A Comparative Study of Earthworm Density and Diversity in Grasslands and Arable Lands

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Grasslands and arable lands differ in their use – grasslands are primarily used as grazing areas or sources of forage while arable lands are designated for intensive crop production, often requiring cultivation practices and fertilization. Earthworms have a crucial role in both ecosystems by influencing soil structure, enhancing aeration processes, and contributing to the decomposition of organic matter.

Research areas

The research was carried out in eight areas, comprising four grasslands and four arable lands, situated in the Wieliczka Foothills, Nowy Wiśnicz Foothills, Rożnów Foothills, Ciężkowice Foothills, and the Low Beskids in southern Poland.

Arable_1

This organically managed field grows vegetables under a no-till regime (1–2 soil treatments/year), fertilising with poultry manure, and no irrigation. The weed control is manual, there is no chemical crop protection, and the field employs a 5-month fallow per year, with active cultivation during the remaining 4 months.

Arable_2

This organic farm produces vegetables and legumes, using a frequent crop rotation (<2 years) with up to four main crops per year. The management includes intensive fertilisation with poultry manure, liquid fertilisers, slurry, and plant compost, regular irrigation (2–3 times/week), and deep ploughing (to 20 cm), with weed control mainly by hand and a short (2 months/year) black fallow.

Arable_3

The organically managed site grows predominantly mixed vegetable crops in a 3–5 years crop rotation, using horse and poultry manure, green manure, compost, and lime, with mechanical and manual weed control. Ploughing to 20 cm is performed 1–2 times a year, with cultivation for 6 months annually and rare irrigation as needed.

Arable_4

Here, organic mixed crops and legumes rotate every two years or less; the field is managed with minimal tillage (up to 130 cm depth), using compost, lime, and poultry manure as fertilisers. Weed control is mostly manual, straw mulch/intercrops are used, and the field spends 5 months fallow and is cultivated for 6 months yearly.

Grassland_1

This grassland under regular mowing and trampling for more than 20 years, receives mineral fertilisation and no herbicide application.

Grassland_2

A long-term (>20 years) permanent grassland cut 2–4 times a year, never trampled or fertilised, nor subject to weed control, and with no agricultural use since 2000.

Grassland_3

Used as grassland for 10–20 years, this site is mowed just once a year, trampled rarely, and sees no fertilisation or weed control.

Grassland_4

A long-established grassland (>20 years) is mown 2–4 times annually and heavily trampled, with mineral fertilisation but no weed control.

Methods

- Five soil blocks measuring 20 × 20 cm and 25 cm deep in each study area were collected, and earthworms from these samples were extracted using the hand-sorting method.
- The collected earthworms were washed and classified using an identification key according to their maturity stage, ecological categories, and species.
- Soil samples (100 g from each block) were combined, mixed, dried, and analyzed for properties such as pH, carbon and nitrogen content, texture, and aggregate stability.

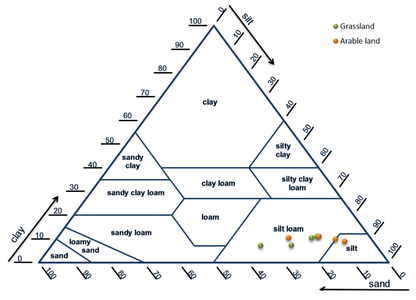



Aims or Research goals

The study aimed to compare the density and species diversity of earthworms in arable soils and grasslands and evaluate the stability of soil aggregates in these environments. In addition, we assessed the relationship between land use, soil structure, and earthworms.

