

ECOLOGICAL STUDY OF EARTHWORMS (OLIGOCHAETA: LUMBRICIDAE) DIVERSITY IN THE BOTANIC PARK OF TIMIȘOARA, ROMANIA

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Abstract

The geographic distribution of earthworms (Oligochaeta: Lumbricidae) has been only lowly studied in Romania, and for the urban diversity a few information is available. As a component of urban diversity, earthworms accomplish important roles in the soil ecosystems and in the global ecosystem, the largely known being the increase of soil fertility, the improvement of the physical-chemical properties of the soil and the management of wastes through vermicompostation. The goal of this study was to establish the species diversity of earthworms (Oligochaeta: Lumbricidae) in the Botanic Park of Timișoara, Romania, and to ecologically characterize this biodiversity through several specific ecological indices (abundance, dominance, constancy, Dzuba ecological signification, Sørensen and Jaccard similarity). Six earthworm species have been identified in the tehnosoil of the Botanic Park from Timișoara: Aporectodea rosea, Aporectodea caliginosa, Allolobophora chlorotica, Dendrodrilus rubidus, Lumbricus terrestris, Lumbricus rubellus.

Key words: earthworms, diversity, urban, Oligochaeta: Lumbricidae.

INTRODUCTION

The earthworms are encountered on Terra in all continents, excepting Antarctica (Phillips et al., 2019). These are organisms of Kingdom Animalia, Phylum Annelida (ringed worms), Class Clitellata (because of their anatomic structure named clitellum), Subclass Oligochaeta, Order Haplotaxida/Opisthopora (the genital male pores are open out of the body, posterior to the female genital pores), Family Lumbricidae (Rafinesque-Schmaltz, 1815).

In Romania, the common name of these organisms is "earthworms" ("râme" in Romanian).

There are approximately 700 earthworm species known all over the world, spread in various environments, excepting the areas with arctic and arid climates. In Europe live approximately 20 earthworm species widely spread, and in Romania there have been identified 80 species and subspecies (Szederjesi et al., 2019).

The geographic distribution of earthworms (Oligochaeta: Lumbricidae) has been only lowly studied in Romania (Pop & Pop, 2006;

Pop et al., 2012; Szederjesi et al., 2014; Csuzdi et al., 2018; Szederjesi et al., 2019), and for the urban diversity there are few information (Iordache et al., 2021).

As a component of urban diversity, earthworms accomplish important roles in the soil ecosystems and in the global ecosystem, those largely known being the increase of soil fertility, the improvement of the physical-chemical properties of the soil and the management of wastes (through vermicompostation).

The social ecology showed that human being cannot be separated by his native natural environment (Richardson et al., 2017; Lumber et al., 2017), and since the urban habitat seems to be the main living environment of the humans now and in the future, becomes more clear why every species of urban biodiversity is important in making the human habitat more understood, and, according to several opinions, more friendly as a indicator of wellness (Richardson et al., 2017; Li et al., 2019; Parsons et al., 2019).

The goal of this study was to establish the species diversity of earthworms (Oligochaeta: Lumbricidae) in the Botanic Park of Timisoara,

Romania, and to ecologically characterize this biodiversity through several specific ecological indices.

MATERIALS AND METHODS

The researches was made in the Botanic Park of Timișoara ($45^{\circ}45'18''\text{N}$, $21^{\circ}13'28''\text{E}$) (Figure 1), located at north of river Bega, with 8,41 ha surface (Ciupa, 2010).

The Botanic Park of Timisoara is also known as Botanic Garden and it has been settled as an arboretum (dendrological park), established

between years 1986-1990 by the architect Silvia Grumeza. There have been planted here over 1650 plant species with various origins, like from other parks of Romania, private collections, or international exchange of seeds. In 1995 the park has been declared scientific reservation, aiming the protection of local and exotic flora (17, 18).

Across the park there have been established four sampling points (Figure 1) to study the earthworm species diversity. These sampling points have been established basing on casting occurrence.



Figure 1. The Botanic Park of Timisoara ($45^{\circ}45'18''\text{N}$, $21^{\circ}13'28''\text{E}$) (capture Google Maps): view with the sampling points

Earthworm sampling has been made using formalin solution combined with direct hand sampling. The taxonomic affiliation has been made on adult worms, the ecological feeding affiliation (epigeic, endogeic, anecic) has been made according to Bouché (1977). The values of abundance, dominance, constancy, index Dzuba have been calculated according to Gomoiu & Skolka (2001). The indicator

constancy has been calculated by relating the number of sampled plots where the species occurred to the total number of plots (Braun-Blanquet, 1932).

The indices Sørensen and Jaccard have been calculated based on species incidence in the sampled points according to Chao & Ricotta (2019).

