

NEW RECORDS AND REMARKS ON EARTHWORMS OF THE VOJVODINA PROVINCE (OLIGOCHAETA: LUMBRICIDAE, CRIODRILIDAE)

Jovana M. Sekulić¹, Mirjana M. Stojanović-Petrović²,
Tanja B. Trakić², Filip J. Popović^{2*}

¹University of Kragujevac, Institute for Information Technologies Kragujevac,
Department of Science, Jovana Cvijića bb, 34000 Kragujevac, Serbia

²University of Kragujevac, Faculty of Science, Institute of Biology and Ecology,
Radoja Domanovića 12, 34000 Kragujevac, Serbia

*Corresponding author; E-mail: filip.popovic@pmf.kg.ac.rs

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ABSTRACT. The aim of this paper is to present the results of the recent collecting earthworms, with new localities and new habitats in Vojvodina Province. The sporadic field investigation was carried out during 2013-2020. In this paper we report new records of *Criodrilus lacuum* Hoffmeister, 1845 (family Criodrilidae) proved to be new species for the fauna of Vojvodina Province. Also, information on the taxonomic status of individual species was provided. Fifteen earthworm species and subspecies from family Lumbricidae have been registered. Six taxa were found to be synonymous with nominal species, so that the number decreases to 31 species, from 10 genera. Our data demonstrate clearly that the earthworm fauna of the Vojvodina Province is relatively poor, monotonous and that the impact of intensification of agricultural practices effect on loss of soil biodiversity.

Keywords: earthworms, Oligochaeta, Lumbricidae, Criodrilidae, Vojvodina Province.

INTRODUCTION

Vojvodina Province is extremely flat area formed after the swelling of the Pannonian Sea. It is situated in the southeastern part of the Pannonian plain. The monotony of the plain break up rivers, canals, sandstone, loess plateau, different crops and other vegetation, densely distributed settlements, and two mountains, whose height barely exceed the upper limit of the hills, and all this gives a special landscape appearance. Natural vegetation is still dominant in only a few very restricted areas. Agriculture, forestry, urbanization, and water management have had profound influences on the distribution, structure, and quality of habitats and species. For these reasons formed several protected areas such as: Fruška Gora Mountain, the Vršac Mountains (also known as Vršac Hill), Danube Basin and Zasavica. The protected areas which represent a major wildlife refuge have a great importance for the preservation of biodiversity (CSUZDI, 1995; ZICSI *et al.*, 1999; BÁLDI, 2003; CSUZDI and ZICSI, 2003; BĂNĂDUC, 2009; COVACIU-MARCOV *et al.*, 2009; FERENTI *et al.*, 2013).

While the taxonomic composition and distribution of earthworms of certain parts of the Pannonian Plain are well known (POP, 1948, 1949; ZICSI, 1991; MRŠIĆ, 1991; CSUZDI and ZICSI, 2003; POP *et al.*, 2010; CSUZDI *et al.*, 2011; SZEDERJESI, 2011), some parts of the region have not been widely studied. Research of earthworms in Vojvodina Province were started at the beginning of the XX century (SZÜTS, 1919; ČERNOSVITOV, 1938). ZICSI (1972) and ŠAPKAREV (1978) continued to work on Lumbricidae Vojvodina Province. These investigations were followed by ŠAPKAREV (1986), MRŠIĆ and ŠAPKAREV (1987), MRŠIĆ (1991), STOJANOVIĆ *et al.* (2008), MILUTINOVIĆ *et al.* (2010). The first larger and significant expedient investigation has been carried out by STOJANOVIĆ and MILUTINOVIĆ (2014) and STOJANOVIĆ *et al.* (2014) and resulted in eight species recorded for the first time in the Vojvodina Province (*Allolobophora mehadiensis voivodinensis* Šapkarev, 1989, *Aporrectodea macvensis* (Šapkarev, 1987), *Dendrobaena veneta veneta* (Rosa, 1886), *Bimastos rubidus* (Eisen, 1874), *Lumbricus friendi* Cognetti, 1904, *Octodrilus gradinescui* (Pop, 1938), *Octolasion cyaneum* (Savigny, 1826) and *Proctodrilus opisthoductus* Zicsi, 1985 and two of these species were identified for the first time throughout the whole territory of Serbia (*L. friendi* and *O. gradinescui*).