Results

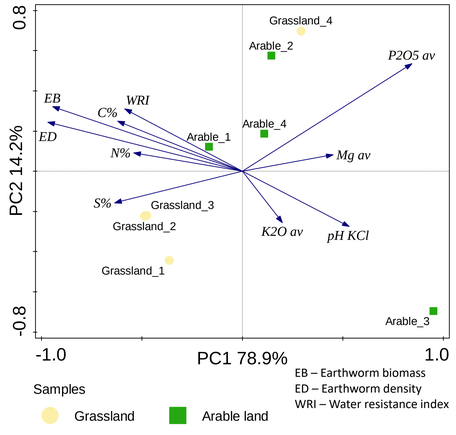
Texture of investigated soils



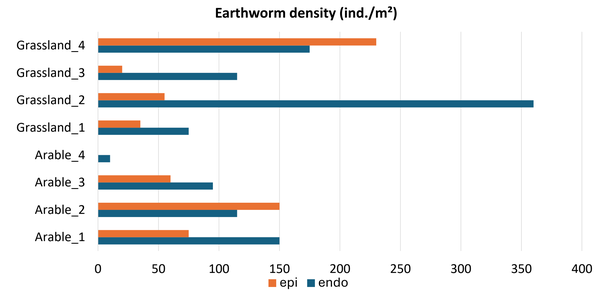
Site	Percentage of:		
	Sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	clay <0.002 mm
Arable_1	8	83	9
Arable_2	23	66	10
Arable_3	15	75	11
Arable_4	10	80	10
Grassland_1	15	74	11
Grassland_2	33	60	7
Grassland_3	24	68	7
Grassland_4	17	73	10

Basic soil properties of investigated soils

Site	pH KCl	C%	N%	C:N ratio	S%	P_2O_5 av	Mg av	K_2O av	WRI (Water Resistance index)
Arable_1	4,2	1,410	0,101	14,0	0,012	5,23	12,17	16,03	0,60
Arable_2	4,9	1,640	0,122	13,4	0,012	16,59	25,60	12,12	0,58
Arable_3	6,5	1,060	0,068	15,6	0,006	16,36	29,28	15,39	0,57
Arable_4	6,4	1,350	0,096	14,1	0,010	9,83	21,45	15,12	0,58
Grassland_1	3,8	2,110	0,195	10,8	0,027	0,97	29,00	7,56	0,59
Grassland_2	4,2	1,510	0,112	13,5	0,013	1,12	19,99	8,37	0,58
Grassland_3	5,4	1,590	0,117	13,6	0,014	1,27	20,92	14,86	0,59
Grassland_4	3,9	1,710	0,134	12,8	0,012	23,38	37,29	5,98	0,59
Arable land	**5,5**	**1,37**	**0,10**	**14,3**	**0,01**	**12,0**	**22,1**	**14,7**	**0,58**
Grassland	**4,3**	**1,73**	**0,14**	**12,7**	**0,02**	**6,7**	**26,8**	**9,2**	**0,58**



The PCA captured most data variability with the first two axes (Axis 1: 78.9% explained variance; Axis 2: 14.2%), showing a separation among site types based on chemical and biological soil properties and confirm strong corellation between Earthworms presence and carbon (C), nitrogne (N) and water resistance index (WRI).



Earthworm species in investigated soils

Site	Aporrectodea caliginosa	A. rosea	Lumbricus castaneus	L. rubellus	Octolasion lacteum	Allolobophora chlorotica	Dendrobaena octaedra	Index Shanona
Arable_1	+	+		+				0,849
Arable_2		+	+	+		+		1,116
Arable_3	+							~0,000
Arable_4	+	+	+				+	1,162
Grassland_1	+	+	+	+				1,083
Grassland_2	+	+	+	+	+	+		1,409
Grassland_3	+	+	+		+		+	1,085
Grassland_4	+	+	+					0,900

Summary

Grassland soils, with minimal disturbance and higher organic inputs from plant residues, consistently demonstrated higher organic carbon, nitrogen, and earthworm populations than the arable sites. Results from four sampling plots per land-use type indicate that grasslands support a higher average earthworm density (133 ind./m²) compared to arable land (81 ind./m²). Similarly, mean earthworm biomass was greater in grasslands (46.8 g/m²) than in arable plots (29.5 g/m²), highlighting the impact of land use on soil fauna communities. Arable fields had higher soil pH and, except for Mg, showed higher concentrations of plant-available P and K, reflecting intensive fertilisation and management. These trends align with well-established patterns of greater biological and organic matter accumulation in grasslands, versus the nutrient enrichment but lower biotic activity typical of cultivated soils.

This research was funded through the 2022-2023 Biodiversa+ COFUND call, under the European Biodiversity Partnership programme, and with the funding organisations: National Science Centre 2023/05/Y/ST10/00098.

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