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Diversity and Zoogeographic Affinities of Earthworms (Clitellata: Lumbricidae) in Kosovo and Metohia

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Abstract: We have summarised the current knowledge on earthworm diversity in Kosovo and Metohia. The complete list of earthworm taxa includes 40 species and subspecies belonging to 11 genera of the family Lumbricidae. Among them, *Aporrectodea handlirschi* (Rosa, 1897), *Cernosvitovia paratuleskovi* (Šapkarev, 1975), *Cernosvitovia strumicae* (Šapkarev, 1973), *Cernosvitovia treskavicensis* (Mršić, 1991), *Dendrobaena vejdovskyi* (Černosvitov, 1935) and *Lumbricus meliboeus* (Rosa, 1884) were registered for the first time in the study area. With respect to the zoogeographical characteristics, most of the earthworm species belong to peregrine (14 species, 35%) and endemic groups (11 species, 27.5%). The group of the endemic species belongs to the genera *Dendrobaena* and *Cernosvitovia*.

Key words: soil fauna, Balkan Peninsula, Oligochaeta, Annelida, new records

Introduction

Serbia, as part of the Balkan Peninsula, is characterised by the extraordinary richness and diversity of the lumbricid fauna, with so far recorded 77 species-group taxa of 13 genera (Stojanović-Petrović et al. 2020). The cause of this richness lies in the specific geographic location on the border between two biogeographical regions (Pannonian and Balkan), each characterised by specific climatic, ecological and geomorphological conditions as well as a specific geological past and palaeoclimatic conditions. Kosovo and Metohia is located in the central part of the Balkan Peninsula. It is surrounded by Prokletije Mountain in the west, Kopaonik Mountain in the north and Šar Mountain in the south (Jakšić & Belij 1995). The specific geographical position of Kosovo and Metohia in the area of the confrontation of two large tectonic plates (Dinarides and Rhodopes) influenced the overall complexity of the geomorphological characteristics of the terrain. Prokletije Mt., as the extreme part of the southeastern Dinarides, contains Dinaric faunistic elements. On the other hand, Šar Mountain marks the beginning of a separate morphotectonic massif of the Dinaric Alps, known in classical geological and geomorphological literature as the Šar-Pindus Mountain system. This

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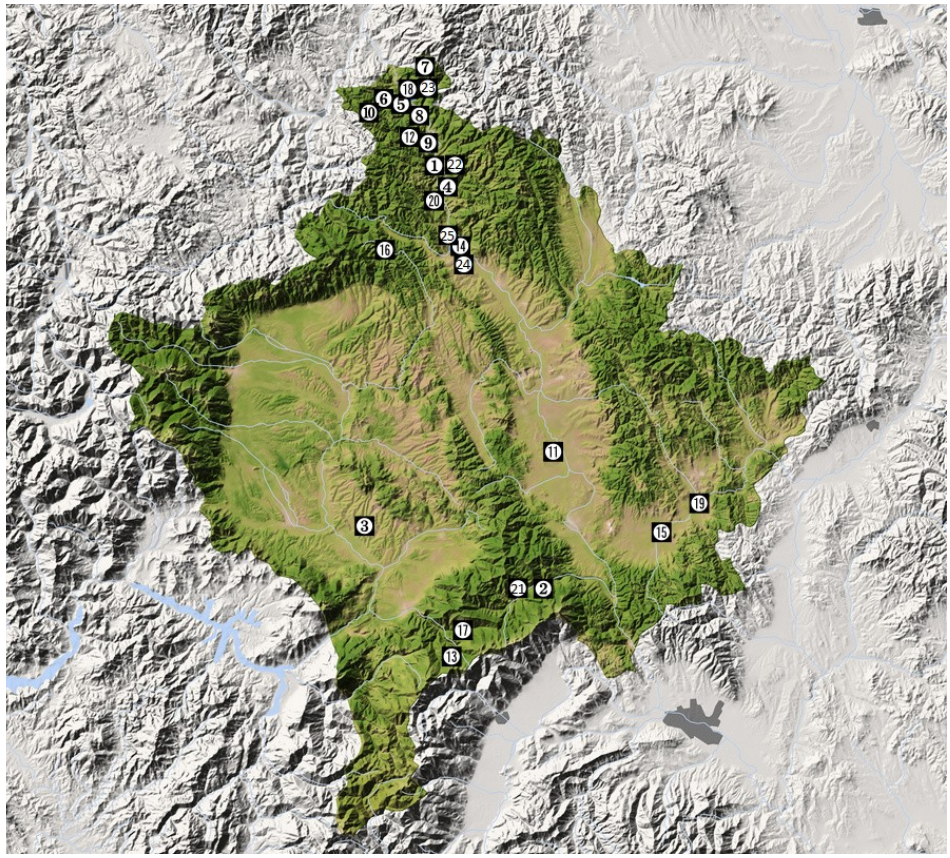