This list of earthworms of Vojvodina Province included 31 species belonging to 10 genera. However, the difference in the number of species between the last work from 2014 and the present checklist is a result of the fact that two taxa were found to be synonymous with nominal species (STOJANOVIĆ *et al.*, 2020). Also, four subspecies was found to be synonymous to the nominal species already reported for the Pannonian Plain.

In that respect, one of our aims has been to present the results of the recent collecting, with a new localities and a new habitats. Another aim was to present the valuable data that we came across from the old collection of our Institute. We report the first record of *Criodrilus lacuum* Hoffmeister, 1845, in Serbia, thus updating the knowledges of its geographical range.

MATERIALS AND METHODS

Our investigations were carried out in the Vojvodina Province, located in the northern part state of Serbia (44°38'-46°10'N; 18°10'-21°15'E) (Fig. 1). Vojvodina extends to the southern part of the Pannonian Region and is a predominantly flat area with two mountain ranges, Fruška gora Mt. and Vršac Mts. Fruška Gora is a low island mountain, located at 502 m.a.s.l., while Vršac Mts. is a low island mountain, located at 641 m.a.s.l. Its valleys are covered by meadows, while its highest parts are covered by the dense deciduous forests. The climate is temperate-continental with central-European and Mediterranean influences. More than 75% of the territory is occupied by agricultural fields which alternate with forests, meadows and pastures.

The sporadic field investigation was carried out during 2013-2020. Over the last investigation period, from all over the territory, we were collecting earthworms from various habitats which included natural biotopes (oak forest, wet meadow, under the stump, near the river, near the stream, mud) and artificial biotopes (garden and agricultural field).

Earthworms were collected using the diluted formaldehyde method complemented with digging (0.4x0.4 m quadrates) and hand sorting as well as turning over rocks, debris and logs. The earthworms were killed in 70% ethanol, immediately fixed in 4% formalin solution and transferred and stored in 90% ethanol. Species identification was made according to the complex features provided in ŠAPKAREV (1978), ZICSI (1985), MRŠIĆ (1991), CSUZDI and ZICSI (2003) and BLAKEMORE (2004).

