Spatial distribution of anecic earthworm populations at agricultural sites:

Investigation of small scale structures in dependence of soil physical properties

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Introduction

Macropores are preferential flow pathways and important for the rapid transport of water and solutes in silty and clayey soils (Beven and Germann, 1982; Zehe and Fühler, 2001). In the Weiherbach valley preferential flow patterns are characterized by the strong relation between macropore density and earthworm activity. Anecic earthworms like *Lumbricus terrestris* are known as ecosystem engineers. They build semi-permanent vertical burrows. These act as pathways for water and solutes and increase the rapid transport of pesticides into deeper soil layers. For a risk assessment of agrochemicals knowledge of the spatial distribution of macropores from point scale to field scale is necessary. So the aim of our study was to identify small scale distribution patterns of anecic earthworms in agricultural soils.

Aims of our research

1) Investigate the small scale spatial distribution of anecic earthworms:
   - Determine the distribution patterns within agricultural sites – clustered or random
   - Verify the sampling desingn to indentify the scale of interest for further researches at the field scale
   - Point out the impact of boundaries
2) Linking the spatial distribution of anecic earthworms to important environmental predictors
   - Determine the spatial variability of soil moiisture, soil temperatur, organic matter content and soil compactation

Sampling design and measurements

Field measurements at each plot:
- Soil moisture content
- Soil temperature
- Organic matter content
- Litter content
- Penetration depth
- Abundance and biomass of earthworms, subdivided into:
  - Three life forms (epigeic, anecic, endogeic)
  - Three stage classes (adult, subadult, juvenile)

We used a stratified simply random sampling (Zimmermann et al. 2008) at three fields with differences in tillage management and topography. One stratum includes our fields and the other stratum represents the boundaries (Fig.1). The minimum distance from point to point was 10m. Each sampling point includes 5 plots (Fig.2) aligned in the same direction. All in all 260 plots at 52 sampling points were sampled. This desing was selected to detect the small scale variability.

Fig.1: study site and sampling points

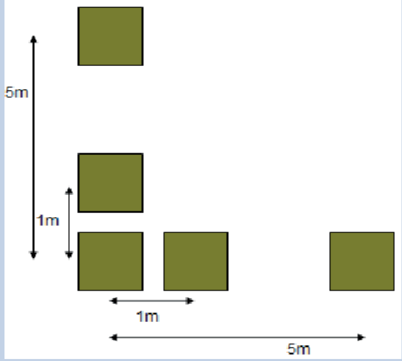

Fig.2: model-based sampling design according to each sampling point

Graphics

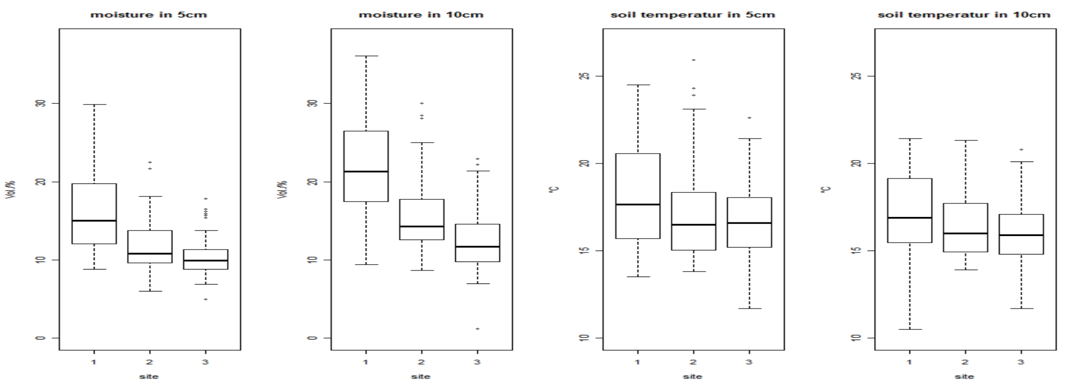

Fig.3: Boxplots with the distribution of soil temperature and soil moisture for the three sites