Fig. 1. Examined area (localities 1–25) and its position in Kosovo and Metohia. Localities: 1 – Leposavić, 2 – Štrpce, 3 – Orahovac, 4 – Sočanica, 5 – Lešak, 6 – Postenje, 7 – Belo Brdo, 8 – Građevac, 9 – Gradac, 10 – Vračevo, 11 – Lipljan, 12 – Donji Krnjin, 13 – Šar Mt., 14 – Zvečan, 15 – Klokot, 16 – Zubin Potok, 17 – Dubrava, 18 – Ostraće, 19 – Gnjilane, 20 – Vuča, 21 – Sirinićka župa, 22 – Kamilja, 23 – Sandžak, 24 – Kosovska Mitrovica, 25 – Žizkovac. Circles represent literature data.

mountain is distinguished by the complex palaeogeographical changes in the past, refugial character during the Ice Age, very complex floristic composition and a combination of various ecological conditions varying in a small area (Amidzić et al. 2012). Unlike the flora, the fauna in the area of Kosovo and Metohia has been partially researched. There are complete faunal lists for a limited number of invertebrate groups only, while the largest number of groups is practically unexplored.

The family Lumbricidae is an ecologically important group of invertebrates, which has been studied from various aspects by a number of researchers. However, very few authors studied the family Lumbricidae in Kosovo and Metohia. Considering that the Balkan Peninsula is characterised by rich biological diversity, it is clear that the faunal research of earthworms of Kosovo and Metohia significantly contributes to understanding the highly diverse and complex terrestrial or soil fauna of the Balkan. The first taxonomic data on earthworms of Kosovo and Metohia appeared in the first half of the 20th century when Černosvitov (1931) registered the species *Dendrobaena byblica* (Rosa, 1893) on Šar Mt. The studies were intensified during the sixties and later (Karaman 1968, Zicsi 1968). Their work was continued by Šapkarev (1972) who added 9 species to the earthworm fauna and later (Šapkarev 1975) provided descriptions and zoogeographic data for 25 species. The first complete summary on the earthworms from Kosovo and Metohia was published by Mršić (1991). In his monograph, Mršić (1991) gave an extensive list of earthworms in the Balkans, listing 34 species registered in Kosovo and Metohia. In the following period, after almost 30 years, Szederjesi (2019) found 14 additional species on the same territory. In addition, Sekulić et al. (2021) gave a list of known earthworm taxa in the area of Šar Mt. (24 taxa).

The aim of this paper is to present new data on the earthworm fauna and to analyse the reported species in order to elaborate an updated list of the known earthworm species of Kosovo and Metohia.

Materials and Methods

Study area

Our investigations were carried out in Kosovo and Metohia (Fig. 1). This area predominantly consists of mountainous terrain (63.5 %), whereas lowlands make up 36.5 % of its relief. The area is characterised by complex climatic and orographic characteristics and has a very complex geological composition, primarily numerous valleys and mountains. The climate varies from mountainous to temperate-continental and continental. In the west and northwest are Prokletije Mt. with Mokra Gora and Žljeb, in the southwest Korab, Paštrik and Koritnik, in the southeast Šar Mt. and Skopska Crna Gora. In the north, the Kosovo region covers the slopes of the middle and southern part of the Kopaonik Mt. To the east is South Pomoravlje, and Kosovo has a mountain range that separates South Pomoravlje from the Kosovo Valley.

Methods

An extensive field investigation was carried out during the period 2012–2021. During this time, more than 30 localities around Kosovo and Metohia were explored. Specimens were collected in spring and summer in forests, meadows, mountain pastures as well as river and creek habitats. The habitats are situated at altitude between 460 and 1600 m. In the analyses, previously published data of the present authors as well as data from earlier sporadic investigations were included. Earthworms were collected by the formalin method, digging (0.4×0.4 m^2) and hand sorting (Csuzdi & Zicsi 2003). The specimens were killed in 70% ethanol, fixed in 4% formalin solution and later transferred to 90% ethanol, in which they were stored. Earthworms were identified in the laboratory of the Faculty of Science in Kragujevac, following the keys by Šapkarev (1978), Zicsi (1982), Mršić (1991) and Csuzdi & Zicsi (2003). All of the specimens collected and (or) examined are deposited in the Earthworm Collection of the University of Kragujevac, Serbia (CEKUS).

To date, only a few works have been published that deal with the distribution of various earthworm species. We have tried to summarise the zoogeographical patterns of earthworms from the study area. According to the distribution types given by several authors (Omodeo 1952, Omodeo & Rota 1991, 1999, Mršić 1991, Csuzdi & Zicsi 2003, Pop et al. 2010, Csuzdi et al. 2011), the present review showed the occurrence of several zoogeographic categories. These categories are: peregrine, Central-European (inhabiting the central part of Europe), Trans-Aegean (distributed from the European Alps to the Ural Mts., including Anatolia, the Levant and Mesopotamia), Circum-Mediterranean, Atlanto-Mediterranean, Illyrian endemics (widespread in the Western Balkans), Balkanic-Alpine and Balkan endemics of wider distribution (widespread in Balkan Peninsula) and endemics of narrow distribution in a limited area of the Balkan Peninsula.

