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Influence of Earthworm (Oligochaeta: Lumbricidae) Populations on Abundance of Soil Fungi

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Abstract. The study explores the influence of earthworms (Oligochaeta: Lumbricidae) on the soil fungi communities. The observation was carried out in poplar forests on three types of soils: Pellic Vertisols, Cromi-Vertic Luvisols and Calcaric Fluvisols. The population of earthworms have a negative effect on the soil fungi. It was revealed that augmentation on the number of lumbricid taxa reduces the soil fungi communities. Earthworm populations and number of soil fungi are in negative correlation (R= -0.9153). In sum, more research is needed to fully understand relationships between earthworms and soil fungi.

Keywords: Earthworms, Lumbricidae, soil fungi, soil microflora, soil fauna.

Introduction

Earthworms take part in various relationships with soil microorganisms (EDWARDS & BOHLEN, 1996). In some cases they are involved in symbiotic or mutualistic, in other cases in antagonistic interactions with soil biota, respectively. Many studies revealed the indirect or direct influence of lumbricid populations on soil microorganisms (GROFFMAN *et al.*, 2004; SUAREZ *et al.*, 2004).

The gut of earthworms decreased growth of some fungal species (MOODY *et al.*, 1996; PARLE, 1963). Several species of fungi showed to be ingested preferentially by earthworms (MOODY *et al.*, 1995; COOK, 1983; BONKOWSKI *et al.*, 2000). This implies that the litter-burying or fragmenting anecic and epigeic species may impose some selection pressures on fungal populations in both litter and soils. Earthworms from family Lumbricidae are vectors of distribution of mycorrhizal fungi (GANGE, 1993; REDDELL & SPAIN, 1991), symbiotic nitrogen-fixing bacteria (DOUBE *et al.*, 1994; MADSEN & ALEXANDER, 1982) and actinomycetes (REDDELL & SPAIN, 1991) in soil.

The aim of the current study is to explore the influence of earthworm populations on microscopic soil fungi communities in uncultivated soils.

Materials and Methods

The study was carried out over the 2011 - 2013 year period on uncultivated soils in Sofia Plain (Bulgaria). Sampling points: Pellic Vertisols from Bozhurishte town - 42° 44′ 52N 23° 13′ 09E, Chromi-Vertic Luvisols from Chelopechene village - 42° 44′ 24N 23° 28′ 15E and Calcaric Fluvisols from Negovan village - 42° 44′ 33N 23° 24′ 07E.

The soil samples were analyzed for densities of microscopic fungi by GRUDEVA *et al.* (2007). The numbers of colony forming

units (CFUs) were determined after 7 day incubition at 28°C using the dilution plate technique. Chapek growth medium was used for development of fungi species (CFUs). The chemical reaction (pH=4) for fungal growth was achieved with adding a lactic acid. The count of soil fungi was calculated per 1 g absolutely dry soil.

Earthworms were collected by the diluted formaldehyde method (RAW, 1959) complemented with digging 0.5 × 0.5 m quadrates, hand sorting and searching under stones and the bark of fallen logs. The abundance of all collected earthworms was adjusted to one square meter.

The main chemical and physical soil characteristics were estimated. The soil pH was measured potentiometric in water, the soil organic carbon was determined applying TURIN (1937) method and the soil texture was estimated by KACHINSKII (1970) method, respectively. Statistical data were presented with correlation analyses.

Results and Discussion

Explorations of soil fauna and micro-flora were carried out on three types of un-cultivated soils. In Pellic Vertisols earth-worm populations had a higher density, ind./m^{-2}. In this soil type the count of soil microscopic soil fungi was 1.0 x 10^3 CFU/g. In Chromi-Vertic Luvisols the lumbricid abundance was lower - 45 ind./m^{-2} and fun-gi communities were – 5.0 x 10^3 CFU/g. In Calcaric Fluvisols the earthworm density was lowest - 32 ind./m^{-2}m but the soil fungi populations in this soil was highest - 11.0 x 10^3 CFU/g (Fig. 1).