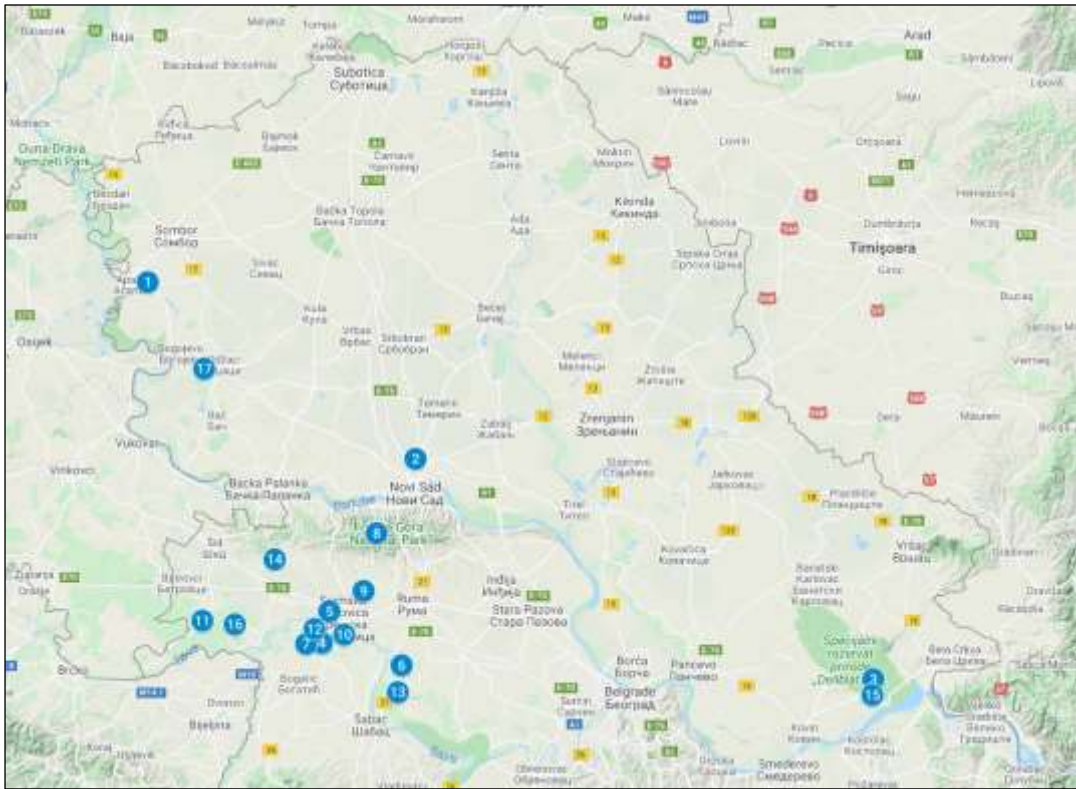


Figure 1. Map showing the study localities in the Vojvodina Province (1 – Banja Junaković, 2 – Rimski Šančevi, 3 – Dubovac, 4 – Nočaj, 5 – Lačarak, 6 – Hrtkovci, 7 – Radenković, 8 – Fruška Gora, 9 – Veliki Radinci, 10 – Salaš Nočajski, 11 – Morović, 12 – Zasavica, 13 – Platičevo, 14 – Erdevik, 15 – Šumarak, 16 – Višnjićevo, 17 – Karavukovo).

RESULTS AND DISCUSSION

During the present study, 15 species and subspecies of earthworms from family Lumbricidae have been registered in Vojvodina Province (Tab. 1). Six taxa were found to be synonymous with nominal species (Tab. 2). By combining these new findings with the previous studies (STOJANOVIĆ *et al.*, 2014; SZEDERJESI *et al.*, 2014), the number of species from family Lumbricidae known to be occurring in the studied region decreases to 31 species from 10 genera. Also, *Criodrilus lacuum* from the family Criodrilidae proved to be new for the fauna of Vojvodina Province (Tab. 1).

In the Vojvodina Province, according to our results, the most common species is *Aporrectodea chlorotica* (Savigny, 1826) which occurs only in the agricultural field and it is a typical synanthropic species. The next most common species are: *Ap. trapezoides* (Dugès, 1828), *Ap. rosea* (Savigny, 1826) and *Lumbricus terrestris* Linnaeus, 1758. High abundance in this group of species reflects their reproductive capacity and the potential to adapt and colonization (Bouché, 1977; Satchell, 1980). Based on the study that was conducted Stojanović and Milutinović (2014), it can be observed a correlation between the type of habitats and species of earthworms that occur in them. In our researches, there are a lot of agricultural habitats, which are characteristic for these earthworm species (Schmidt *et al.*, 2001, 2003; Krück *et al.*, 2006; Scullion *et al.*, 2006; Pelosi *et al.*, 2009a, b). In particular, *Ap. trapezoides* and *Ap. rosea* occur commonly in soils used for grain production (Baker *et al.*, 2003). Otherwise, cropping systems thus modify the functional composition of earthworms (Pelosi *et al.*, 2009b).

Table 1. List of the collected lumbricid taxa and their localities (2013-2020).

