

Earthworm functioning in soil ecosystem services in relation to land use intensity

Jack H. Faber¹, Guénola Pérès^{2,3}, Arjen de Groot¹, Paul Henning Krogh⁴, Marjetka Suhadolc⁵, Rok Mihelič⁵, Jörg Römbke⁶, Stefan Jaensch⁶, Rüdiger Schmelz⁶, A.K. Keith⁷, O. Schmidt⁸, Walter Andriuzzi^{8,9}, Abad Chabbi¹⁰

¹Alterra-DLO, Wageningen, the Netherlands; ²INRA Agrocampus Ouest, Rennes, France; ³Rennes 1 Univ., France; ⁴Århus Univ., Denmark; ⁵Ljubljana Univ., Slovenia; ⁶ECT Oekotoxikologie, Flörsheim, Germany; ⁷Lancaster Environment Centre, UK; ⁸Univ. College Dublin, Ireland; ⁹Wageningen Univ., the Netherlands; ¹⁰INRA Poitou Charentes, France



Objective

The FP7 EcoFINDERS project aimed to assess the relationship between soil biodiversity and ecosystem service provision. We studied functional responses for earthworms and fungi on soil formation and water regulation under different agricultural land uses representing a range in land use intensity. The aim was to establish and quantify these functional relationships by literature and field studies.

Sites and methods

Different long-term observatories (LTO) were studied in France, Germany, United Kingdom, Slovenia, Denmark, with several land uses: grassland, arable cropping, crop-grassland conversions, conventional and reduced tillage.

Earthworms were sampled by hand sorting and chemical extraction; **Aggregate stability** was measured by wet sieving method; **Macropore** distribution (numbers and diameter of earthworm burrows) were quantified at successive horizontal layers along the soil profile, and classified by diameter size.

Water infiltration rates were measured as saturated hydraulic conductivity.

Results

Macropores

At the French LTO (Lusignan), results showed that the occurrence and distribution of burrows were affected by land use and management: total number of burrows was higher under pasture vs crop; permanent grassland had highest incidence on larger sized burrows, but mostly so in the topsoil; rotation system (with or without grass) presented similar pore distributions (Fig. 1).

Macropore number and size distributions varied between sites (Fig. 2).

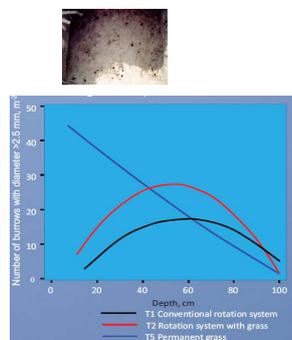


Figure 1. Trends in depth distribution of large macropores under three land use treatments at LTO Lusignan

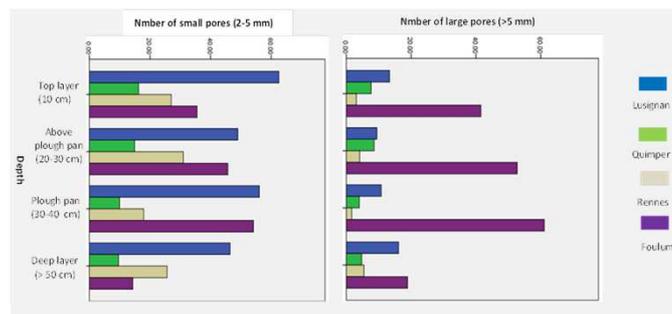


Figure 2. Number of small pores (left pane) and large pores (right) quantified at four soil depths at four sites (Lusignan, Quimper, Rennes, Foulum)

Soil aggregate formation

Differences in soil physical structure were demonstrated between land management treatments at the french (Lusignan) and slovenian (Moskanjci) sites, with greater aggregate stability under reduced land use intensity (pasture vs crop; reduced tillage vs plough). These increases in aggregate stability were accompanied by increases in earthworm abundance/biomass and changes in their functional composition.

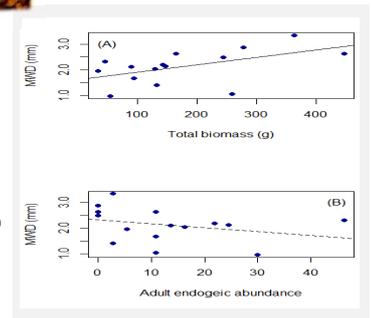


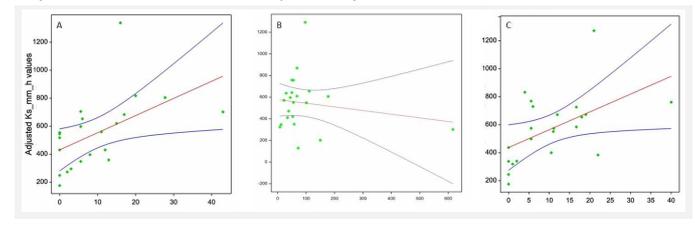
Figure 3. Microaggregate mean weight diameter (MWD) as related to (A) total earthworm biomass and (B) endogeic species abundance (adults m⁻²), at 10 cm depth at Lusignan.

Water infiltration rate



Site-specifically, we found significant relations with total worm abundance, both positive and negative; it is likely that soil management was a key factor to determine the net outcome, but we have no replication between sites to check this. Weather conditions preceding the field measurements significantly affected results.

Figure 4. Relationship between the activity of three earthworm functional types (A=epigeics, B=endogeics, C=aneics) and water infiltration rate. Fitted relationship (red line) with 95% confidence intervals (blue lines) based on literature data.



Conclusions

- Functional differences exist between ecological groups of earthworms; however, functional responses could not be demonstrated at all sites and land uses.
- At Lusignan, large macropores are related to anecic earthworms, from top soil to deeper layers; small pores in top soil are mainly related to relatively small species of anecic worms and endogeic; in deeper soil small pores are less frequent and linked to endogeic species.
- The relationship between earthworms and soil aggregates formation was different between sites; no generalised regression could be produced.
- Literature data reveal functional differences between earthworm ecological groups; in our field studies impact on water infiltration rate was significant for Lusignan only, and for one year only; at this particular site, infiltration rates were lowest.