grazing management. In the context of extensive grazing, we predicted that: (i) Grazing contributes to change spatial heterogeneity of herbaceous. (ii) Seasonal grazing has a varying effect on Orthoptera abundance over the summer period. (iii) Changes in grazing pressure and herbaceous structure contribute to changes in Orthoptera abundance.

2. Material and methods

2.1. Study area

The study area was located in the mountainous zone of the Massif Central (southern France), specifically on a high limestone plateau (Causse Méjean) characterized by karst topography, poor soil, and steppe-like grasslands with some cultivated zones. The mixed continental and Mediterranean climate and high altitude (800–1250 m) result in alternating seasons of cold wet winters and hot dry summers. The mean maximum temperature occurs in July (23 °C) and the minimum in January (3 °C). Precipitation is about 1000 mm per year, but the high permeability of the subsoil and frequent wind result in a low level of soil humidity. The eastern part of the plateau consists predominantly of steppe-like grasslands, with a herbaceous stratum made up principally of *Festuca* spp., *Bromus erectus* Huds. and *Stipa pennata* L., and several species of shrubs (*Buxus sempervirens* L., *Juniperus communis* L., *Amelanchier ovalis* Miller, *Crataegus monogyna* Jacq. and *Rosa* spp. L.) that are more or less dispersed. The grasslands of Causse Méjean have been used for sheep grazing for several centuries, as have similar neighbouring plateaus, with which they constitute the largest extent of steppe-like grasslands in France and one of the largest in southern Europe.

Observations were conducted in 2010 on an experimental farm (44°17′ N, 3°31′ E) in the eastern part of the plateau, at an altitude between 950 m and 1100 m. The farm (and a large part of the surrounding area) is managed by the Cévennes National Park, which controls the intensity, period and localization of the sheep-grazing program. In the study area, a flock of 340 sheep extensively grazed five large pastures in a total rangeland area of 214 ha (Table 1), with a density of 1.6 sheep ha^{-1} or 0.24 Livestock Units ha^{-1}. This experimental farm is representative of others in the Causse Méjean in regard to its surface area, flock size, pasture configuration and grazing management, enabling research experiments conducted here to be applied to working farms in this region.

2.2. Sampling design

This study was carried out in seven pasture areas, five of which had been grazed by sheep every year for at least 10 years, and two of which had not been grazed (ungrazed grassland) for at least six years and were used as control plots (Table 1). The seven pastures were adjacent and had highly homogenous vegetation, so they presented very similar characteristics of vegetation, soil and topography. Season and grazing pressure (identified as the number of sheep per day and per hectare: ([number of grazed days * number of sheep]/pasture area in ha) for the five grazed pastures have been similar since 2006. Every year, each of the five pastures has been grazed continuously over a period of approximately one month between May and November (Table 1).

We randomly placed 25 10-m^2 plots in each of the seven pastures, excluding a 10-m buffer zone from the boundary edge. We performed six sampling sessions in the field (each lasting 4–5 days) at a two-week frequency during the summer period, i.e. 05-July to 24-Sept. 2010 (on the weeks starting 05-July, 26-July, 09-Aug., 23-Aug., 06-Sept. and 20-Sept.), according to the lifecycle of adult Orthoptera species present in the study area (the survey started when adults were identifiable, and ended when species decreased to very low densities). All 25 plots on a pasture were sampled before performing observations in another pasture, and we randomly sorted the order of pasture for each sampling session. During the six sampling sessions, three pastures changed their status from pre-grazed to post-grazed (pastures 3, 4 and to a lesser degree 5), whereas two pastures (1 and 2) had already been grazed at the beginning of July (Table 1). We thus obtained 1050 sampling plots (25 plots per pasture × 7 pastures × 6 sampling sessions), with three different sheep-grazing treatments (250 pre-grazed plots, 500 post-grazed plots, and 300 ungrazed plots), for each of which we recorded information about Orthoptera and the vegetation.

2.3. Orthoptera data

At each sampling plot, we counted and identified Orthoptera (Ensifera and Califera) along a permanent 10-m^2 line-transect