Earthworm abundance and species richness: contribution of farming system and habitat type

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Abstract

The aim of this study was to investigate whether earthworm populations in different habitats and under different farming systems (organic vs. integrated) are different. Arable land was compared with alley cropping systems, meadows and field margins. For comparison there were also investigations on the three natural habitats fallow, forest and forest edge. The field study yielded the following results: In the meadow, the tree row within the alley cropping system and in the natural reference habitats (with exception of the studied forest), the abundance and species diversity was higher compared with arable land. In addition the tree rows in the alley cropping system had a positive effect on the earthworm population. The arable fields in the alley cropping system stood out due to higher abundance and species diversity compared to similar arable land without tree row. Moreover, differences in the earthworm population became apparent in the consequence of organic or integrated farming. In all habitat types higher earthworm abundance was found in the organic farming system. Concerning species diversity, the results differed from each other in the different habitats.

Introduction

The goal of the paper is to reveal the differences in earthworm populations in different habitat types and farming systems concerning abundance and species richness. Whereas earthworm populations are well studied in most agricultural habitat types and farming systems, there are only a few studies on earthworms in agroforestry systems in temperate regions. Moreover information about species richness refers mostly just to the number of species found on the investigated plots. That could be problematic because number of species found within a single plot can depend on various factors. To deal with that problem we used species accumulation curves that ensure better standardization and comparability of the results (Gotelli & Colwell 2001).

Material and methods

The field study was conducted at the experimental farm in Scheyern (South Germany). As in Scheyern an integrated as well as an organic farming system was installed in 1992, both, organic and integrated sites were examined. Table 1 illustrates the management practices. Survey took place in following habitat types: Arable field, alley cropping system installed in 2009 (Poplar in the tree row, arable stripe), meadow and field margin as well as the natural habitats forest, forest edge and fallow. For this earthworms were extracted by a chemical expellant solution (0,01 % Allylisothiocyanat) from plots with an area of 0,09 m². This was followed by handsorting down to 30 cm soil depth. There were three replications per habitat with one replication containing of four individual plots measured. Sampling took place in spring 2012. Adult earthworms were identified to species level and number of individuals and biomass was measured. From plot size and number of individuals earthworm abundance (Individuals m^{-2}) was calculated. Statistical analyses were performed using R (R Core Team 2013) and the iNEXT version 1.0 package for R (Hsieh et al. 2013).

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Table 1:Management characteristics

	Integrated farming	Organic farming
Crop rotation	Potato – Winter wheat (Catch crop (CC): mustard) – Corn – Winter wheat (CC)	Alfalfa-grass-clover (AGC) - Potato – Winter wheat – Sunflower – AGC – Winter wheat – Winter rye
Pesticide use	Herbicides, Fungicides, Insecticides	None, except copper based fungicide in potatoes
Soil tillage	Conservation (Cultivator, 10 cm)	Inverting (Plough, 25 cm)

Results

With regard to the habitat type in the meadow, in the field margins, in the poplar within the alley cropping system and in the natural reference habitats (with exception of the studied forest), earthworm abundance was higher compared with the arable land. In addition the tree row within the alley cropping system had a positive effect on the earthworm population. The arable field within the alley cropping system stood out due to higher abundance compared to similar arable land without tree rows. Simultaneously all organic managed habitats showed higher earthworm abundance than the comparable integrated managed habitat types (Figure 1).

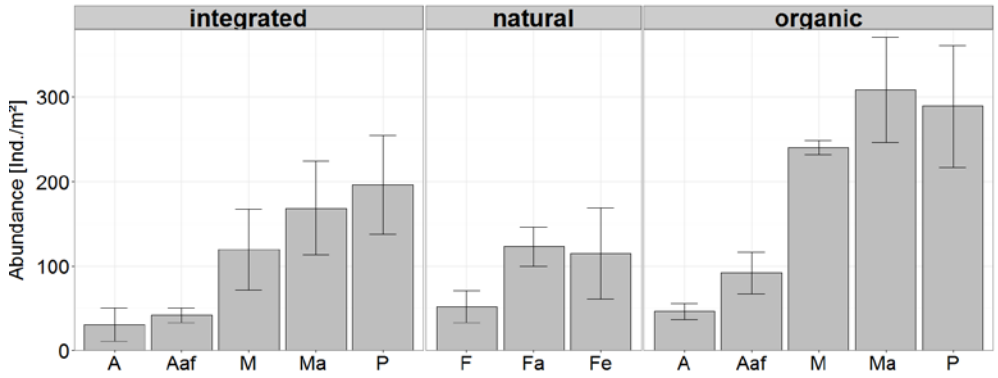

Figure 1: Overall mean earthworm abundance [Individuals m^{-2}] in various habitats (A= arable land, Aaf= arable land agroforestry, M= meadow, Ma= margin, P= poplar, F= forest, Fa= fallow, Fe= forest edge) in different farming systems. Error bars show ±standard deviation.

