The earthworms (Oligochaeta: Lumbricidae) of the Pannonian region of Serbia, Vojvodina Province: Zoogeography and Diversity

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Abstract. Based on 30-years field investigation and literature data collected over the last 90 years, this paper includes the current knowledge on earthworms in the part of the southern Pannonian Region, that corresponds to Vojvodina Province, Serbia that is a part of the southern Pannonia region. The aim of this paper is to present new data on the earthworm fauna of the Vojvodina Province. Also by analysing the newly reported species together with literature records, we establish the definitive list of known earthworm taxa. The List underlines earthworm diversity and provides a general overview of their distribution and zoogeographical position. Currently, 32 taxa, belonging to 11 genera, are known from the investigation area. Seven species are recorded for the first time in the Vojvodina Province (Aporrectodea macvensis, Dendrobaena veneta veneta, Dendrodrilus rubidus subrubicundus, Octodrilus gradinesci, Octolasion cyaneum, Proctodrilus opisthoductus, and Allolobophora mehadiensis voivodinensis). Of these, Octodrilus gradinesci is identified for the first time throughout the whole territory of Serbia. The earthworm fauna of the Vojvodina Province is relatively poor and monotonous. Peregrines species are predominant and the number of endemic species is quite low. Summing up the three Dacian endemics and the Central European species, 28.13 % of the total lumbricid fauna shows an autochthonous character.

Key words: earthworms, Vojvodina Province, Serbia, zoogeography.

Introduction

Vojvodina is a province in the northern Serbia, situated in the part of the southern Pannonian Region (EEA 2003). As regards main features of its relief, the Pannonian Region is dominated by large flat alluvial basin transected by two major rivers - the Danube and the Tisa. The basin is almost completely enclosed on all sides, 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 here (Pop et al. 2010; Csuzdi et al. 2011).

Natural vegetation is still dominant in 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. Special Nature Reserves have been established to protect the most important morphological characteristics of the Pannonian Region such as wide valleys and low mountains. The protected areas which represent a major wildlife refuge have a great importance for the preservation of biodiversity (Mahunka 1987, Csuzdi 1995, Zicsi et al. 1999, Csuzdi & Zicsi 2003, Pop et al. 2010, Csuzdi et al. 2011, Szederjesi 2011). However, the earthworm fauna in the part of southern Pannonian Region, in Vojvodina Province, has not been widely studied (Table 1). To date, only a few works have been published that deal with the distribution of various earthworm species. The first data on the earthworms from Vojvodina were provided by Szüts (1919) and, twenty years later, by Černosvitov (1938). Their work was continued by Zicsi (1972) who added 9 species to the earthworm fauna raising the number of lumbricid species recorded for Vojvodina to 11. The first complete summary on the earthworms of Vojvodina was published by Šapkarev (1978b), who documented the presence of 25 species altogether (20 species and 5 subspecies). Of these, 14 species were new for the earthworm fauna of Vojvodina. Later, another new subspecies, Allolobophora mehadiensis voivodinensis (Šapkarev 1986) was added to the earthworm fauna. These investigations were followed by sporadic research of local scientists: Šapkarev (1986), Mršić & Šapkarev (1987), Mršić (1991), Stojanović et al. (2008), and Milutinović et al. (2010). Their works provided new data on the earthworm fauna from Vojvodina.

The earthworm taxonomic composition and species distribution from the certain parts of Pannonian Region are well known (Pop 1948, 1949, Zicsi 1991, Mršić 1991, Csuzdi & Zicsi 2003, Pop et al. 2010, Csuzdi et al. 2011, Szederjesi 2011). However, the earthworm fauna of the Vojvodina Province has not been widely studied (Table 1). To date, only a few works have been published that deal with the distribution of various earthworm species. The first data on the earthworms from Vojvodina were provided by Szüts (1919) and, twenty years later, by Černosvitov (1938). Their work was continued by Zicsi (1972) who added 9 species to the earthworm fauna raising the number of lumbricid species recorded for Vojvodina to 11. The first complete summary on the earthworms of Vojvodina was published by Šapkarev (1978b), who documented the presence of 25 species altogether (20 species and 5 subspecies). Of these, 14 species were new for the earthworm fauna of Vojvodina. Later, another new subspecies, Allolobophora mehadiensis voivodinensis (Šapkarev 1986) was added to the earthworm fauna. These investigations were followed by sporadic research of local scientists: Šapkarev (1986), Mršić & Šapkarev (1987), Mršić (1991), Stojanović et al. (2008), and Milutinović et al. (2010). Their works provided new data on the earthworm fauna from Vojvodina.
However, some of the species given by these authors are synonyms of other species, or some of these species have been relegated to other genera (Table 1). Therefore, the aim of this paper is to present new data on the earthworm fauna of the Vojvodina Province and, by analysing the newly reported species together with literature records, to establish the definitive list of known earthworm taxa. The List underlines earthworm diversity and provides a general overview of their distribution and zoogeographical position. The List of earthworms is based on 30 years field investigation and literature data over the last 90 years.