Species	Habitat	Localities
Fam. Lumbricidae		
<i>Allolobophora chlorotica chlorotica</i> (Savigny, 1826)	Agricultural field	134 exp., Rimski Šančevi (45°19'N, 19°50'E), 9.05.2013.; 34 exp., Rimski Šančevi (45°19'N, 19°50'E), 15.11.2013.; 132 exp., Rimski Šančevi (45°19'N, 19°50'E), 3.06.2014.; 130 exp., Rimski Šančevi (45°19'N, 19°50'E), 15.09.2014.; 17 exp., Rimski Šančevi (45°19'N, 19°50'E), 25.05.2015.; 3 exp., Rimski Šančevi (45°19'N, 19°50'E), 9.09.2015.; 58 exp., Rimski Šančevi (45°19'N, 19°50'E), 22.04.2016.
<i>Allolobophora leoni</i> Michaelsen, 1891	Forest, wet meadow	1 exp., Apatin, Banja Junaković (45°40'N, 18°58'E), 26.06.2015.; 1 exp., Dubovac (44°47'N, 21°12'E), 31.07.2015.; 1 exp., Noćaj, Preseka (44°55'N, 19°33'E), 13.06.2016.
<i>Allolobophora robusta</i> Rosa, 1895	Forest	1 exp., Vršac Mts.(45°08' N, 21°24'E), 14.10.1989.; 1 exp., Višnjičevo (44°57'N; 19°17'E), 10.07.2013.; 1 exp., Laćarak (45°00'N, 19°34'E), 01.07.2014.; 1 exp., Hrtkovci (44°52'N, 19°46'E), 10.07.2014.
<i>Aporrectodea rosea</i> (Savigny, 1826)	Oak forest, agricultural field	1 exp., Radenković, Pačja Bara (44°55'N, 19°29'E), 11.04.2013.; 2 exp., Rimski Šančevi (45°19'N, 19°50'E), 09.05.2013.; 8 exp., Rimski Šančevi (45°19'N, 19°50'E), 15.11.2013.; 2 exp., Rimski Šančevi (45°19'N, 19°50'E), 15.09.2014.; 2 exp., Rimski Šančevi (45°19'N, 19°50'E), 9.09.2015.; 2 exp., Rimski Šančevi (45°19'N, 19°50'E), 22.04.2016.
<i>Aporrectodea trapezoides</i> (Dugès, 1828)	Agricultural field, forest	11 exp., Rimski Šančevi (45°19'N, 19°50'E), 9.05.2013.; 15 exp., Rimski Šančevi (45°19'N, 19°50'E), 15.11.2013.; 14 exp., Rimski Šančevi (45°19'N, 19°50'E), 3.06.2014.; 7 exp., Rimski Šančevi (45°19'N, 19°50'E), 15.09.2014.; 3 exp., Rimski Šančevi (45°19'N, 19°50'E), 25.05.2015.; 1 exp., Zsavica I (44°57'N, 19°30'E), 11.10. 2016.
<i>Aporrectodea dubiosa</i> (Örley, 1881)	Mud	1 exp., Višnjičevo (44°57'N; 19°17'E), 9.08.2013.
<i>Dendrobaena octaedra</i> (Savigny, 1826)	Near the stream	3 exp., Fruška gora (45°09'N, 19°43'E), 6.07.2019.
<i>Eisenia fetida</i> (Savigny, 1826)	Agricultural field	1 exp., Rimski Šančevi (45°19'N, 19°50'E), 25.05.2015.
<i>Eisenia lucens</i> (Waga, 1857)	Agricultural field ,near the stream	2 exp., Laćarak (45°00'N, 19°34'E), 1.07.2014.; 2 exp., Rimski Šančevi (45°19'N, 19°50'E), 22.04.2016.; 2 exp., Fruška gora (45°09'N, 19°43'E), 6.07.2019.
<i>Lumbricus friendi</i> Cognetti, 1904	Garden	9 exp., Novi Sad (45°25'N, 19°84'E), 20.07.1990.
<i>Lumbricus rubellus</i> Hoffmeister, 1843	Meadow, forests, under the stump	1 exp., Veliki Radinci (45°02'N, 19°40'E), 25.06.2014.; 1 exp., Salaš Noćajski (44°56'N, 19°35'E), 13.07.2014.; 1 exp., Morović (44°59'N, 19°12'E), 19.07.2014.; 3 exp., Šumarak (44°49'N; 21°08'E) 11.04.2015.; 3 exp., Apatin, Banja Junaković (45°40'N, 18°58'E), 26.06.2015.; 3 exp., Višnjičevo (44°57'N; 19°17'E), 11.03.2017.

Table 1. continued

<i>Lumbricus terrestris</i> Linnaeus, 1758	Garden, meadow, forest, coast.	2 exp., Veliki Radinci (45°02'N, 19°40'E), 25.06.2014.; 1 exp., Veliki Radinci (45°02'N, 19°40'E), 28.06.2014.; 2 exp., Lačarak (45°00'N, 19°34'E), 1.07.2014.; 3 exp., Hrtkovci (44°52'N, 19°46'E), 10.07.2014.; 3 exp., Morović (44°59'N, 19°12'E), 19.07.2014.; 2 exp., Platičevo (44°49'N, 19°47'E), 30.07.2014.; 1 exp., Zasavica I, (44°57'N, 19°30'E), 11.10. 2016.; 3 exp., Radenković, Vrbovac (44°55'N, 19°29'E), 29.10.2016.; 2 exp., Erdevik (45°07'N; 19°24'E), 23.03.2017.; 1 exp., Sremska Mitrovica (44°58'N, 19°36'E), 10.10.2015.; 1 exp, Sremska Mitrovica (44°58'N, 19°36'E), 19.10.2015.; 1 exp., Sremska Mitrovica (44°58'N, 19°36'E), 25.12.2019.; 1 exp., Sremska Mitrovica (44°58'N, 19°36'E), 07.03.2020.; 1 exp., Sremska Mitrovica (44°58'N, 19°36'E), 20.03.2020.
<i>Octolasion lacteum</i> (Örley, 1881)	Near the Sava River, forest	1 exp., Radenković, Pačja Bara (44°55'N, 19°29'E), 11.04.2013.; 1 exp., Ravnje, Trebljevine (44°56'N, 19°25'E) 2.04.2015.; 1 exp., Ravnje, Batve (44°56'N, 19°25'E), 19.06.2016.; 1 exp., Radenković, Vrbovac (44°55'N, 19°29'E), 29.10.2016.; 2 exp., Erdevik (45°07'N; 19°24'E), 23.03.2017.; 2 exp., Temerin, Jegrička obala (45°24'N, 19°53'E), 25.07.2020.
<i>Octodrilus complanatus</i> (Dugès, 1828)	Forest	1 exp., Dubovac (44°47'N, 21°12'E), 31.07.2015.
<i>Octodrilus transpadanus</i> (Rosa, 1884)	Near the Sava River, forest	1 exp., Zasavica, Turske livade (44.95°N, 19.53°E), 19.11.2013.; 1 exp., Salaš Noćajski (44°57'N, 19°35'E), 7.08.2013.; 1 exp., Hrtkovci (44°52'N, 19°46'E), 10.07.2014.; 1 exp., Zasavica I (44°57'N, 19°30'E), 11.10. 2016.; 1 exp., Erdevik (45°07'N; 19°24'E), 23.03.2017.
Fam. Criodrilidae		
<i>Criodrilus lacuum</i> Hoffmeister, 1845	Mud and roots of aquatic plants	4 exp., Karavukovo (45°29'N, 19°11'E), 17.06.1993.; 1 exp., Karavukovo (45°29'N, 19°11'E), 11.07.1993.; 17 exp., Karavukovo (45°29'N, 19°11'E), 12.07.1993.