The evaluation of species richness showed the following results. The natural habitats (except the forest) as well as the margins, meadows and the poplar had higher species richness compared to the arable fields. By contrast the arable fields in the agroforestry system had higher species richness values as the arable fields without tree rows (Figure 2).

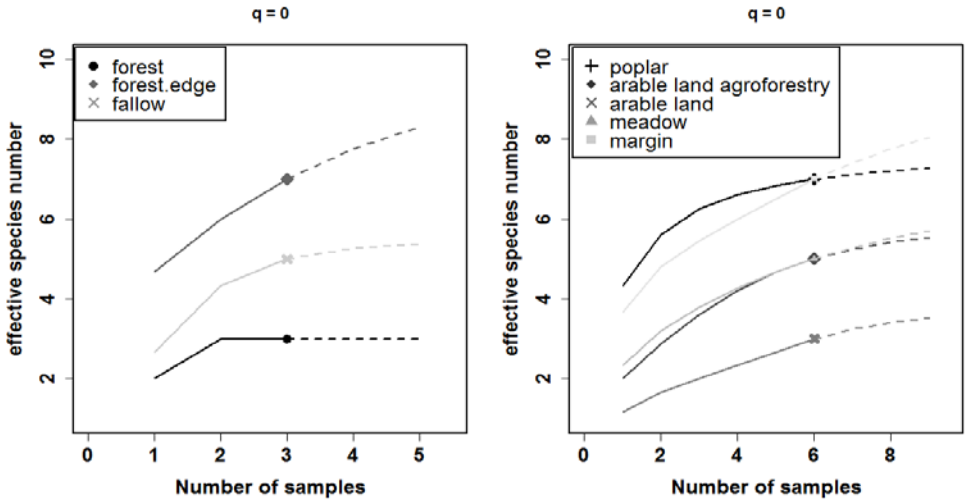

Figure 2: Sample-size-based rarefaction and extrapolation of accumulation curves.

Based on farming system the accumulation curves pointed out higher γ-diversity (overall species number within a management system) in the intergrated farming system whereas α-diversity (mean number of species per plot) was little higher in organic farming. If the analysis was conducted only on the intensive managed arable fields, there was higher species diversity on the organically managed arable fields (Figure 3).

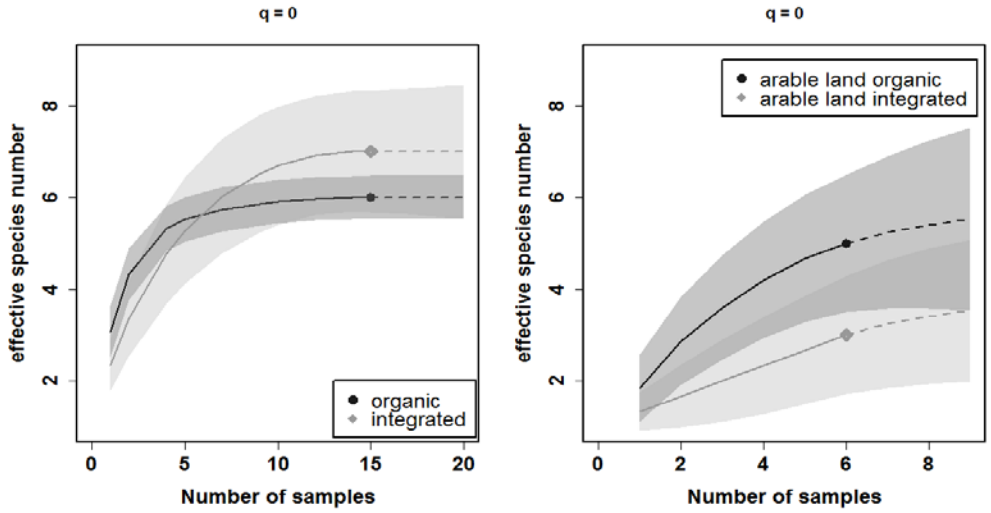

Figure 3: Sample-size-based rarefaction and extrapolation of accumulation curves with shaded 95% confidence regions.

Discussion

In Scheyern the positive effect of organic farming on the earthworm population is due to the favourable input of organic matter in terms of quantity and continuity of food supply throughout the year (see Riley et al. 2008). The negative effect of the plough reported in literature (Jordan et al. 2004, Johnson-Maynard et al. 2007 etc.) seems not to influence the earthworm population in this study. It seems that with increasing management intensity the habitat types differed more in species diversity due to organic or integrated farming.

Obviously the tree rows in the alley cropping system had a positive effect on the earthworm population not only in the tree row but also in the arable field. There´s possibly a positive influence from a changed microclimate, with the less climatic extremes and the additional organic matter from leaf fall (Price & Gordon 1999).

An enhancement of the earthworm population is especially important for organic agriculture which depends on ecosystem services like the promotion and regulation of soil fertility and its beneficial effects to plant growth or carbon and nitrogen cycling (Edwards & Bohlen 1996). Moreover the tree rows themselves could

be a useful element in the landscape for nature conservation. They offer a biosphere that´s comparable to natural habitats.

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