Materials and Methods

Study area
Our investigations were carried out in the Vojvodina Province in the state of Serbia (Fig. 1).

Located in the northern part of Serbia, the Province of Vojvodina (44°38'-46°10'N; 18°10'-21°15'E) is predominantly a flat region, occupying the part of the south Pannonian Region. It is a forest-steppe region with a temperate-continental climate, in which central-European and Mediterranean influences are noticeable. More than 75% of the Province’s territory is used for agriculture and only 6.6% is covered by forests. The rest of territory belongs to meadows and hill pastures. The areas of steppe and forest-steppe are decreasing being modified by agricultural expansion (Matvej 1989). High levels of the habitat destruction and disturbances, throughout the territory of Vojvodina Province make the reserve system such as: Fruska Gora Mountain, the Vrsac Mountains, Danube Basin and Zasavica, Special Nature Reserve, especially important for conservation of biodiversity.

In the Vojvodina, the hilly landscape west of the Danube includes two small mountain ranges. One of them, Fruska Gora is a low island mountain. Its highest parts are covered by the dense deciduous forests, while its valleys are covered by meadows. The Vrsac Mountains are also low mountains characterized by occurrence of the numerous types of habitats. Zasavica, Special Reservation of Nature in the Vrsac Mountains established in 1997 is placed under the state protection as the Category I – a natural treasure of exquisite value.

Data collection methods
The extensive field investigation was carried out during the 2005-2010 period. However, in the analyzed data have been included unpublished data from the period 1985 to 1993, as well as from earlier sporadic investigation.

Species identity, locality and collection date are reported for each specimen and included in the database (Appendix 1). Earthworms were collected by the formalin method, digging (0.4 x 0.4 m quadrates) and hand sorting (Csuzdi & Zicsi, 2003), as well as by turning over rocks, debris and logs. The earthworms were killed in 70% ethanol, immediately fixed in 4% formalin solution and later transferred to 90% ethanol, in which they were stored.


Zoogeographic distribution
We have tried to summarize the biogeographical patterns of earthworms from the whole study area. According to the distribution types given by several authors (Omodeo 1952, Mršić 1991, Omodeo & Rota 1991, 1999, Csuzdi & Zicsi 2003, Pop et al. 2010, Csuzdi et al. 2011), the review shows the occurrence of the following zoogeographic categories: peregrine, Central European, Trans-Aegean (distributed from the European Alps to the Ural Mts., in-
the rare species, such as...the investigated area. We have, as well, registered some of...recently recorded them throughout the whole investigated area of Serbia (Stojanović et al. 2008). According to Šapkarev (1989) and Csuzdi & Zicsi (2003), Aporrectodeas sensu Borza and Bosiau (1965) include the taxa that are restricted to the historical Dacian province. However, the same term used by Beldie (1967) refers exclusively to the Carpathian-Balkan elements. The Dacian endemic taxa are the most representative element in the endemic earthworm fauna of the Romanian Carpathians (Csuzdi et al. 2011). They include the species whose extension is limited between the Carpathian and Ponto-Danubial areas. The suggested distribution centrum for the Dacian earthworm endemics is in the Apuseni Mts. (Pop et al. 2010). In the Vojvodina Province, there are three Dacian endemics: Allo lobophora mehadiensis mehadiensis, Aporrectodea rosea, and Octodrilus gradinescui. A. mehadiensis had been discovered by Rosa (1895) in Mehadia (Romania). Subsequently, it was registered in South Bulgaria (Mihailova, 1964) and in the eastern part of Hungary (Csuzdi & Zicsi 2003). According to Šapkarev (1989) and Csuzdi & Zicsi (2003), A. mehadiensis is a highly variable species concerning the number of the clitteral segments, position of the papillae on setae ab, size of the body, and the number of body segments. These variations in the external features of A. mehadiensis offer a possibility to separate a few subspecies. The first, out of the four currently recognized subspecies, A. mehadiensis mehadiensis known from South Romania (Pop 1949, Csuzdi et al. 2011), Bulgaria (Mihailova 1964, 1965), and East Hungary (Csuzdi & Zicsi 2003, Csuzdi et al. 2011) have been found for the first time in the eastern part of the Vojvodina Province (Table 1). Two other subspecies in Romania, namely A. mehadiensis boscaiui Pop 1948 and A. mehadiensis orepilica Pop 1978 have been known from the southwestern...The earthworms (Oligochaeta: Lumbricidae) of the Vojvodina Province