Results

Throughout the history of research of earthworm fauna in Kosovo and Metohia, 38 species and subspecies of lumbricid earthworms have been registered. However, some species given by previous authors (Šapkarev 1975, Mršić 1991, Szederjesi 2019) are synonyms of other species and some species have been transferred to other genera. In comparison with the most recent list of earthworm species from Kosovo and Metohia, the following changes have occurred: four species were found to be synonymous with species already reported: *Allolobophora chlorotica kosovensis* (Šapkarev, 1977) = *All. chlorotica* (Savigny, 1926), *Dendrobaena alpina popi* (Šapkarev, 1971) = *Dendrobaena alpina alpina* (Rosa, 1884), *Dendrodrilus rubidus tenius* (Eisen, 1874) = *Bimastos rubidus* (Savigny, 1826), *Eiseniella tetraedra pupa* (Eisen, 1874) = *Eiseniella tetraedra hercynia* (Eisen, 1874). For two species listed earlier for the fauna of Kosovo and Metohia (Šapkarev 1975, Mršić 1991), *Allolobophora chlorotica kosovensis* (Šapkarev, 1977) and *Dendrobaena alpina popi* (Šapkarev, 1971), it was determined that the previous identification was erroneous. By combining new findings with the previous records (Šapkarev 1975, Mršić 1991, Szederjesi 2019), the number of lumbricids known to occur in the studied region rises to 40 species-group taxa belonging to 11 genera (Table 1). Of these, six taxa are new for the earthworm fauna of Kosovo and Metohia: *Aporrectodea handlirschi*, *Cernosvitovia paratuleskovi*, *Cernosvitovia strumicae*, *Cernosvitovia treskavicensis*, *Dendrobaena vejdovskyi* and *Lumbricus meliboeus* (Table 2).

Discussion

The majority of the recorded species belong to the genera *Dendrobaena* (nine species) and *Aporrectodea* (seven species). Bearing in mind that few works deal with the biogeography of earthworms from Ko-

Table 1. Complete list and zoogeographical characteristics of earthworm taxa in Kosovo and Metohia

Species	Šapkarev (1975)	Mršić (1991)	Szederjesi (2019)	Sekulić et al. (2021)	Present study	Zoogeographical type
Allolobophora chlorotica (Savigny, 1926)	+	+	+	+	+	Peregrine
Allolobophora (*s.l.*) *kosowensis* Karaman, 1968	+	+	–	–	–	Broad range Balkanic endemic
Allolobophora leoni Michaelsen, 1891	+	+	–	+	–	Trans-Agean
Allolobophora (*s.l.*) *zisci* Šapkarev, 1975	+	+	–	–	–	Narrow range Balkanic endemic
Aporrectodea caliginosa (Savigny, 1826)	+	+	+	+	+	Peregrine
Aporrectodea georgii (Michaelsen, 1890)	+	+	–	+	+	Atlanto-Mediterranean
Aporrectodea handlirschi (Rosa, 1897)	–	–	–	–	+	Trans-Aegean
Aporrectodea jassyensis Michaelsen, 1891	+	+	–	+	+	Trans-Aegean
Aporrectodea rosea (Savigny, 1826)	+	+	+	+	+	Peregrine
Aporrectodea smaragdina (Rosa, 1892)	+	+	+	–	+	Central European
Aporrectodea trapezoides (Duges, 1828)	–	+	–	+	+	Peregrine
Bimastos eiseni (Levinsen, 1884)	–	+	–	–	+	Peregrine
Bimastos rubidus (Savigny, 1926)	+	+	+	+	–	Peregrine
Cernosvitovia paratuleskovi (Šapkarev, 1975)	–	–	–	–	+	Vardar endemic
Cernosvitovia strumicae (Šapakrev, 1973)	–	–	–	–	+	Vardar endemic
Cernosvitovia treskavicensis (Mršić, 1991)	–	–	–	–	+	Vardar endemic
Dendrobaena attemsi (Michaelsen, 1902)	–	–	–	+	–	Trans-Aegean
Dendrobaena byblica (Rosa, 1893)	+	+	+	+	+	Circum-Mediterranean
Dendrobaena illyrica (Cognetti, 1906)	+	+	–	+	+	Illyrian
Dendrobaena octaedra (Savigny, 1926)	–	+	–	+	+	Peregrine
Dendrobaena platyura (Fitzinger, 1833)	–	–	–	+	–	Central European
Dendrobaena serbica Karaman, 1973	–	+	–	–	–	Broad range Balkan endemic
Dendrobaena vejdovski (Černosvitov, 1935)	–	–	–	–	+	Balkanic-Alpine
Dendrobaena jahorensis (Mršić, 1991)	–	–	+	+	–	Broad range Balkanic endemic
Dendrobaena montenegrina Mršić, 1988	–	–	+	–	–	Broad range Balkanic endemic
Dendrobaena zicsi Karaman, 1973	–	+	–	–	–	Narrow range Balkanic endemic
Eisenia fetida (Savigny, 1826)	+	+	+	+	+	Peregrine
Eisenia lucens (Waga, 1857)	+	+	–	+	+	Central European
Eisenia spelaea (Rosa, 1901)	–	+	–	–	–	Central European
Eiseniella tetraedra tetraedra (Savigny, 1826)	+	+	+	+	+	Peregrine
Eiseniella tetraedra hercynia (Eisen, 1874)	+	+	–	–	–	Peregrine
Helodrilus balcanicus balcanicus (Černosvitov, 1931)	–	–	+	–	–	Broad range Balkanic endemic
Helodrilus balcanicus plavensis (Karaman, 1972)	–	–	+	+	–	Broad range Balkanic endemic
Lumbricus castaneus (Savigny, 1826)	–	+	–	+	+	Peregrine
Lumbricus meliboeus (Rosa, 1884)	–	–	–	–	+	Alpine-Dinaric
Lumbricus rubellus Hoffmeister, 1843	+	+	+	+	+	Peregrine
Lumbricus terrestris Linnaeus, 1758	+	+	–	+	+	Peregrine
Octodrilus transpadanus (Rosa, 1884)	+	+	–	+	–	Trans-Aegean
Octolasion lacteum (Örley, 1881)	+	+	+	+	+	Peregrine
Proctodrilus antipai (Michaelsen, 1891)	+	+	–	–	+	Central European
Proctodrilus tuberculatus (Černosvitov, 1935)	+	+	–	–	–	Trans-Aegean