Table 2. Lumbricid taxa excluded from the checklist of Vojvodina Province.

Species name	Explanation
<i>Allolobophora kosowensis kosowensis</i> Karaman, 1968	= <i>All. kosowensis</i> Karaman, 1968
<i>Allolobophora mehadiensis voivodinensis</i> Šapkarev, 1989	= <i>All. m. boscaiui</i> Pop, 1948, (SZEDERJESI <i>et al.</i> , 2014)
<i>Allolobophora robusta robusta</i> Rosa, 1895	= <i>All. robusta</i> Rosa, 1895
<i>Dendrodrilus rubidus rubidus</i> (Savigny, 1826)	= <i>Bimastos rubidus</i> (Savigny, 1826)
<i>Dendrodrilus rubidus subrubicundus</i> (Eisen, 1874)	= <i>Bimastos rubidus</i> (Savigny, 1826)
<i>Fitzingeria platyura depressa</i> (Rosa, 1893)	= <i>Dendrobaena depressa</i> (Rosa, 1893)

Lumbricus friendi is European species, known mainly from the Atlantic region of Europe (BOUCHE, 1972). This species has been introduced to the USA (CSUZDI and SZLAVECZ, 2003). The first finding of *L. friendi* in Vojvodina Province (STOJANOVIĆ *et al.*, 2014) was in the area of Fruška Gora Mt. (Iriški Venac, 450 m.a.s.l.). However, based on our old Institute collection this species lives, as well, on the lower altitudes (near 80 m.a.l.s.). Therefore, the easternmost limit of distribution of this species is Pannonian part of Serbia. The fact that *L. friendi* occurs in northern Serbia in only two locations indicates that it is probably a recent introduction.