RESULTS AND DISCUSSIONS

Within the studied area of the park there have been identified six earthworm species. As habitat ecology, two of these species are epigeic, three are endogeic, and one of these is anecic (Table 1). The classification as feeding ecology showed three earthworm species detritivore and three geophage (Table 1).

Table 1. The earthworm species identified in the Botanic Park of Timisoara, Romania

No.	Species	Habitat ecology	Feeding ecology
1	<i>Aporrectodea rosea</i> (Savigny, 1826)	endogeic	geophage, microphage
2	<i>Aporrectodea caliginosa</i> (Savigny, 1826)	endogeic	geophage, microphage
3	<i>Allolobophora chlorotica</i> (Savigny, 1826)	endogeic	geophage, microphage
4	<i>Dendrodriilus rubidus</i> (Savigny, 1826)	epigeic	detritivore, mezophage
5	<i>Lumbricus terrestris</i> (Linnaeus, 1758)	anecic	detritivore, macrophage
6	<i>Lumbricus rubellus</i> (Hoffmeister, 1845)	epigeic, endogeic, anecic	detritivore, mezophage

In Table 2 is shown the distribution of earthworm species found in the four sampling points in the Botanic Park of Timisoara, with the mention that this is only for the adult individuals, the only ones that can be taxonomically identified.

Table 2. The distribution (species incidence) of earthworm species in the sampling points of the park

No.	Species	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4
1	<i>Aporrectodea rosea</i>	x	x	x	x
2	<i>Aporrectodea caliginosa</i>	x		x	x
3	<i>Allolobophora chlorotica</i>		x		x
4	<i>Dendrodriilus rubidus</i>		x		
5	<i>Lumbricus terrestris</i>	x	x	x	x
6	<i>Lumbricus rubellus</i>	x	x		

In Table 3 there are presented the numerical and biomass abundance for the sampled earthworm species, both for adults and juveniles.

Table 3. The numerical and biomass abundance for the sampled earthworm species

No.	Species	Sampling point 1		Sampling point 2		Sampling point 3		Sampling point 4	
		Number of adults	Total biomass (adults+ juveniles) (g)	Number of adults	Total biomass (adults+ juveniles) (g)	Number of adults	Total biomass (adults+ juveniles) (g)	Number of adults	Total biomass (adults+ juveniles) (g)
1	<i>Aporrectodea rosea</i>	3	12 g	3	19 g	2	75 g	4	83 g
2	<i>Aporrectodea caliginosa</i>	1		-		1		3	
3	<i>Allolobophora chlorotica</i>	-		5		-		1	
4	<i>Dendrodriilus rubidus</i>	-		1		-		-	
5	<i>Lumbricus terrestris</i>	1		3		10		9	
6	<i>Lumbricus rubellus</i>	1		1		-		-	
		Total earthworms (adults+juveniles): 6		Total earthworm (adults+juveniles): 23		Total earthworms (adults+juveniles): 18		Total earthworms: (adults+juveniles) 41	

There was found that *Lumbricus terrestris* is the most abundant species in the studied urban ecosystem, both as number and biomass (Table 3), the weight of the adults ranging between 3 and 8 g.

The values of *dominance* (D) are listed in Table 4 and represent values more explanatory compared to the indicator *abundance* alone, and therefore more precise in establishing the numerically dominance ranking of the earthworm species within the studied urban ecosystem. There was thus found that four species are eudominant in the studied ecosystem: *Lumbricus terrestris*, *Aporrectodea rosea*, *Allolobophora chlorotica*, and *Aporrectodea caliginosa*, and *Dendrodriilus rubidus* is a recedent species encountered in a single sample, with one individual.

The values of the indicator *constancy* are shown in Table 5. There have been found three euconstant earthworm species, encountered in all samples: *Lumbricus terrestris*, *Aporrectodea rosea* and *Aporrectodea caliginosa*. *Dendrodriilus rubidus* is the only one accessory species.

Table 4. The values of the ecological indicator *dominance* (D) for the sampled earthworm species

No.	Species	Values of <i>dominance</i> (D)	Signification
1	<i>Aporrectodea rosea</i>	D sp. <i>Aporrectodea rosea</i> = 24.48%	eudominant species
2	<i>Aporrectodea caliginosa</i>	D sp. <i>Allolobophora chlorotica</i> = 10.20%	eudominant species
3	<i>Allolobophora chlorotica</i>	D sp. <i>Dendrodriilus rubidus</i> = 12.24%	eudominant species
4	<i>Dendrodriilus rubidus</i>	D sp. <i>Lumbricus terrestris</i> = 2.04%	recedent species
5	<i>Lumbricus terrestris</i>	D sp. <i>Lumbricus rubellus</i> = 46.93%	eudominant species
6	<i>Lumbricus rubellus</i>	D sp. <i>Lumbricus rubellus</i> = 4.08%	subdominant species

