GRADIENTS IN ABUNDANCE AND DIVERSITY OF GROUND-DWELLING ARTHROPODS IN TEMPERATE SILVOARABLE FIELDS

Pardon P[1,2,3*], Reheul D[2], Mertens J[1,4], Reubens B[3], De Frenne P[1,2], De Smedt P[1], Proesmans W[1], Van Vooren L[1,3], Verheyen K[1]

(1) Department of Environment, Ghent University, 9090 Gontrode, Belgium (2) Department of Plants and Crops, Ghent University, 9000 Ghent, Belgium (3) Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), 9820 Merelbeke, Belgium (4) Department of Applied Biosciences, Ghent University, 9000 Ghent, Belgium

*Corresponding author: paul.pardon@ugent.be

Abstract

Ground-dwelling arthropods play an important role in agricultural systems by providing multiple ecosystem services (ES), such as affecting nutrient and carbon cycling and providing biological pest control. However, potential patterns in presence of these arthropods in temperate agroforestry systems (AFS) have only been investigated to a limited extent. Therefore we have assessed the abundance and diversity of woodlice (Isopoda), millipedes (Diplopoda), rove beetles (Coleoptera: Staphylinidae) and carabids (Coleoptera: Carabidae) in function of distance to the tree row in temperate arable AFS. Abundance and diversity of woodlice and millipedes was significantly increased in the tree rows and in the arable zone near mature trees. These results indicate that the tree component of temperate AFS contributes to the preservation of arthropod biodiversity and the enhancement of associated ES, both in the tree rows and in the arable field zone.

Keywords: woodlice, millipedes, poplar, maize, winter cereals

Introduction

Ground-dwelling arthropods play an important role in agricultural systems by providing multiple ecosystem services (ES). Detritivorous species, for instance, affect nutrient and carbon cycling, and predatory species biological pest control. The presence of semi-natural landscape features, such as the tree component of agroforestry systems (AFS), may contribute to increasing functional agrobiodiversity and optimizing the delivery of abovementioned ES in agricultural landscapes. Alley cropping is a particular type of AFS whereby trees are organized in rows over the field. As a result, it can efficiently be combined with the use of modern farming techniques and machinery for the cultivation of agricultural crops in the intercropping zone between the tree alleys. Hence, this cropping system may be especially suited to increase the presence of semi-natural landscape features while maintaining agricultural production (Quinkenstein et al. 2009; Tsonkova et al. 2012). However, potential patterns in abundance and diversity in temperate [illegible] soil-dwelling [illegible] ere assess the abundance and diversity of woodlice (Isopoda), millipedes (Diplopoda), rove beetles (Coleoptera: Staphylinidae) and carabids (Coleoptera: Carabidae) as function of distance to the tree row in temperate arable fields.

Materials and methods

Two types of experimental fields were selected to investigate the abundance and diversity of beneficial arthropods on alley cropping fields of varying age (Figure 1). The resulting set comprised six young alley cropping fields. In addition, since older arable alley cropping systems in Flanders are scarce, a set of eight arable fields that are partly bordered by a tree row and partly by a treeless grassy edge (further referred to as “boundary planted fields”) was selected as a proxy (Table 1). On the young alley cropping fields, two transects were laid out between and perpendicular to the tree rows. Seven sampling points were fixed on a transect: two were located within the tree alleys (“A”), and the others at distances 1 (“B”) and 5 (“C”) m away from the field edge near both tree rows and one in the center of the intercropping zone (“D”, approximately at 12 m from the field edge) (Figure 1a). Two control points were marked at a distance varying between 18 to 55 m away from the tree rows (“E”). In each boundary planted field, two transects were installed perpendicular to the tree row and to the treeless border (Figure 1b). The treeless parts of these fields hereby act as a reference situation. Four sampling points were marked in each transect, located in the field border (“F”) and at distances 1 (“G”), 5 (“H”) and 30 (“I”) m away from the field edge (Figure 1b). At each sampling point in both systems, a pitfall trap was installed during the last week of May 2015. The traps were in place during four weeks. For each individual trap the total number of woodlice, millipedes, carabid beetles and rove beetles caught was counted. The captured specimens of every taxon, except for rove beetles, were identified to species-level. This procedure was repeated in 2016 on a subset of the fields. Generalized mixed effects models with a Poisson error structure and Linear mixed effects models were used to investigate differences in abundance (expressed as “activity-density”), species richness and Shannon-Wiener diversity.