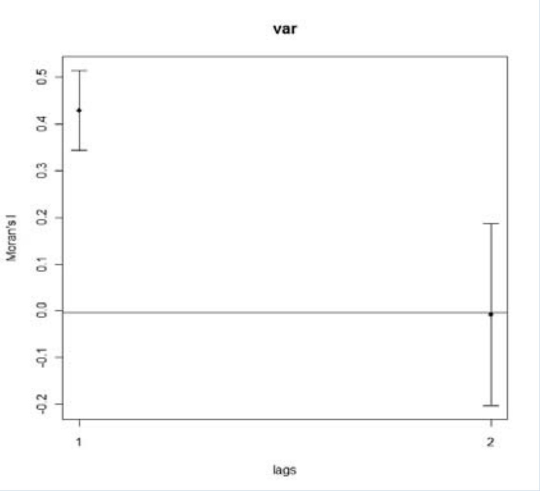

Fig.4: Correlogram of anecic biomass

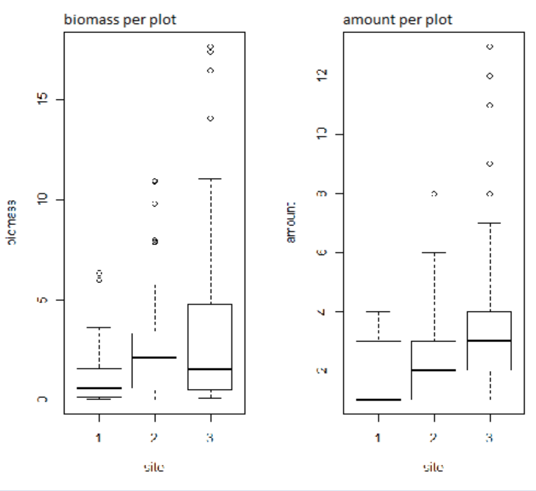

Fig.5: Distribution of anecic earthworms

Distance class [m]	0,99	1,38	4,51	5,09	7,07	17, 34	30,97	60,98
Number of pairs	99	57	195	109	53	34	85	149
correlation-coefficient	0,14	0,62	0,16	0,67	0,68	0,10	0,07	0,098

Tab.1: Moran´s I for several distances

Results and Discussion

In coincide with Pelosi et al. (2008), we expected that moisture and soil temperature influence the distribution and occurrence of anecic earthworms. We tried to fit a linear and a generalized linear model without success. Only penetration and organic matter content show a high significance (p-value: $4{,}22 \times 10^{-6}$) . Figure 3 shows the distribution of temperature and moisture in 5 and 10 cm depth. These variables are strongly related to their position on the slope. If there is a positive correlation between occurrence and moisture, then the amount and biomass of anecic species should be higher for site 1 than for site 3. Nevertheless we found an increase of amount and biomass of anecic earthworms from hillfoot to hilltop (Fig.5). At the opposite site the endogeic and epigeic species raise up in amount and biomass from hilltop to hillfoot.

Furthermore the small scale spatial distribution of anecic species was studied. Therefore we produced variograms and correlograms, as shown in figure 4 we figured out a correlation between the first neighbours. This correlation pulls to all plots within a sampling point (Tab.1) and mitigates with greater distances (Fig.4), hence we can depict the distribution as aggregated.

The stratification of the sampling design was selected to find out if wether the borders of our sites are can be considered as retreat areas from where they spread out into the field after tillage. This hypothesis was not confirmed by our observations. Lagerlöf et al. (2002) mentioned that only high level agricultural treatment results in borders as retreat areas. We guess that the from Zehe and Flühler observed relation between moisture and species occurrence was interfered in our case by the slope effect. This can be a subject for further studies because it would have an important impact to risk assessment for agrochemicals.

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