Results

During the present study, 30 species and subspecies of lumbricid earthworms have been registered in Vojvodina Province (Appendix 1). By combining these new findings with the previous records (Šapkarev 1978b, 1986, Mršić & Šapkarev 1987, Mršić 1991, Milutinović et al. 2010), the number of species known to be occurring in the studied region rises to 32 taxa belonging to 11 genera. The definitive list of earthworm taxa currently known is given in Table 1. Of these, seven taxa are new for the earthworms fauna of the Vojvodina Province (Aporrectodea macvensis, Dendrobaena veneta, Dendrodrilus rubidus subrubicundus, Octodrilus gradinescui, Octodrilus cyaneum, Proctodrilus episoductus and Allo lobophora mehadiensis voivodinensis). Of these, Octodrilus gradinescui is identified for the first time throughout the whole territory of Serbia. When analyzing frequency of occurrence of the identified species in the all recorded localities for the earthworms endemics is in the Apuseni Mts. (Pop et al. 2010). In the Vojvodina Province, there are three Dacian and two Balkanic endemics from the genera Allo lobophora (3 taxa), Aporrectodea (1 taxon) and Octodrilus (1 taxon).

Regarding the zoogeographical position (Table 1) the majority of earthworms in the Vojvodina Province (14 taxa, 43.75%) constitute peregrine species. Then there follow Central European (18.75%), Trans-Aegean (15.63%), and less numerous Moesian (3.13%) and Circum-Mediterranean species (3.13%). The degree of endemism in the Pannonian area of Serbia is relatively low, exceeding 15.63%.

In the distribution area of endemic lumbricids, Csuzdi & Zicsi (2003) recognized four large biogeographic domains (the Franco-Iberian, Aegean, Turanian and North American domains). The Vojvodina Province belongs to the Aegean domain. In the Vojvodina Province, only five endemic species were reported (Table 1). There are present three Dacian and two Balkanic endemics from the genera Allo lobophora (3 taxa), Aporrectodea (1 taxon) and Octodrilus (1 taxon).