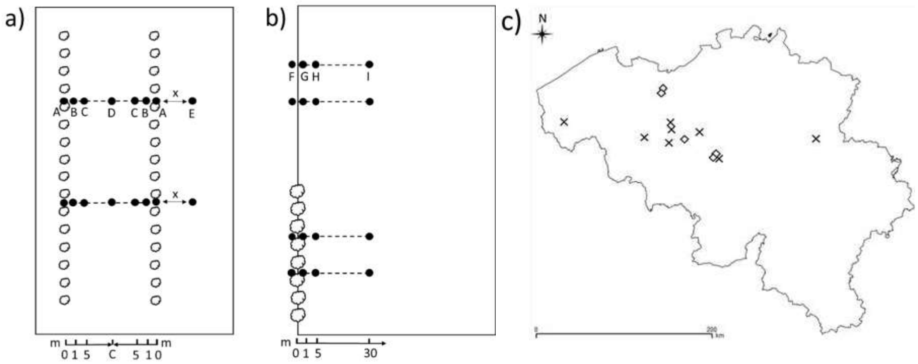

Figure 1: Experimental design. a) alley cropping fields, b) boundary planted fields. Black dots represent measuring positions. c) Location of experimental fields in Belgium (◊ alley cropping, x boundary planting).

Table 1: Characteristics of experimental fields. Year of plantation was estimated based on pers. comm. with farmer and/or tree coring. “Orientation”: orientation of tree alleys (EW: East-West, NS: North-South). “Exposition”: location of sampling field with regard to tree row. “NA”: no samples collected in 2016.

ALLEY CROPPING				
Location	**Year of plantation**	**Orientation**	**Crop 2015**	**Crop 2016**
Lochristi 1	2011	EW	Forage maize	Winter wheat
Lochristi 2	2011	EW	Forage maize	Forage maize
Lochristi 3	2012	EW	Winter wheat	Forage maize
Vollezele	2010	NS	Winter barley	NA
Haut-Ittre 1	2011	NS	Winter wheat	Winter wheat
Haut-Ittre 2	2011	NS	Grain maize	Winter wheat
BOUNDARY PLANTING				
Location	**Estimated year of plantation**	**Exposition**	**Crop 2015**	**Crop 2016**
Sint Pieters Leeuw	2001	West	Grain maize	NA
Haut-Ittre	2000	West	Winter wheat	NA
Maarkedal	1998	East	Grain maize	Grain maize
Tongeren	1998	West	Winter wheat	NA
Ieper	1985	East	Grain maize	Grain maize
Geraardsbergen	1988	West	Winter barley	NA
Herzele	1977	West	Forage maize	NA
Steenhuize	1985	East	Forage maize	NA

Results

Activity-density, species richness and Shannon-Wiener diversity of woodlice and millipedes were significantly affected in both systems by distance to the tree rows/treeless field edges with decreasing values at further distances in the field (Figure 2, Table 2). In addition, for activity-density, species richness and Shannon-Wiener diversity of woodlice and for activity-density of millipedes, a significant effect of tree presence was found on the boundary planted fields with increased values in and nearby the tree rows when compared to the treeless field edges.

