Regional variability of European earthworm communities under different farming systems

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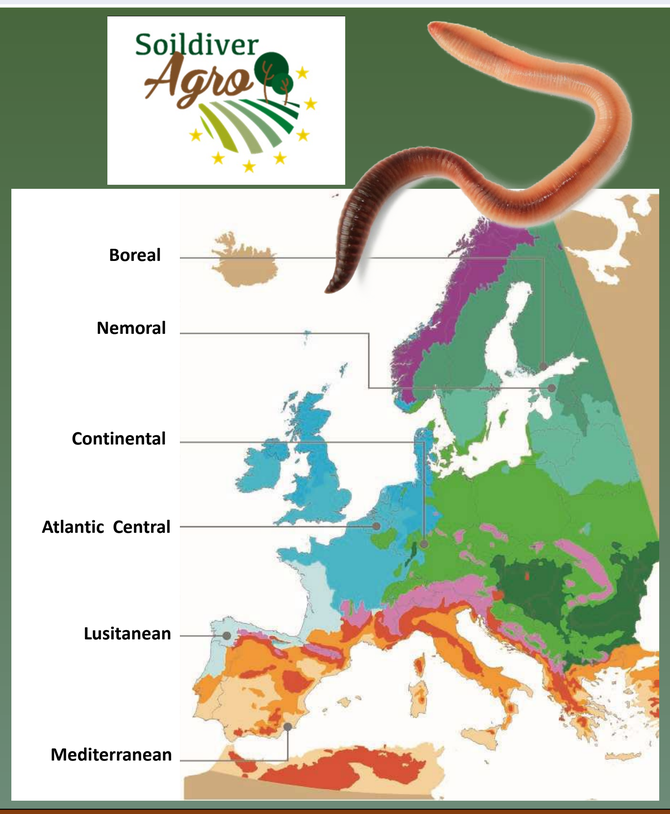
INTRODUCTION

Earthworms show low tolerance to alterations in their soil physical and chemical environment and to reduced availability of food sources in response to agricultural practices. In addition, climatic conditions are influential factors determining earthworm community structure. Recent data compilations of earthworm surveys have revealed general geographical patterns in species distributions within regions on the European scale (Rutgers et al. 2016) and demonstrated that precipitation strongly affects species richness, abundance and biomass of earthworms on the global scale (Phillips et al. 2019).

To date, a European wide earthworm survey using standardised methods with specific focus on how contrasting agricultural systems affect earthworm community structure across climatic regions has not been produced. Therefore, in this study, we assessed the impacts of conventional and organic farming on earthworm communities from nine pedoclimatic regions of Europe to elucidate how the local soil and environmental conditions as well as agricultural management shape their communities.



MATERIALS AND METHODS

We studied the response of earthworm communities to agricultural management as a part of a Europe wide survey of arable soil biodiversity (SoildiverAgro -project, EU H2020 No. 817819). The study covered nine pedoclimatic regions from Mediterranean to Boreal (S to N) and from Lusitanian to Pannonian (W to E) regions.

In each region, 20-25 wheat fields under long-term conventional or organic management were surveyed resulting in total of 188 fields. Earthworms were sampled once in each field by combined soil hand-sorting and AITC-extraction of three samples during the period of peak earthworm activity in topsoil, which varied locally due to severe drought conditions (from 2019 (most of the samplings) to 2021).

Supporting data on environmental conditions, soil properties and field management were collected from each field and analyzed together with earthworm community metrics (total abundance and biomass and species richness) using mixed models (GLMM).

RESULTS & DISCUSSION

Species	Ecological group	Region								
		atl_cent	atl_north	boreal	cont	lusit	med_north	med_south	nemoral	pann
Eisenia fetida	epigeic	●								●
Lumbricus castaneus	epigeic	●		●					●	
Lumbricus rubellus	epigeic	●	●	●		●			●	
Octolasion tyrtaeum	epiendogeic			●						
Satchellius madeirensis	epiendogeic					●				
Aporrectodea caliginosa	endogeic	●	●	●	●				●	●
Allolobophora chlorotica	endogeic	●	●	●	●	●			●	●
Aporrectodea georgii	endogeic									●
Aporrectodea limicola	endogeic	●								
Aporrectodea rosea	endogeic	●	●	●	●	●	●	●	●	●
Microscolex dubius	endogeic						●			
Microscolex phosphoreus	endogeic					●				
Octolasion cyaneum	endogeic	●			●	●			●	
Octolasion lacteum	endogeic	●								●
Proctodrilus antipai	endogeic									●
Aporrectodea longa	anecic	●	●			●			●	●
Aporrectodea trapezoides	anecic					●		●		●
Lumbricus friendi	anecic					●				
Lumbricus terrestris	anecic	●	●	●	●				●	

