Agriculture, Ecosystems and Environment 200 (2015) 21–32

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Response of carabid beetles diversity and size distribution to the vegetation structure within differently managed field margins

Abdelhak Rouabah [a,b,*], Jean Villerd [a,b], Bernard Amiaud [c,d], Sylvain Plantureux [a,b], Françoise Lasserre-Joulin [a,b]

[a] Université de Lorraine, UMR 1121 "Agronomie & Environnement", ENSAIA, 2 avenue de la Forêt de Haye, TSA 40602, 54518-Vandoeuvre Cedex, France
[b] INRA, UMR 1121 "Agronomie & Environnement", ENSAIA, 2 avenue de la Forêt de Haye, TSA 40602, 54518-Vandoeuvre Cedex, France
[c] Université de Lorraine, UMR 1137 "Écologie & Écophysiologie Forestière", Faculté des Sciences et Technologies, 54500 Vandœuvre-lès-Nancy, France
[d] INRA, UMR 1137 "Écologie & Écophysiologie Forestière", Faculté des Sciences et Technologies, 54500 Vandœuvre-lès-Nancy, France

ARTICLE INFO

Article history:
Received 7 January 2014
Received in revised form 8 October 2014
Accepted 10 October 2014
Available online xxx

Keywords:
Carabidae
Body size
Functional diversity
Vegetation heterogeneity
Biological control
Regression trees

ABSTRACT

Managing field margins to promote carabid diversity requires understanding the diverse responses of these insects to vegetation structure within these margins. This diversity in carabid responses could be determined by variation in species functional traits, of which body size is likely to be a key factor. In the present study, the effect of vegetation structure within differently managed field margins on species richness, activity-density and size distribution of carabids was investigated. Experimental margin plots were established in three cereal fields using a replicated block design. Carabids were sampled using pitfall traps in the margin plots, the crop edge, and the crop area of the fields. A decision tree analysis was used to classify structural variables of the vegetation according to their effect on carabids. Both a high number of carabid species and those important for effective pest control were associated with the field margins. Management influenced carabids only in the field margin. Higher plant functional diversity was identified as the primary factor promoting carabid species richness. Their activity-density was negatively correlated to the vegetation heterogeneity and positively to percentage of bare ground. Large species presented high activity-density in homogenous vegetation with high proportion of bare ground, whilst small species preferred high plant functional diversity and heterogeneous vegetation. High activity of medium sized species was associated with high but less heterogeneous vegetation. This diversity in carabid responses to the vegetation structure appears to be related not only to variation in their body size, but also in other life history traits such as diet.

1. Introduction

After more than half a century of agricultural intensification that has completely changed the European agricultural landscapes and where increasing productivity received the most attention, biodiversity conservation and more generally natural resources management are increasingly integrated in the E.U. Common Agricultural Policy (CAP). Installing field margins within the arable cropping systems is one of the most widely adopted conservation measures (Landis et al., 2000; Marshall and Moonen, 2002; Vickery et al., 2009). According to Smith et al. (2008), the establishment of these agro-ecological infrastructures generally aims three key ecological functions (i) increasing species density in an agro-ecosystem (biodiversity value), (ii) providing habitats for rare or endangered species (conservation value) and (iii) enhancing ecosystem services, particularly biological control of pests (functional value).

Carabid beetles (Coleoptera: Carabidae) are an important group of beneficial arthropods and their conservation in agricultural landscapes is targeted by the installation of field margins (Marshall and Moonen, 2002). They are widely distributed throughout most agro-ecosystems (Holland et al., 2002), but their populations are increasingly threatened by the intensification of crop production practices and the simplification of agricultural landscapes. Both larvae and adults of most carabid species are carnivorous and have been implicated as predators of many invertebrate pests such as aphids (Schmidt et al., 2004), lepidopteran larvae (Sunderland, 2002), and slugs (Mair and Port, 2001; Oberholzer and Frank, 2003). Several other species are granivorous and have been shown to be effective and important predators of weed seeds (Holland, 2002; Gaines and Gratton, 2010).

By adapting the initial establishment and the management of field margins in order to meet habitat requirements of carabids,

* Corresponding author. Tel.: +33 3 83 59 58 19; fax: +33 3 83 59 57 99.
E-mail address: abdelhak.rouabah@univ-lorraine.fr (A. Rouabah).

http://dx.doi.org/10.1016/j.agee.2014.10.011
0167-8809/

farmers may improve biological control of pests and weeds provided by these insects. From this perspective, previous studies have investigated the response of carabids to field margins establishment and management. Thus, Meek et al. (2002) and Smith et al. (2008) have investigated the response of carabids to field margins sown with different seed mixtures. Mowing (Cameron and Leather, 2012; Haysom et al., 2004), herbicide application (Hawthorne et al., 1998; Smith et al., 2008), soil disturbance (Smith et al., 2008), and inorganic fertilizer application (Woodcock et al., 2007a) have been the main management practices studied. Presenting the general pattern of carabid response, these studies have suggested that increasing the vegetation heterogeneity of the field margins benefits these insects by providing shelter and more diversified food resources (Wardle and van der Putten, 2002). However, carabids are both taxonomically and ecologically diverse and different species could have different habitat requirements, and may respond in different ways to this habitat structure and management. For example, Haysom et al. (2004) showed that increasing cutting frequency opened the vegetation and significantly increased the abundance-activity of three carabid species; *Pterostichus melanarius*,*Pterostichus niger* and *Nebria brevicollis*, but at the same time it decreased that of three other species; *Pterostichus strenuus*, *Trechus quadristriatus* and *Amara communis*.