Table 2. List of the earthworm species collected at new sampling locations (including habitat type and altitude) in Kosovo and Metohia

Species	Habitat	Localities	Altitude	Coordinates
All. chlorotica	Oak forest	2 exp., Leposavić, Octobar 2018	544 m	43°06′N, 20°48′E
	Forest	7 exp., Štrpce, September 2020	939 m	42°14′N, 21°01′E
	Meadow	2 exp., Orahovac, September 2020	475 m	42°23′N, 20°39′E
	Beech forest	6 exp., Štrpce, September 2020	939 m	42°14′N, 21°01′E
	Meadow	2 exp., Orahovac, September 2020	475 m	42°23′N, 20°39′E
	Oak forest	1 exp., Sočanica, March 2020	533 m	43°03′N, 20°49′E
Ap. caliginosa	Near wastewater	4 exp., Lešak, April 2013	445 m	43°09′N, 20°44′E
	Beech forest	1 exp., Postenje, May2013	484 m	43°11′N, 20°42′E
	Meadow	1 exp., Dubrava, April 2015	630 m	43°06′N, 20°48′E
	Arable land	2 exp., Građevac, April 2015	483 m	43°10′N, 20°44′E
	Beech forest	2 exp., Štrpce, May 2019	930 m	42°14′N, 21°01′E
	Oak forest	1 exp., Sočanica, March 2020	610 m	43°03′N, 20°49′E
	Beech forest	2 exp., Štrpce, September 2020	1000 m	42°14′N, 21°02′E
	Beech forest	2 exp., Štrpce, September 2020	930 m	42°14′N, 21°00′E
Ap. georgii	Oak forest	1 exp., Ostraće, May 2015	960 m	43°11′N, 20°45′E
Ap. handlirschi	Beech forest	1 exp., Vračevo, June 2016	570 m	43°10′N, 20°39′E
	Beech forest	2 exp., Štrpce, September 2020	930 m	42°14′N, 21°00′E
Ap. jassyensis	Oak forest	1 exp., Lešak, May 2013	520 m	43°09′N, 20°44′E
Ap. rosea	Meadow	1 exp., Šar Mt., May 2012	1240 m	42°07′N, 20°50′E
	Meadow	3 exp., Lipljan, June 2012	543 m	42°31′N, 21°06′E
	Oak forest	1 exp., Dubrava, April 2013	660 m	43°06′N, 20°48′E
	Near wastewater	3 exp., Lešak, April 2013	445 m	43°09′N, 20°44′E
	Beech forest	1 exp., Postenje, May 2013	484 m	43°11′N, 20°42′E
	Beech forest	4 exp., Donji Krnjin, May 2013	590 m	43°08′N, 20°44′E
	Meadow	2 exp., Šar Mt., May 2019	1600 m	42°07′N, 20°49′E
	Oak forest	9 exp., Ostraće, May 2015	690 m	43°11′N, 20°45′E
	Meadow	1 exp., Zvečan, September 2019	530 m	42°54′N, 20°49′E
	Meadow	1 exp., Klokot, March 2020	570 m	42°22′N, 21°24′E
	Meadow	7 exp., Orahovac, June 2020	470 m	42°23′N, 20°39′E
	Meadow	1 exp., Šar Mt., June 2020	1560 m	42°07′N, 20°49′E
	Beech forest	1 exp., Štrpce, September 2020	930 m	42°14′N, 21°00′E
Ap. smaragdina	Oak forest	1 exp., Dubrava, April 2013	660 m	43°06′N, 20°48′E
Ap. trapezoides	Near wastewater	2 exp., Lešak, April 2013	445 m	43°09′N, 20°44′E
	Meadow	13 exp., Leposavic, April 2017	455 m	43°06′N, 20°48′E
	Meadow	1 exp., Štrpce, May 2019	930 m	42°14′N, 21°01′E
	Beech forest	3 exp., Štrpce, September 2020	930 m	42°14′N, 21°00′E
B. eiseni	Beech forest	1exp., Postenje, May 2013	484 m	43°11′N, 20°42′E
C. paratuleskovi	Oak forest	1 exp., Dubrava, April 2013	656 m	43°06′N, 20°48′E
	Meadow	1 exp., Lešak, May 2015	542 m	43°10′N, 44°44′E
	Meadow	1 exp., Postenje, May 2015	562 m	43°11′N, 20°41′E
	Meadow	5 exp., Sočanica, May 2020	479 m	43°03′N, 20°48′E
C. strumicae	Oak forest	1 exp., Ostraće, May 2015	690 m	43°11′N, 20°45′E
C. treskavicensis	Humid meadows	1 exp., Belo Brdo, May 2019	1163 m	43°14′N, 20°49′E
	Oak forest	1 exp., Belo Brdo, May 2019.	1050 m	43°13′N, 20°49′E