Table 1. Presence (dot) of earthworm species at each of the nine European pedoclimatic regions. Regions abbreviations: atl_cent = Atlantic central; atl_north = Atlantic north; boreal = Boreal; cont = Continental; lusit = Lusitanean; med_north = Mediterranean north; med_south = Mediterranean south; nemoral = Nemoral; pann = Pannonian.

EARTHWORM SPECIES RICHNESS ACROSS NINE EUROPEAN PEDOCLIMATIC REGIONS

Altogether 19 earthworm species were found in the nine pedoclimatic study regions of the survey (Table 1). Their distribution among the ecological groups (sensu Bouché 1977) as follows: 3 species are assigned to epigeics, 2 species to epiendogeics, 10 species to endogeics and 4 species to anecic species (Table 1).

The three most commonly found species were endogeic earthworms: *Aporrectodea rosea* was present in all regions, *Allolobophora chlorotica* in seven and *Aporrectodea caliginosa* in six regions. Of the deep burrowing, anecic species *Aporrectodea longa* and *Lumbricus terrestris* were both present in five regions. *Lumbricus rubellus* was the most commonly found epigeic litter dwelling species in five regions. Eight of the species were present only in one region. Their restricted ranges corresponded relatively well with the known European distribution patterns, as compared with GBIF-records (https://www.gbif.org/).

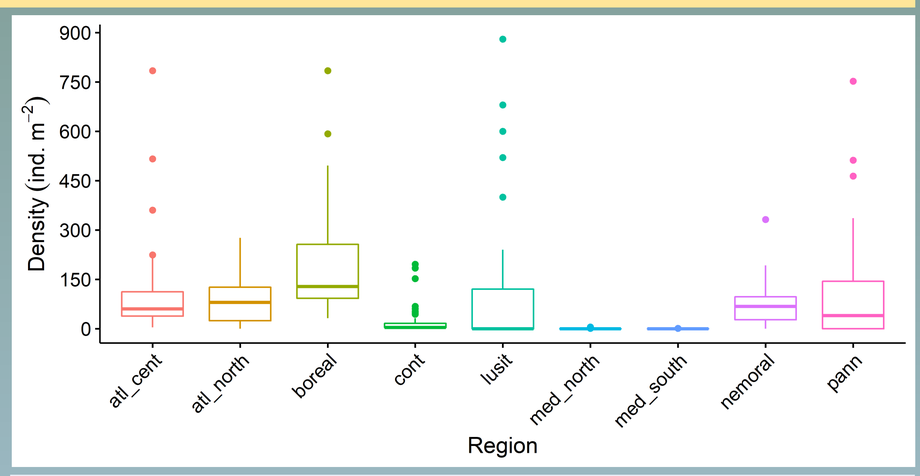
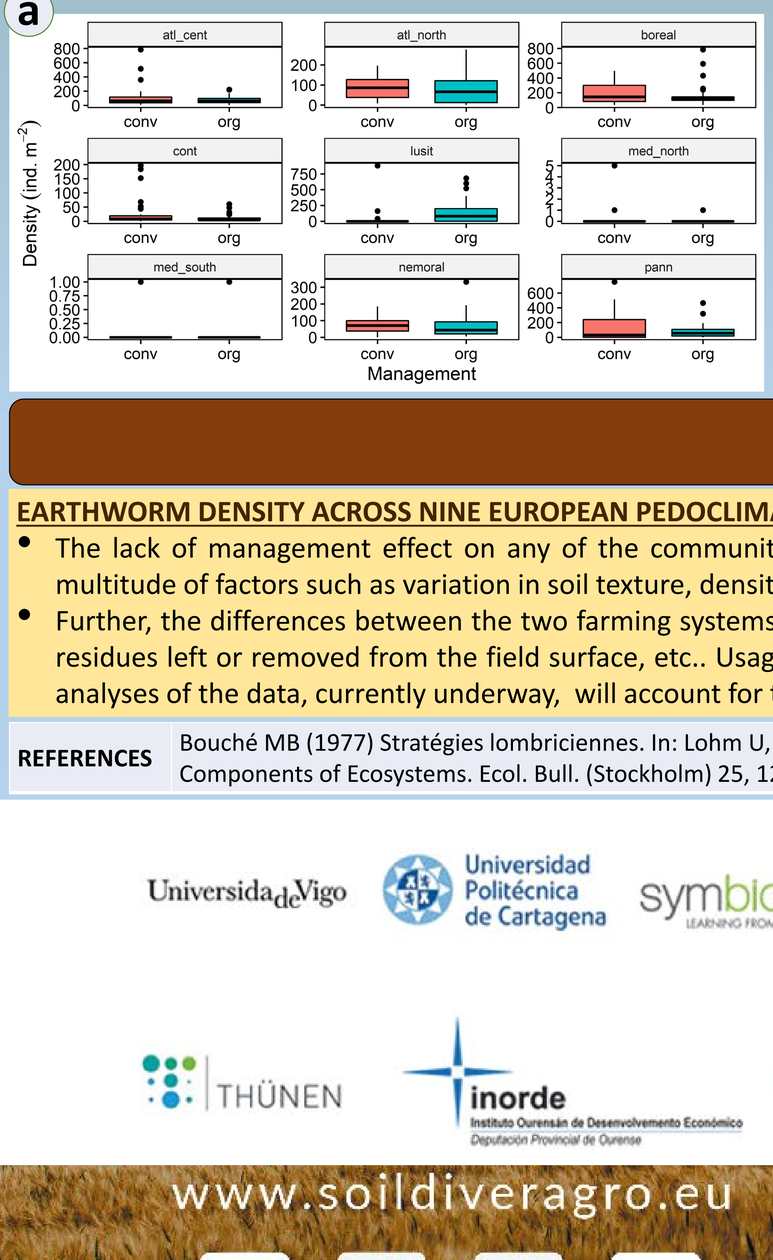