The degree of endemism in the Pannonian area of Serbia is relatively low, with five taxa (three Dacian and two Balkanic endemics) (STOJANOVIĆ *et al.*, 2020). Dacian endemics are the most representative element in endemic earthworm fauna of the Romanian Carpathians (CSUZDI *et al.*, 2011), with the Apuseni Mountains where the distribution center is located (BODNARIUC *et al.*, 2002; POP *et al.*, 2010; CSUZDI *et al.*, 2011). Five Dacians stenoendemas are present only in the Apuseni Mountains, while spreading widespread Dacian endemics occupy lower altitudes (POP *et al.*, 2010) and inhabit the Pannonian Plain between the Carpathians and the Danube. Two subspecies are also present in the Pannonian part of Serbia: *All. mehadiensis mehadiensis* Rosa, 1895 and *All. mehadiensis boscaiui* Pop, 1948. However, Dacian endemic *All. mehadiensis* is a polytypic species quite variable in the number of segments in clitellum and tubercles. The position of the clitellum and tubercles in the subspecies *boscaiui* and *voivodinensis* is almost identical and, therefore, according to SZEDERJESI *et al.* (2014) *All. mehadiensis voivodinensis* is synonym of *All. mehadiensis boscaiui* Pop, 1948. Based on this data, number of endemic species decreased to 5 taxa in relation to the report they gave STOJANOVIĆ and MILUTINOVIĆ (2014). Endemic species *All. mehadiensis mehadiensis*, known from South Romania, Bulgaria (MIHAILOVA, 1964), East Hungary (CSUZDI and ZICSI, 2003; CSUZDI *et al.*, 2011) and east part of Vojvodina (STOJANOVIĆ and MILUTINOVIĆ, 2014). However, under the name *All. mehadiensis voivodinensis* Šapkarev, 1989 this species registered in east Vojvodina (STOJANOVIĆ and MILUTINOVIĆ, 2014) and in east Serbia (SZEDERJESI, 2013). The other subspecies *All. mehadiensis oreophila* Pop, 1978 has been known from the southwestern Romania and the western Carpathians (CSUZDI *et al.*, 2011) and does not registered in Vojvodina Province. *Octodrilus gradinescui* is another endemic species of Dacian origin and it occurs in Romania, Slovakia, Ukraine, and Hungary (CSUZDI and ZICSI, 2003; CSUZDI *et al.*, 2011). Two endemic taxa, *Allolobophora kosowensis* Karaman, 1968 and *Aporrectodea macvensis* (Šapkarev, 1987), belong to the broad range Balkan endemic species, registered in the Balkan part of Serbia and in the only one locality on the border between the Pannonian Plain and the Balkan Peninsula (STOJANOVIĆ and MILUTINOVIĆ, 2014). *Allolobophora kosowensis* has been registered mainly in the southern and southeastern part of Serbia. Based on the distribution data of this species, it is certain that it is the hilly area of Serbia around the river Velika Morava possible migratory road to the northernmost point of its distribution on the perimeter Pannonian Basin. *Aporrectodea macvensis* is a rare endemic species. It is represented mainly in the western and northern part Balkan part of Serbia (MILUTINOVIĆ *et al.*, 2015; STOJANOVIĆ and MILUTINOVIĆ, 2014; STOJANOVIĆ *et al.*, 2018).

Except the family Lumbricidae, in the Vojvodina Province for the first time is registered one species from the family Criodrilidae. *Criodrilus lacuum* Hoffmeister, 1845 is aquatic species which widely distributed in Europe and common all around the Mediterranean (MISIRLIOĞLU, 2012). This is peregrine species, distributed worldwide (Blakemore, 2008). So far in Serbia this species found only in the Danube River (ATANACKOVIĆ *et al.*, 2013). Near the border with Bosnia and Herzegovina, we have found 22 examples of *C. lacuum* and it is the first finding place in Vojvodina Province.

Vojvodina Province is from all sides surrounded by mountains, by the Alps in the west, the Dinarides in the south, the Carpathian Mts. in the north and the east, and the Balkan Mts. in the southeast. In geomorphological and ecological terms, mountains have had a significant

impact on biodiversity in the Pannonian Plane (POP *et al.*, 2010; CSUZDI *et al.*, 2011). On the other hand, due to the agriculture impacts, the earthworm fauna of the Vojvodina Province is on the distinct stress of anthropogenic factors which are unification of living conditions. Therefore, it is understandable that the number of endemic earthworms from Pannonian part of Serbia is quite low compared with the 25 endemic taxa recorded from the Balkan part of Serbia (STOJANOVIĆ *et al.*, 2020). Only one Dacian endemic, *O. gradinescui* does not present in the Balkan part of Serbia. Four other endemics from Vojvodina Province exist in the Balkan part of Serbia, as well. Despite of the fact that is the Vojvodina Province is a much smaller part of the country, our data demonstrate clearly that the earthworm fauna of the Vojvodina Province is relatively poor and monotonous. It is clear that the impact of intensification of agricultural practices effect on loss of soil biodiversity (HOLE *et al.*, 2005) and therefore it is not surprising that peregrine species are predominant. On the other hand, we cannot ignore the fact that the Balkan Peninsula is a specific region with frequent changes in global ecological conditions throughout geological history that have greatly contributed to the occurrence of an exceptionally heterogenous fauna in this area (MRŠIĆ, 1991). However, instead of prevalence of distinctly uniform agrobiotopes that affect on the unification of living conditions that strongly endanger biodiversity in Vojvodina, there are still natural areas which deserve protection, and that could maintain the functioning of natural ecosystems and act as refuge for earthworm species.

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