Table 2. Continuation.

Species	Habitat	Localities	Altitude	Coordinates
D. alpina alpina	Oak forest	1 exp., Belo Brdo, May 2019	1050 m	43°13′N, 20°49′E
D. byblica	Meadow	1 exp., Belo Brdo, May 2019	1163 m	43°14′N, 20°49′E
D. illyrica	Meadow	2 exp., Šar Mt., May 2012	1240 m	42°07′N, 20°50′E
	Beech forest	10 exp., Gnjilane September 2020	550 m	42°26′N, 21°29′E
D. octaedra	Meadow	1 exp., Šar Mt., May 2012	1240 m	42°07′N, 20°50′E
	Oak forest	2 exp., Belo Brdo, May 2019	1050 m	43°13′N, 20°49′E
	Beeh forest	3 exp., Gradac, September 2019	710 m	43°06′N, 20°48′E
	Oak forest	4 exp., Sočanica, October 2019	500 m	43°03′N, 20°48′E
	Oak forest	9 exp., Vuča, October 2019	510 m	43°02′N, 20°48′E
	Beech forest	3 exp., Štrpce, September 2020	930 m	42°14′N, 21°00′E
	Meadow	2 exp., Orahovac, September 2020	475 m	42°23′N, 20°39′E
D. vejdovskyi	Meadow	2 exp., Belo Brdo, May 2019	1014 m	43°14′N, 20°49′E
E. fetida	Meadow	3 exp., Sirinićka župa, Octobar 2012	957 m	42°14′N, 20°58′E
	Oak forest, Under rock	3 exp., Lešak, April 2013	558 m	43°09′N, 20°44′E
	Meadow	1 exp., Leposavić, April 2017	455 m	43°06′N, 20°48′E
	Beech forest	2 exp., Štrpce, September 2020	930 m	42°14′N, 21°00′E
E. lucens	Beech forest	7 exp., Postenje, September 2019	540 m	43°11′N, 20°42′E
	Meadow	1 exp., Orahovac, June 2020	477 m	42°23′N, 20°39′E
Ei. tetraedra tetraedra	Oak forest	1 exp., Kamilja, September 2019	860 m	43°06′N, 20°49′E
	Beech forest	1 exp., Štrpce, September 2020	975 m	42°14′N, 21°01′E
L. castaneus	Beech forest	1 exp., Ostraće, May 2015	690 m	43°11′N, 20°45′E
	Beech forest	1 exp., Vuča, October 2019	510 m	43°02′N, 20°48′E
	Meadow	1 exp., Orahovac, June 2020	470 m	42°23′N, 20°39′E
L. meliboeus	Oak forest	1 exp., Dubrava, April 2013	660 m	43°06′N, 20°48′E
L. rubellus	Meadow	5 exp., Šar Mt., May 2012	1240 m	42°07′N, 20°50′E
	Beech forest	2 exp., Donji Krnjin, May 2013	590 m	43°08′N, 20°44′E
	Oak forest	1 exp., Dubrava, April 2013	660 m	43°06′N, 20°48′E
	Near wastewater	4 exp., Lešak, April 2013	558 m	43°09′N, 20°44′E
	Beech forest	3 exp., Postenje, May 2013	484 m	43°11′N, 20°42′E
	Arable land	9 exp., Građevac, April 2015	483 m	43°10′N, 20°44′E
	Oak forest	3 exp., Vračevo, June 2016	570 m	43°10′N, 20°39′E
	Oak forest	1 exp., Belo Brdo, May 2019	1014 m	43°14′N, 20°49′E
	Oak forest	3 exp., Sandžak, June 2019	950 m	43°12′N, 20°46′E
	Oak forest	1 exp., Kamilja, September 2019	860 m	43°06′N, 20°49′E
	Meadow	1 exp., Zvečan, September 2019	530 m	42°54′N, 20°49′E
	Oak forest	3 exp., Gradac, September 2019	660 m	43°06′N, 20°48′E
	Meadow	1 exp., Klokot, March 2020	570 m	42°22′N, 21°24′E
	Meadow	3 exp., Kosovska Mitrovica, May 2020	496 m	42°53′N, 20°50′E
	Beech forest	10 exp., Štrpce, September 2020	975 m	42°14′N, 21°01′E
	Beech forest	1 exp., Donji Krnjin, August 2020	510 m	43°07′N, 20°46′E
	Meadow	3 exp., Orahovac, June 2020	470 m	42°23′N, 20°39′E
	Meadow	3 exp., Šar Mt., June 2020	1560 m	42°07′N, 20°49′E
L. terrestris	Pasture	7 exp., Zubin Potok, May 2012	567 m	42°54′N, 20°41′E
	Meadow	12 exp., Šar Mt., October 2012	1560 m	42°07′N, 20°49′E