Figure 1. Regional variation of earthworm total density. Regions abbreviations: atl_cent = Atlantic central; atl_north = Atlantic north; boreal = Boreal; cont = Continental; lusit = Lusitanean; med_north = Mediterranean north; med_south = Mediterranean south; nemoral = Nemoral; pann = Pannonian.

EARTHWORM DENSITY ACROSS NINE EUROPEAN PEDOCLIMATIC REGIONS

The results for total earthworm abundances (Fig. 1) evidenced the existence of high variability across pedoclimatic regions, although the mean densities typically ranged between 0 and 150 individuals per m^2 in agreement with previous global estimates (Phillips et al. 2019).

In addition, a clear latitudinal/climatic gradient was observed, with colder and wet climates rendering the highest population densities and the hot and dry Continental and Mediterranean areas sustaining small population sizes



EFFECTS OF AGRICULTURAL MANAGEMENT ON EARTHWORM COMMUNITIES ACROSS NINE EUROPEAN PEDOCLIMATIC REGIONS

Agricultural system (conventional vs. organic) did not significantly affect earthworm abundance (Fig. 2a) nor their species richness (Figure 2b) in any of the pedoclimatic regions. The comparison of systems may have been confounded by the uncontrolled variation of environmental conditions between the fields (e.g. soil type and organic matter content). Further, the various management differences between the two systems are unlikely to be unambiguously positive or negative.

Figure 2. . Variation of earthworm community metric in relation to agricultural management (conventional (red) vs. organic (blue): (a) earthworm total density, (b) number of earthworm species. Regions abbreviations: atl_cent = Atlantic central; atl_north = Atlantic north; boreal = Boreal; cont = Continental; lusit = Lusitanean; med_north = Mediterranean north; med_south = Mediterranean south; nemoral = Nemoral; pann = Pannonian.

CONCLUSIONS

EARTHWORM DENSITY ACROSS NINE EUROPEAN PEDOCLIMATIC REGIONS

- The lack of management effect on any of the community metrics was unexpected and indicates that earthworm abundance and community composition in a given field is, however, affected by a multitude of factors such as variation in soil texture, density, moisture and chemical properties.
- Further, the differences between the two farming systems may also be sometimes less clearly defined: organic fertilizers are used in both systems as are rotations with leys and crop diversification, crop residues left or removed from the field surface, etc.. Usage of pesticides in conventional farming may also often remain in a level which is not harmful for earthworms. Using the field metadata, refined analyses of the data, currently underway, will account for the relevant local variation in environment and field management.

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