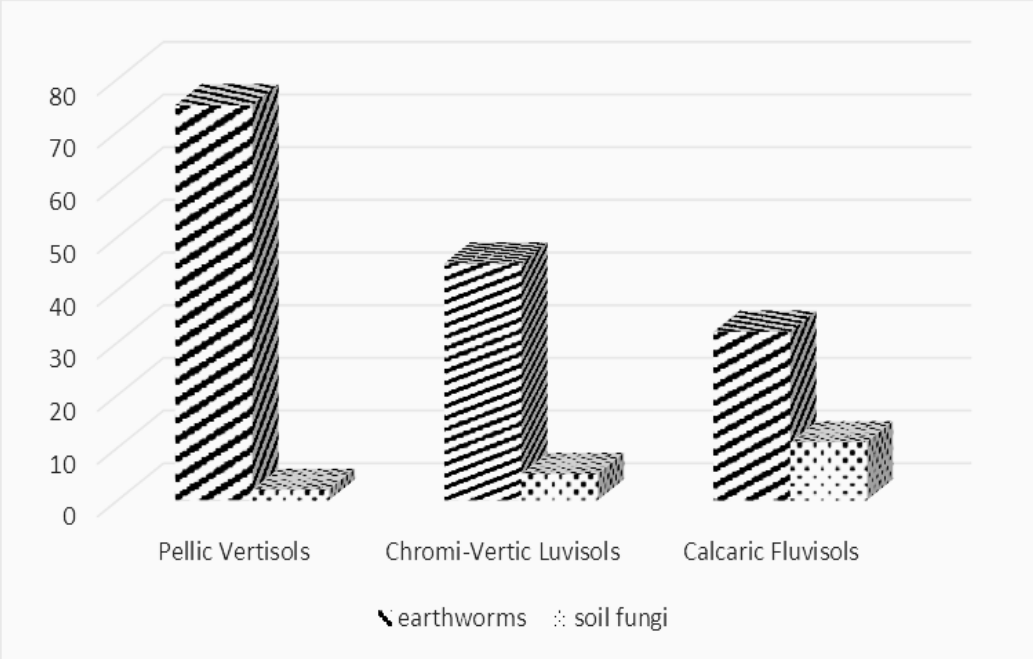

Fig. 1. Abundance of earthworms and soil fungi in explored uncultivated plots.

Explored Pellic Vertisols soil plot was with optimal soil moisture, neutral soil pH, high clay content – 76% and organic matter content– 11.87% (Table 1). All those abiotic characteristics favor the earthworm growth and activity. In contrast, Calcaric Fluvisols was with low soil moisture – 6%, low soil organic matter – 1.8% and low clay content – 20.8%. Those parameters are adversely to earthworm populations. Chromi-Vertic Luvisols plot had average soil characteris-tics. In this soil the organic matter content was – 3%, clay content – 44% and soil moisture - 11%, which conduce to balance between the earthworms and soil fungi communities.

The burrowing activity of earthworm species breakdowns the soil fungi mycelium. Many studies showed that the intestinal tract of earthworms suppressed the development of fungal spores. Passage through the gut of earthworms cause decreasing of the soil fungi density (PARLE, 1963; MOODY *et al.*, 1996).

Earthworm casts have a higher bacteria count and lower fungi density in comparison with surrounding soil (VALCHOVSKI, 2011). Bacterial-to-fungal ratios in soils are also often greater in earthworm-worked soils because biotur-bation tends to affect fungal populations negatively more than those of bacteria (HENDRIX *et al.*, 1986).

Influence of earthworm count on microscopic fungi density was estimated using correlation analysis (Fig. 2). The statistical analysis showed that the abundance of earthworms and soil fungi are in a high reverse correlation (R= -0.9153). Therefore, increasing the density of lumbricid populations cause augmentation of soil fungi communities. More explorations are needed in order to reveal the influence of soil fauna on biodiversity of fungi microorganisms in different soil ecosystems.

Table 1. Chemical and physical characteristics of studied types of soils.

Soil	pH (H_2O)	Soil organic matter (%)	Soil moisture (%)	Clay content (%)
Pellic Vertisols	6.8	11.87	30	76
Chromi-Vertic Luvisols	6.5	3.0	11	44
Calcaric Fluvisols	6.9	1.8	6	20

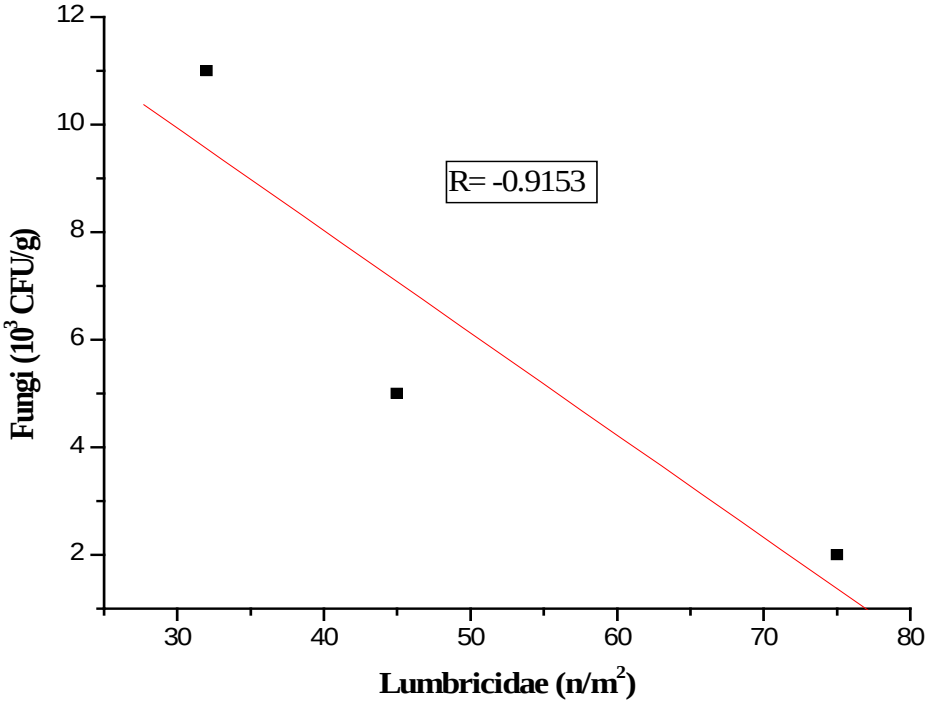

Fig. 2. Correlation analysis between abundance of earthworm populations and density of microscopic soil fungi.