Table 2. Continuation.

Species	Habitat	Localities	Altitude	Coordinates
	Meadow	10 exp., Sirinićka župa, October 2012	957 m	42°14′N, 20°58′E
	Meadow	3 exp., Lipljan, June 2012	550 m	42°31′N, 21°06′E
	Meadow	4 exp., Lipljan, June 2013	563 m	42°32′N, 21°05′E
	Meadow	1 exp., Žizkovac, June 2015	490 m	42°55′N, 20°49′E
	Arable land	3 exp., Leposavić, March 2017	455 m	43°06′N, 20°48′E
	Meadow	2 exp., Zvečan, September 2019	545 m	42°54′N, 20°50′E
	Pasture	1 exp., Sočanica, October 2019	500 m	43°03′N, 20°48′E
	Meadow	1 exp., Vuča, March 2020	560 m	43°02′N, 20°48′E
	Meadow	4 exp., Sočanica, May 2020	470 m	43°03′N, 20°48′E
O. lacteum	Meadow	1 exp., Lipljan, June 2012	550 m	42°31′N, 21°06′E
	Near wastewater	1 exp., Lešak, April 2013	558 m	43°09′N, 20°44′E
	Oak forest	1 exp., Dubrava, April 2013	660 m	43°06′N, 20°48′E
	Beech forest	1 exp., Postenje, May 2013	484 m	43°11′N, 20°42′E
	Beech forest	1 exp., Donji Krnjin, May 2013	590 m	43°08′N, 20°44′E
	Arable land	1 exp., Građevac, April 2015	483 m	43°10′N, 20°44′E
	Meadow	1 exp., Leposavić, April 2017	455 m	43°06′N, 20°48′E
	Arable land	2 exp., Leposavić, March 2017	455 m	43°06′N, 20°48′E
	Meadow	1 exp., Štrpce, May 2019	850 m	42°14′N, 21°01′E
	Beech forest	3 exp., Šar Mt., May 2019	1100 m	42°13′N, 21°00′E
	Oak forest	1 exp., Sočanica October 2019	500 m	43°03′N, 20°48′E
	Oak forest	2 exp., Kamilja, September 2019	860 m	43°06′N, 20°49′E
	Beech forest	1 exp., Zvečan, September 2019	530 m	42°54′N, 20°49′E
	Beech forest	1 exp., Vuča, October 2019	560 m	43°03′N, 20°48′E
	Meadow	1 exp., Klokot, March 2020	570 m	42°22′N, 21°24′E
	Beech forest	1 exp., Klokot, March 2020	710 m	43°06′N, 20°48′E
	Beech forest	1 exp., Donji Krnjin, August 2020	510 m	43°07′N, 20°46′E
	Meadow	4 exp., Orahovac, September 2020	475 m	42°23′N, 20°39′E
	Meadow	1 exp., Šar Mt., June 2020	1560 m	42°07′N, 20°49′E
Pr. antipai	Oak forest	2 exp., Leposavić, March 2017	700 m	43°06′N, 20°48E′

sovo and Metohia, we have tried to summarise the biogeographical patterns of earthworms from the whole study area. One of the most common zoogeographical types of earthworms fauna in the studied region is the widespread peregrine type (14 species or 35 %) of the genera *Allolobophora, Aporrectodea, Bimastos, Cernosvitovia, Dendrobaena, Eisenia, Eiseniella, Lumbricus* and *Octolasion.* When analysing the frequency of occurrence of the identified species in all recorded localities in the studied area, the peregrine species *O. lacteum* appears to be the most common and widespread taxon (recorded in 41.6 % of localities). After peregrine species, the most represented type is that of the endemic species (27.5 %). Among the registered 11 endemic species, six (54.54 %) are endemics with a wider Balkanic distribution, three (27.27%) are Vardar endemics and other two species (18.18%) are endemics of narrow Balkanic distribution.