Variation in carabid responses to the habitat conditions could be influenced by variation in the species functional traits, of which mobility and trophic level are likely to be key factors (Davies et al., 2000; Ribera et al., 2001). Indeed, it has been suggested that differences in mobility between the carabid species result in different patterns of habitat occupancy (Haysom et al., 2004; Rainio and Niemelä, 2003), rapidly moving species (e.g. *P. melanarius* and *N. brevicollis*) may prefer habitats with open and sparse vegetation (Haysom et al., 2004). It has been also expected that bare ground patches of different sizes would benefit differently to carabid species according to their rate of movement, as this would affect how easy it is for an individual carabid to access the vegetation for shelter and feeding (Cameron and Leather, 2012). The phytophagous carabids that show a preference for feeding on seeds of grasses, umbellifers and crucifers (Purtauf et al., 2005), are likely to be more habitat specialist and dependent on local habitat type, compared to predatory ones (Woodcock et al., 2010).

Some morphological traits also influence habitat choice by the carabid species. Body size is considered to be a key functional trait and often used as an indicator of habitat quality for carabid beetles (Bommarco, 1998; Eyre et al., 2013). In addition, body size distribution of the species present in a habitat is a parameter potentially indicating different types of environmental stress (McGeoch, 1998; Ribera et al., 2001). A common trend for this is that smaller carabids should be more abundant than larger one in habitats with higher disturbance levels compared to less disturbed ones (McGeoch, 1998; Ribera et al., 2001).

Understanding how the vegetation structural characteristics of managed field margins could affect carabid species with different functional traits is critically important. It identifies indicator species that are susceptible to particular managements, and help to better guide such managements depending on the objective targeted by the initial establishment of the field margins, i.e. biodiversity conservation or biological control. Biological control does not necessarily need a diverse predator community, however, the performance of a predator community with regard to pest suppression may be driven by whether key species with high performance (e.g. with high consumption rates) are present (Ives et al., 2005; Rouabah et al., 2014; Sih et al., 1998). This corresponds to the sampling or positive selection effect of increasing predator diversity (Ives et al., 2005). For carabid beetles, we have previously shown that prey suppression was strengthened by the presence of large species, such as *P. melanarius* and *Carabus auratus* (Rouabah et al., 2014).

The objective of the present study was to investigate how management of field margins affects carabid diversity and body size distribution, through changing the structure of vegetation. Thus, five management treatments (One Cut, Two Cuts, Stubble ploughing, Stubble ploughing fallowed by a Cut, and an Unmanaged treatment) were applied to margin strips of cereal fields with the aim of creating plots with different composition and different degrees of vegetation structural heterogeneity. Species richness, activity-density, and body size distribution of carabids within the field margin, the crop edge, and in the crop area were compared between the five management treatments. Using a recently described decision tree approach, structural characteristics of the vegetation within the margin strips were classified according to their effect importance on carabids. It was hypothesized that (1) field margin management increases the species richness and activity-density of carabids through increasing vegetation structural heterogeneity, (2) unlike cutting which homogenizes the vegetation, stubble ploughing allows seeds germination, increases the diversity of plant functional diversity, and then increases the vegetation heterogeneity and promotes carabid diversity, and (3) the influence of the vegetation structure on carabids would vary between species with different body sizes.

2. Materials and methods

2.1. Study site

The study was undertaken in 2012 on a mixed farm in Saint-Jean sur Tourbe in northeastern France (49°07′35.63″N, 4°40′46.29″E). Located in a very poor landscape in terms of agro-ecological infrastructures, this 320 ha farm is considered as the pilot site of the “Arc en Ciel” project. This project aims to evaluate the relevance of installing non-cropped field margins, from both biodiversity enhancement and potential agronomic repercussions points of view. Thus, between 2007 and 2009 several field margin strips, were established in the farm to divide many 20 ha fields into two parts.

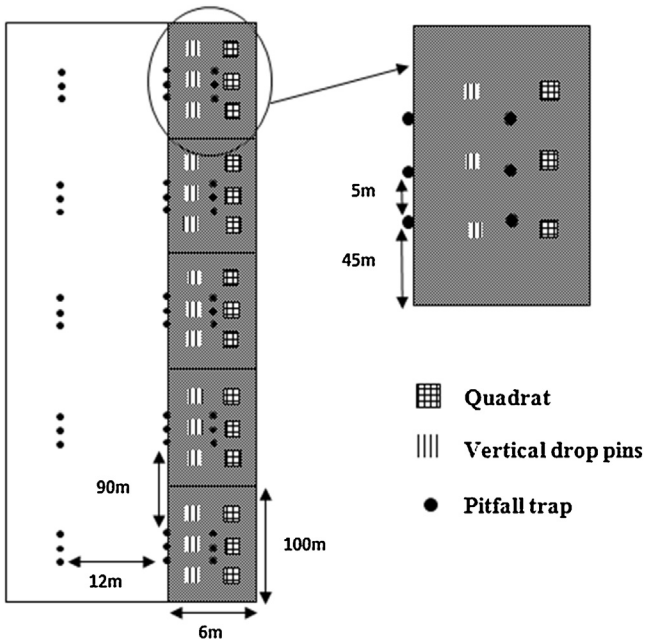

Fig. 1. Field margin plots and the sampling positions for carabids and vegetation in the field.