Table 5. The values of the ecological indicator *constancy* (C) for the sampled earthworm species

No.	Species	Values of <i>constancy</i> (C)	Signification
1	<i>Aporrectodea rosea</i>	C sp. <i>Aporrectodea rosea</i> = 100%	euconstant species
2	<i>Aporrectodea caliginosa</i>	C sp. <i>Allolobophora chlorotica</i> = 75%	euconstant species
3	<i>Allolobophora chlorotica</i>	C sp. <i>Dendrodrilus rubidus</i> = 50%	accessory species
4	<i>Dendrodrilus rubidus</i>	C sp. <i>Lumbricus terrestris</i> = 25%	accidental species
5	<i>Lumbricus terrestris</i>	C sp. <i>Lumbricus rubellus</i> = 100%	euconstant species
6	<i>Lumbricus rubellus</i>	C sp. <i>Lumbricus rubellus</i> = 50%	accessory species

The indicator *Dzuba* (W) was calculated to find out the relation existing between constancy (C) as a structural indicator and *dominance* (D) as a productive indicator, this combination offering a more accurate view about the ecological signification of the earthworm species found in the studied ecosystem as compared to the *dominance* (D) alone.

The ranking of these species according to the *Dzuba* indicator (W) is shown in Table 6.

Table 6. The values of the ecological indicator *Dzuba* (W) for the sampled earthworm species

No.	Species	Values of indicator <i>Dzuba</i> (W)	Signification
1	<i>Aporrectodea rosea</i>	W sp. <i>Aporrectodea rosea</i> = 24.48%	eudominant species
2	<i>Aporrectodea caliginosa</i>	W sp. <i>Allolobophora chlorotica</i> = 7.65%	dominant species
3	<i>Allolobophora chlorotica</i>	W sp. <i>Dendrodrilus rubidus</i> = 6.12%	dominant species
4	<i>Dendrodrilus rubidus</i>	W sp. <i>Lumbricus terrestris</i> = 0.51%	recedent species
5	<i>Lumbricus terrestris</i>	W sp. <i>Lumbricus rubellus</i> = 46.93%	eudominant species
6	<i>Lumbricus rubellus</i>	W sp. <i>Lumbricus rubellus</i> = 2.04%	subdominant species

To establish the values of the indicators Sørensen and Jaccard there have been considered the incidence (the presence or absence) of the earthworm species in the sampling areas.

There has been found a high Sørensen similarity between all pairs of sampling points, ranging between 50 - 100% (Table 7).

Table 7. Sørensen similarity (%) of the sampling points in the urban park: the values of the Sørensen indicator

	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4
Sampling point 1	100%	0.66	0.85	0.75
Sampling point 2	66%	100%	0.50	0.66
Sampling point 3	85%	50%	100%	0.85
Sampling point 4	75%	66%	85%	100%

These values show that, as species composition, the sampling areas (selected on the basis of castings occurrence) are homogenous (over 50%), although the earthworms have been collected only from four sampling points related to the entire surface of the park.

The dendrogram of Sørensen similarity (Figure 2) shows that the sampling point 1 is that establishing the most numerous hierarchical clusters with the other sampling points, meaning the highest similarities as earthworm species composition, followed by the sampling point 4.

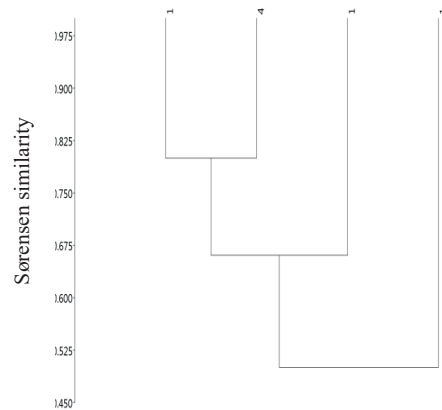


Figure 2. Dendrogram of Sørensen similarity (%) of the four sampling points across the urban park (the values range from 0 to 1, equivalent to 0 to 100% similarity)

In order to establish the relations of coenotic affinity between the earthworm species identified within the park, the *similarity Jaccard* has been calculated (Table 8).

A single pair of earthworm species was found to have 100% coenotic affinity: *Lumbricus terrestris* - *Aporrectodea rosea*.

Also, a single pair of earthworm species was found to have 0% coenotic affinity: *Aporrectodea caliginosa* - *Dendrodrilus rubidus*.

Two pairs of earthworm species had 75% coenotic affinity: *Aporrectodea rosea* - *Aporrectodea caliginosa* and *Lumbricus terrestris* - *Aporrectodea caliginosa*.