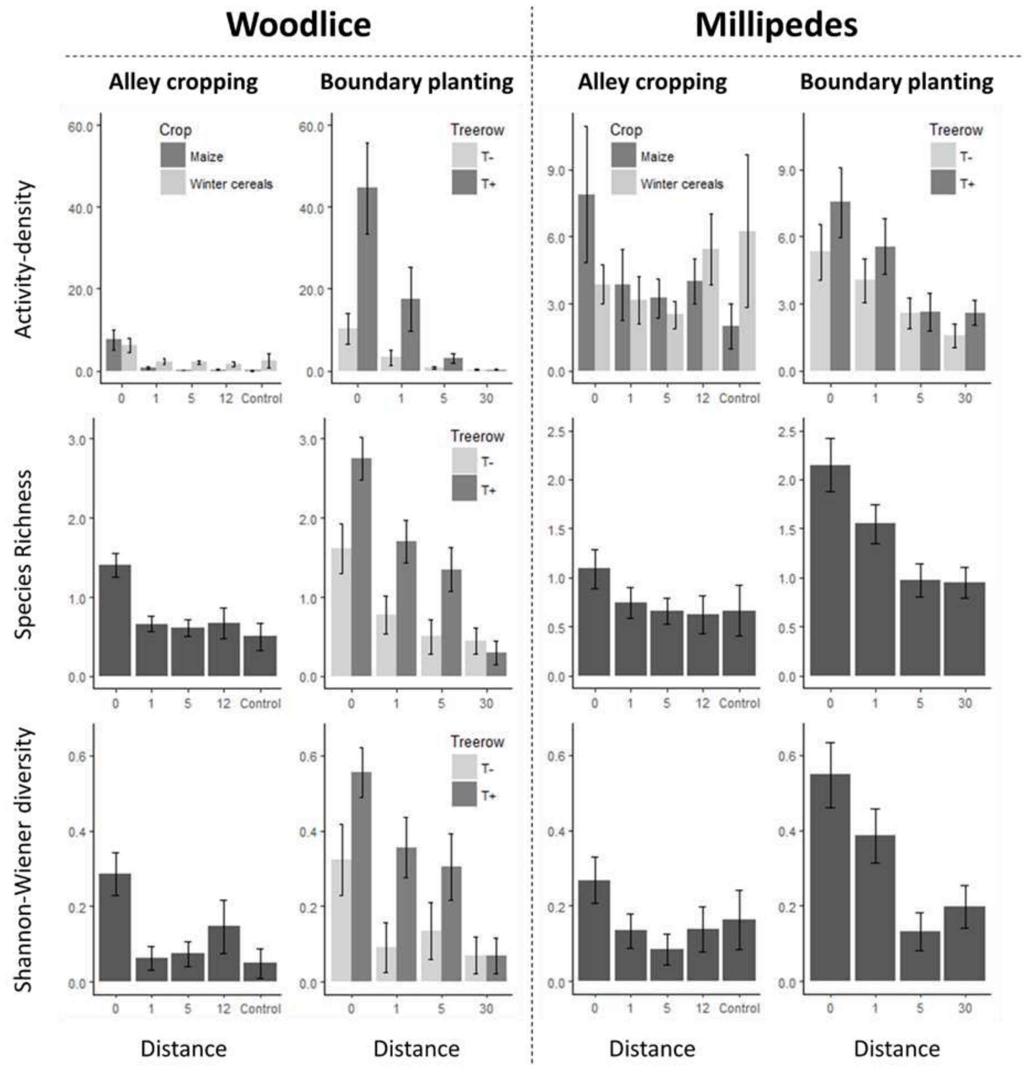

Figure 2: Activity-density, species richness and Shannon-Wiener diversity of woodlice and millipedes in alley cropping and boundary planted fields for each level of significant (interactions between) fixed effects. Barplots and errorbars indicate mean ± S.E.

Table 2: (Generalized) Linear Mixed Modelling results for detritivorous arthropods. Included fixed effects for the alley cropping fields are distance to the field edge (“Distance”), crop type (“Crop”) and their two-way interaction. Included fixed effects for the boundary planted field are presence or absence of a tree row (“T+/T-”), distance to the field edge (“Distance”), crop type (“Crop”) and their two-way interactions. “*AD*”: Activity-density, “*SR*”: Species richness, “H” Shannon-Wiener diversity. Bold characters indicate a significant effect (P-value<0.05). (*) indicates 0.05 < P-value < 0.10.

Main effect:		T+T-	Distance	Crop	Distance: T+T-	Distance: Crop	T+T-: Crop
BOUNDARY PLANTED							
Woodlice	AD	**0.0045**	**<0.0001**	0.5349	**<0.0001**	**<0.0001**	0.6556
	SR	**0.0004**	**<0.0001**	0.9077	0.1006	0.1328	0.1209
	H	**0.0017**	**<0.0001**	0.7191	0.1331	0.4350	0.1592
Millipedes	AD	0.0582*	**<0.0001**	0.6359	0.4185	0.3849	0.6254
	SR	0.1168	**<0.0001**	0.2716	0.9177	0.7458	0.7838
	H	0.3660	**<0.0001**	0.1030	0.9782	0.5259	0.6184
ALLEY CROPPING							
Woodlice	AD		**<0.0001**	**<0.0001**		**<0.0001**	
	SR		**0.0001**	0.1860		0.1174	
	H		**<0.0001**	0.7717		0.5887	
Millipedes	AD		**<0.0001**	0.2469		**0.0005**	
	SR		0.0626*	0.9878		0.9108	
	H		**0.0195**	0.2817		0.6620	

Discussion

The increased detritivore abundance and diversity in the tree rows are assumed to result from the favorable habitat and refuge conditions (e.g. increased shade, soil and air humidity, food sources and nesting habitat) created by the relatively diverse and permanent presence of vegetation and litter, the absence of regular (soil) disturbances and the reduced use of crop protection agents. Strongly contrasting conditions occur in the arable field zone where the intensive agricultural management may cause profound adverse effects on the survival and reproduction of soil communities (Paoletti and Hassall 1999; Smith et al. 2008; Souty-Grosset et al. 2005) resulting in the observed decreases in activity-density and diversity.

Based on our results, tree row presence can increase abundance and diversity of detritivores in the arable zone, probably through colonization starting from these semi-natural refuges and through the mitigation of abovementioned adverse field conditions. Farmers may potentially benefit from the enhanced delivery of ES in silvoarable fields (e.g. enhanced decomposition and nutrient cycling), linked to the abovementioned increase in detritivorous arthropod abundance and diversity. However, to optimize this potential for ES delivery, adapted management may be advisable, e.g. by retaining dead plant material in the tree rows (such as pruning material), limiting the use of pesticides and herbicides (both in the tree component and in the arable zone), and striving for a diverse herbaceous composition in the tree rows.

Conclusion

Furthers analysis will focus on predatory arthropods (carabids & rove beetles), whereby a similar approach is used to study gradients in abundance, species richness and Shannon-Wiener diversity.

Acknowledgments

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