Allolobophora (*s.l.*) *kosowensis* is an endemic species with a broad distribution. It occurs in the northeastern part of Montenegro, the northern part of Kosovo and the central part of Serbia (Stojanović-Petrović et al. 2020). *Allolobophora* (*s.l.*) *zicsi* is an endemic species of narrow distribution, known only from its type locality (Orahovac) (Trakić et al. 2016). These species with unusual taxonomic characteristics are part of the genus *Allolobophora* (*s.l.*) and have an uncertain taxonomic status. Some data based on a limited molecular phylogenetic research suggested that these Balkanic species might belong to the genus *Cernosvitovia* (Domínguez et al. 2015,

Szederjesi et al. 2016, Popović et al. 2022). The taxonomic status of these species will most likely be clarified by further molecular phylogenetic studies.

In a recent phylogenetic study (Popović et al. 2022), Balkanic samples previously identified as *Allolobophora* (*s.l.*) *paratuleskovi*, *Allolobophora* (*s.l.*) *strumicae* and *Allolobophora* (*s.l.*) *treskavicensis* nested in the genus *Cernosvitovia*. The Vardar endemic species *Cernosvitovia paratuleskovi*, *Cernosvitovia strumicae* and *Cernosvitovia treskavicensis* are for the first time registered in Kosovo and Metohia. After almost thirty years, Popović et al. (2020) indicated that *C. paratuleskovi* is still present in almost the same territory. Our recent investigations revealed new records of *C. paratuleskovi* in the north part of Kosovo and Metohia. The new site at Leposavić is the southernmost limit of the natural range of this species and the first finding in Kosovo. Taking into account the new locality, the extension of the distribution of this species to the south is evident. The Vardar endemic species *Cernosvitovia strumicae* was previously known only from the Strumica region (Strumica and Kosturino-Bjelasnica) in the Republic of North Macedonia (Šapkarev 1973, Mršić 1991). Until a few years ago, *C. strumicae* was thought to be endemic for the Republic of North Macedonia. Popović et al. (2020) reported this species for the first time from a few localities in Kopaonik in Serbia. Our study provides faunistic data about a new locality of this species in the north part of Kosovo and Metohia (Ostraće). The present study is the first report that *C. strumicae* is recorded throughout the whole territory of Kosovo and Metohia. Mršić (1991) found *C. treskavicensis* only in one locality in the Republic of North Macedonia (Treska near Skopje), describing it as *Italobalkaniona treskavicensis* (named after the Treska River). According to Trakić et al. (2016), *C. treskavicensis* has a narrow geographical range in the Balkans, known from the Republic of North Macedonia only. However, Popović et al. (2022) showed that this species belonged to the group of Vardar endemics based on the record in the western part of Kopaonik Mt. (Treska and Semeteš). Our recent study indicated the presence of this species in the southern part of Kopaonik Mt. in the area of Belo Brdo (Kosovo and Metohia).

The distribution range of *A. kosowensis, C. paratuleskovi, C. strumicae, C. treskavicensis* and *A. zisci* is an ancient mainland (Vardar zone), which is related with the transitional position this zone between the Adriatic and the European plate. Actually, in the middle Miocene, a "land bridge" was formed between the Adriatic passive margin (Western Vardar zone, Dinaride ophiolite zone and Drina-Ivanjica zone) and of the European active margin (Eastern Vardar zone, Dacia, Rhodopes and Moesia) (Toljić et al. 2019, Van Hinsbergen et al. 2020). The tectonic origin of Kosovo and Metohia consists of two large parts. The eastern part is of autochthonous origin, formed as a result of the collision of the Dacia and Eastern Vardar zone. The western part of the mentioned province is a fragment of the Western Vardar zone, which was affected by extensive Tertiary volcanism (Schmid et al. 2008). The volcanic products that patchily overlaid the serpentine (ophiolites) parent material resulted in fragmentation and isolation of the original earthworm fauna. This might led to the speciation of the endogeic/anecic endemic species in Kosovo and Metohia. These endemic species are adapted to live in the deeper layers of the soil, where high humidity and constant temperature provide more constant conditions compared to the surface layers of the soil.

The genus *Dendrobaena* is represented in the territory of Kosovo and Metohia with nine species, of which four species are endemic: *Dendrobaena serbica*, *D. jahorensis*, *D. montenegrina* and *D. zicsi*. *Dendrobaena serbica* has been found at only three sites in central Serbia and the west part of Kosovo (Čakor near Peć) (Karaman 1973, Šapkarev 1980, Mršić 1991, Stojanović-Petrović et al. 2020). *Dendrobaena jahorensis* was exclusively endemic to Bosnia. However, Szederjesi (2019) found this species in Kosovo and Metohia, at the foot of the Šar Mt. Since *D. jahorensis* is a high mountain species, we can only assume that it moved along the Dinaric mountain ranges and, by this reason, it was found in a remote place. *Dendrobaena montenegrina* has been considered a species endemic to a restricted part of Montenegro, being for long time known only from its type locality (Crno Jezero, Durmitor) (Mršić 1988, 1991, Stojanović & Milutinović 2013, Trakić et al. 2016). Recent study (Szederjesi 2019) indicated the expansion of its range to the east. This species was found at Žleb, i.e. near the state border between Montenegro and Kosovo and Metohia (Szederjesi 2019). If our assumption is correct, then it means that it moved along the Dinaric Mountain range of Montenegro (from Durmitor Mt. to Prokletije Mt.). *Dendrobaena zicsi* is an endemic species with a narrow distribution, known only from its type locality (Trakić et al. 2016).