Conclusion

Earthworms are one of the major biotic factors on soil fungi communities. The results from this study revealed a relationship between populations of earthworms and soil fungi. The density of fungi communities decreased with augmentation of lumbricid abundance. Fungivorous and locomotor activity of earthworms cause decreasing of microscopic

fungi. Further researches need to estimate properly the functional roles of earthworms in the soil ecosystems.

References

BONKOWSKI M., B.S. GRIFFITHS, K. RITZ. 2000. Food preferences of earthworms for soil fungi. - *Pedobiologia*, 44: 666-676. [DOI]

COOK A. 1983. The effects of fungi on food selection by *Lumbricus terrestris* L. - In: SATCHELL J.E. (Ed.): *Earthworm Ecology: From Darwin to Vermiculture*. Chapman & Hall, New York, NY, pp. 365-373.

DOUBE B.M., P.M. STEPHENS, C.W. DAVOREN, M.H. RYDER. 1994. Earthworms and the introduction and management of beneficial soil microorganisms. - In: Pankhurst C.E., Doube D.M., Gupta V.V.S.R., Grace P.R. (Eds.): *Soil Biota*: Management in Sustainable Farming Systems. 46 CSIRO Information, Melbourne, pp. 32–41.

EDWARDS C., P.J. BOHLEN. 1996. *Biology and Ecology of Earthworms*. Chapman & Hall, London.

GANGE A.C. 1993. Translocation of mycorrhizal fungi by earthworms during early succession. - *Soil Biolology and Biochemistry,* 25, 1021–1026. [DOI]

GROFFMAN P.M., P.J. BOHLEN, M.C. FISK, T.J. FAHEY. 2004. Exotic earthworm invasion and microbial biomass in temperate forest soils. – *Ecosystems,* 7: 45–54. [DOI]

GRUDEVA V., P. MONCHEVA, P. NEDEVA, B. GOCHEVA, S. ANTONOVA-NIKOLOVA, S. NAUMOVA. 2007. *Textbook of microbiological studies.* Sofia University "St. Kl. Ohridski" edition (In Bulgarian).

HENDRIX P.F., R.W. PARMELEE, D.A. CROSSLEY, D.C. COLEMAN, E.P ODUM, P.M. GROFFMAN. 1986. Detritus food webs in conventional and no-tillage agroecosystems. - *BioScience,* 36: 374-380. [DOI]

KACHINSKII N.A. 1970. *Soil physics.* Part I and II. Moscow, Vishaia shcola (In Russian).

MADSEN E.L., M. ALEXANDER. 1982. Transport of *Rhizobium* and *Pseudomonas* through soil. - *Soil Science Society American Journal,* 46: 557–560. [DOI]

MOODY S.A., M.J.I. BRIONES, T.G. PIEARCE, J. Dighton. 1995. Selective consumption of decomposing wheat straw by earthworms. - *Soil Biology and Biochem*istry, 27: 1209-1213. [DOI]

MOODY S.A., T.G. PIEARCE, J. DIGHTON. 1996. Fate of some fungal spores associated with wheat straw decomposition on passage through the guts of *Lumbricus terrestris* and *Aporrectodea longa*. - *Soil Biology and Biochemistry,* 28: 533-537. [DOI]

PARLE J.N. 1963. A microbiological study of earthworms casts. – *Journal of General Microbiolology*, 3: 13-22. [DOI]

RAW F. 1959. Estimating earthworm population by using formalin. – *Nature,* 184: 1661-1662. [DOI]

REDDELL P., A.V. SPAIN. 1991. Earthworms as vectors of viable propagules of mycorrhizal fungi. - *Soil Biology and Biochemistry*, 23: 767–774. [DOI]

SUAREZ E.R., T.J. FAHEY, P.M. GROFFMAN, P.J. BOHLEN, M.C. FISK. 2004. Effects of exotic earthworms on soil phosphorus cycling in two broadleaf temperate forests. – *Ecosystems,* 7: 28–44. [DOI]

TURIN I.V. 1937. *Organic Substances of Soils.* Moscow, Russia: Selhozgis (In Russian).

VALCHOVSKI H. 2011. Microbiological and Agrochemical Characteristics of Earthworm Midden Casts of *Lumbricus terrestris*. - *Journal of Balkan Ecology,* 14(4): 383-390.

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