Because more than half of species pairs of earthworms (9 from 15) possess over 50% coenotic affinity, becomes clear the affinity of these species to co-inhabit the same biotope.

The cluster dendrogram of the Jaccard similarity (coenotic affinity) for the six

earthworm species identified within the park (noted with 1 to 6) (Figure 3) shows three very affine earthworm species: 1 - *Aporrectodea rosea*; 2 - *Aporrectodea caliginosa*; 3 - *Lumbricus terrestris*.

Two groups comprise species lowly affine: the group (1, 4, 6) and the group (1, 5, 6), which consist of the species (*Aporrectodea rosea*, *Dendrodriilus rubidus*, *Lumbricus rubellus*) and respectively (*Aporrectodea rosea*, *Lumbricus*

terrestris, *Lumbricus rubellus*), while the group formed by the species 1, 5 (*Aporrectodea rosea*, *Lumbricus terrestris*) presents 100% coenotic affinity. The species *Dendrodriilus rubidus* (4) is entirely separated from the others, with which it has no coenotic affinity (singleton). This species was also found to be rare in another urban park from Timișoara studied as earthworm species composition (Iordache et al., 2021).

Table 8. Diagram of Jaccard similarity (coenotic affinity - %) of the sampled earthworm species within the Botanic Park from Timisoara, Romania

Species	<i>Aporrectodea rosea</i>	<i>Aporrectodea caliginosa</i>	<i>Allolobophora chlorotica</i>	<i>Dendrodriilus rubidus</i>	<i>Lumbricus terrestris</i>	<i>Lumbricus rubellus</i>
<i>Aporrectodea rosea</i>		75%	50%	25%	100%	50%
<i>Aporrectodea caliginosa</i>			25%	0%	75%	25%
<i>Allolobophora chlorotica</i>				50%	50%	33.33%
<i>Dendrodriilus rubidus</i>					25%	50%
<i>Lumbricus terrestris</i>						50%
<i>Lumbricus rubellus</i>						

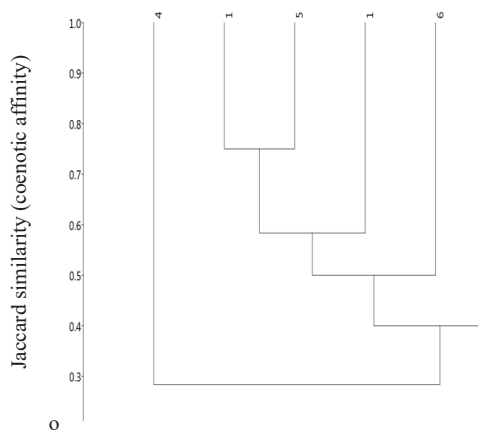


Figure 3. Dendrogram of Jaccard similarity (coenotic affinity): 1 - *Aporrectodea rosea*; 2 - *Aporrectodea caliginosa*; 3 - *Allolobophora chlorotica*; 4 - *Dendrodriilus rubidus*; 5 - *Lumbricus terrestris*; 6 - *Lumbricus rubellus*

CONCLUSIONS

Six earthworm species have been identified in the tehno soil of the Botanic Park from Timisoara: *Aporrectodea rosea* (endogeic, geophage), *Aporrectodea caliginosa* (endogeic, geophage), *Allolobophora chlorotica* (endogeic, geophage), *Dendrodriilus rubidus* (epigeic,

detritivore), *Lumbricus terrestris* (anecic, detritivore), *Lumbricus rubellus* (epigeic, detritivore).

The species *Lumbricus terrestris* has been found to be the most abundant in the studied urban ecosystem, both numerically and as biomass.

Four earthworm species are numerically eudominant in the studied urban ecosystem: *Lumbricus terrestris*, *Aporrectodea rosea*, *Allolobophora chlorotica*, *Aporrectodea caliginosa*, and *Dendrodriilus rubidus* is a recedent species, encountered in one specimen in a single sampling surface.

Three earthworm species are euconstant, found in all sampling points: *Lumbricus terrestris*, *Aporrectodea rosea* and *Aporrectodea caliginosa*. *Dendrodriilus rubidus* is the only accessory species (one specimen in a single sampling surface).

As species composition, the studied perimeters are very homogenous, which is sustained by high values of the Sørensen similarity (9 from 15 sampling points show over 50% similarity). A single pair of earthworm species was found to have 100% coenotic affinity: *Lumbricus terrestris* - *Aporrectodea rosea*.

Also, a single pair of earthworm species was found to have 0% coenotic affinity:

Aporrectodea caliginosa - *Dendrodrilus rubidus*.

Because more than half of species pairs of earthworms (9 from 15) possess over 50% coenotic affinity, becomes clear the affinity of these species to co-inhabit the same biotope.

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