The genus *Helodrilus* includes 20 species; except two of them occurring in Asia Minor and the Middle East, the remaining species occur in the central and southern parts of Europe. In the fauna

of Serbia, four species of the genus *Helodrilus* have been identified, including three endemic. *Helodrilus balcanicus plavensis* has been recorded in few localities in Serbia and Montenegro, while *Helodrilus balcanicus balcanicus*, in addition to localities in Serbia and Montenegro, has been recorded in the Republic of North Macedonia (Černosvitov 1931, Karaman 1969, 1972, Šapkarev 1970, 1979, 1980, 1983). In addition, Szederjesi (2019) provided data on the first records of *H. balcanicus balcanicus* and *H. balcanicus plavensis* in Kosovo and Metohia. On the other hand, Sekulić et al. (2021) recorded the Balkanic endemic *H. balcanicus plavensis* and the Illyrian *Dendrobaena illyrica* from the Šar Mountain, which is the southernmost limit of the geographical ranges of these species.

After peregrine and endemic zoogeographical elements, there are also Trans-Aegean (12.5%), Central European (10%) and Balkanic-Alpine (5%) species in the studied fauna. There is also a widespread Trans-Aegean type of distribution on the territory of Kosovo and Metohia (*Allolobophora leoni, Ap. handlirschi, Aporrectodea jassyensis, Dendrobaena attemsi, Octodrilus transpadanus* and *Proctodrilus tuberculatus*); these species, in addition to their wider distributions in Central Europe, occupy smaller areas around the east and the southern shores of the Black Sea. They are present in areas from northern Italy to Turkey (Misirlioğlu 2008, Csuzdi et al. 2011). In the present study, *Ap. handlirschi* has been recorded throughout the whole territory of Kosovo and Metohia for the first time.

The two taxa of the Balkanic-Alpine zoogeographical type have been registered in the northern part of Kosovo and Metohia (*Dendrobaena alpina alpina* and *D. vejdovskyi*). *Dendrobaena alpina alpina* occurs in the Balkans, the Alps and Carpathian arcs (Rota 2005, Pop et al. 2007, Csuzdi et al. 2011). After 30 years, we have confirmed its existence in the same territory, although only one specimen was found.

Dendrobaena vejdovskyi is present in the Balkans, in the alpine parts of Austria and Germany; it also reaches Slovakia and Hungary (Csuzdi & Zicsi 2003, Stojanović et al. 2018). This species is distributed in the central and southeast parts of Serbia (Stojanović-Petrović et al. 2020). The latest data show that it was previously registered in the area of Kopaonik Mt., which belongs to Serbia (Popović et al. 2021) but not on the territory of Kosovo and Metohia. Our research has recorded its presence on the slopes of Kopaonik Mt., which belong to Kosovo, indicating that it has an extended distribution range in the south direction. This new location is the southernmost point of occurrence of this species in the Balkans.

Lumbricus meliboeus represents a new record for Kosovo. The major centre of origin of *L. meliboeus* is the subalpine part in the Alps from where it spreads across Dinarides (Croatia, Bosnia and Montenegro) to western Serbia (Tara). We assume that one of the possible routes goes from Tara Mountain (part of the Dinaric Alps) across Kosovo and Metohia to Rila Mt. Based on published data, Germany is the northernmost limit of distribution of this species, and Rila Mt. in Bulgaria is its easternmost border (for references, see Milutinović et al. 2013). This was the reason to classify the species into the Balkanic-Alpine distribution type (Milutinović et al. 2013, Stojanović-Petrović et al. 2020). Only one specimen of *L. meliboeus* was registered in Bulgaria; in North Macedonia, Albania, Greece and the southeastern part of Serbia, this species has not been registered (Šapkarev 1978, Szederjesi & Csuzdi 2012, Szederjesi et al. 2017, Stojanović-Petrović et al. 2020). Therefore, we accept the assumption that *L. meliboeus* belongs to the Alpine-Dinaric type of distribution (Kutuzović D.H. & Kutuzović B.H. 2013).

The smallest number of species belonged to the Atlanto-Mediterranean (*Aporrectodea georgii*), Circum-Mediterranean (*Dendrobaena byblica*) and Illyrian (*Dendrobaena illyrica*) types (2.5% each). Overall, taking into account all zoogeographical types (except peregrine), we can conclude that 65% of species of the earthworm fauna in Kosovo and Metohia have autochthonous character.

Conclusion

This study provides a survey of the complete list of earthworm taxa of Kosovo and Metohia. Our study has included locations in Kosovo and Metohia, with particular emphasis on the national parks Kopaonik and Šar Mountain. According to our results, six species are new to the fauna of Kosovo and Metohia. Despite the increasing sampling, we believe that the vast portion of the terrain is still insufficiently explored and little information is available about the earthworm fauna in the south part of Kosovo and Metohia. We hope that our research will serve as an incentive for further investigation in this direction.

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