Dacian elements sensu Borza and Bosiau (1965) include the taxa that are restricted to the historical Dacian province. However, the same term used by Beldie (1967) refers exclusively to the Carpathian-Balkan elements. The Dacian endemic taxa are the most representative element in the endemic earthworm fauna of the Romanian Carpathians (Csuzdi et al. 2011). They include the species whose extension is limited between the Carpathian and Ponto-Danubial areas. The suggested distribution centrum for the Dacian earthworm endemics is in the Apuseni Mts. (Pop et al. 2010). In the Vojvodina Province, there are three Dacian endemics: Allo lobophora mehadiensis mehadiensis, A. mehadiensis voivodinensis, and Octodrilus gradinescui. A. mehadiensis had been discovered by Rosa (1895) in Mehadia (Romania). Subsequently, it was registered in South Bulgaria (Mihailova, 1964) and in the eastern part of Hungary (Csuzdi & Zicsi 2003). According to Šapkarev (1989) and Csuzdi & Zicsi (2003), A. mehadiensis is a highly variable species concerning the number of the clitteral segments, position of the papillae on setae ab, size of the body, and the number of body segments. These variations in the external features of A. mehadiensis offer a possibility to separate a few subspecies. The first, out of the four currently recognized subspecies, A. mehadiensis mehadiensis known from South Romania (Pop 1949, Csuzdi et al. 2011), Bulgaria (Mihailova 1964, 1965), and East Hungary (Csuzdi & Zicsi 2003, Csuzdi et al. 2011) have been found for the first time in the eastern part of the Vojvodina Province (Table 1). Two other subspecies in Romania, namely A. mehadiensis boscaiui Pop 1948 and A. mehadiensis orepilica Pop 1978 have been known from the southwestern...
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Allolobophora chlorotica chlorotica (Savigny, 1826)</td>
<td>+</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Allolobophora leoni Michaelsen, 1891</td>
<td>+</td>
<td>Trans-Aegean</td>
<td></td>
</tr>
<tr>
<td>Allolobophora mehadiensis mehadiensis Rosa, 1895</td>
<td>+</td>
<td>Dacian endemism</td>
<td></td>
</tr>
<tr>
<td>Allolobophora mehadiensis voivodinensis Šapkarev, 1989</td>
<td>-</td>
<td>Dacian endemism</td>
<td></td>
</tr>
<tr>
<td>Allolobophora robus tus robustus Rosa, 1895</td>
<td>-</td>
<td>Moesian</td>
<td></td>
</tr>
<tr>
<td>Aporrectodea caliginosa (Savigny, 1828)</td>
<td>+</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Aporrectodea dubiosa (Orley, 1891)</td>
<td>+</td>
<td>Trans-Aegean</td>
<td></td>
</tr>
<tr>
<td>Aporrectodea javagensis (Michaelsen, 1891)</td>
<td>-</td>
<td>Balkan endemism</td>
<td></td>
</tr>
<tr>
<td>Aporrectodea macemensis (Šapkarev, 1987)</td>
<td>-</td>
<td>Balkan endemism</td>
<td></td>
</tr>
<tr>
<td>Aporrectodea rosea (Savigny, 1826)</td>
<td>+</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Aporrectodea trapezoides (Dugès, 1828)</td>
<td>+</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Dendrobaena octaedra (Savigny, 1826)</td>
<td>-</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Dendrobaena veneta (Rosa, 1896)</td>
<td>-</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Dendrodrilus rubidus rubidus (Savigny, 1826)</td>
<td>+</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Dendrodrilus rubidus subrubidus (Eisen, 1874)</td>
<td>-</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Eisenia fetida (Savigny, 1826)</td>
<td>-</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Eisenia lucens (Waga, 1857)</td>
<td>+</td>
<td>Central European montane</td>
<td></td>
</tr>
<tr>
<td>Eisenia spilana (Rosa, 1901)</td>
<td>+</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Eiseniella trinodra (Savigny, 1826)</td>
<td>-</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Lumbricus polyphemus (Fitzinger, 1835)</td>
<td>+</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Lumbricus rubellus Hoffmeister, 1843</td>
<td>+</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Lumbricus terrestris Linnaeus, 1758</td>
<td>+</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Octodrilus complanatus (Dugès, 1828)</td>
<td>+</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Octodrilus gundineisci (Pop, 1938)</td>
<td>-</td>
<td>Dacian endemism</td>
<td></td>
</tr>
<tr>
<td>Octodrilus truncatus (Rosa, 1894)</td>
<td>+</td>
<td>Trans-Aegean</td>
<td></td>
</tr>
<tr>
<td>Octodrilus quaeum (Savigny, 1826)</td>
<td>-</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Octodrilus lacteus (Orley, 1881)</td>
<td>+</td>
<td>Peregrine</td>
<td></td>
</tr>
<tr>
<td>Proctodrilus antipai (Michaelsen, 1891)</td>
<td>-</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Proctodrilus opisthoductus (Zčsi, 1885)</td>
<td>-</td>
<td>Central European</td>
<td></td>
</tr>
<tr>
<td>Proctodrilus tuberculatus (Černosvitov, 1935)</td>
<td>-</td>
<td>Trans-Aegean</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. List of all earthworm taxa recorded in the Vojvodina Province.
The earthworms (Oligochaeta: Lumbricidae) of the Vojvodina Province

Table 2. Distinguishing taxonomic characters of four subspecies of Allolobophora mehadiensis.

<table>
<thead>
<tr>
<th>Subspecies</th>
<th>Body shape</th>
<th>Size</th>
<th>Segment number</th>
<th>Clitellum</th>
<th>Tubercula pubertalis</th>
<th>Pigmentation</th>
<th>Prostomium</th>
<th>1st dorsal pore</th>
<th>Male pores</th>
<th>Glandular papillae</th>
<th>Seminal vesicles</th>
<th>Receptaculum seminalis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allolobophora mehadiensis</td>
<td>Cylindrical</td>
<td>150-210mm</td>
<td>200-270</td>
<td>32-36-47-51</td>
<td>40, 42-47, 48</td>
<td>red</td>
<td>Epilobous 1/2</td>
<td>9/10 and 10/11</td>
<td>15</td>
<td>ab on 13 to 20, 39, 40 and 41</td>
<td>9-12</td>
<td>10, 11</td>
</tr>
<tr>
<td>A. mehadiensis boscaiui</td>
<td>Cylindrical</td>
<td>95-195mm</td>
<td>228-248</td>
<td>33, 34-44,45</td>
<td>38-1/2 43, 44</td>
<td>Purplish red</td>
<td>Epilobous 1/3</td>
<td>9/10 and 10/11</td>
<td>15</td>
<td>ab on 8 to 14, 16 to 19</td>
<td>9-12</td>
<td>10, 11</td>
</tr>
<tr>
<td>A. mehadiensis voivodiensis</td>
<td>Cylindrical</td>
<td>120-180mm</td>
<td>280-316</td>
<td>33, 34-46</td>
<td>38, 39-45</td>
<td>Brown-violet</td>
<td>Epilobous 1/3</td>
<td>9/10</td>
<td>15</td>
<td>ab on 26, 27, 29 and 30</td>
<td>9-12</td>
<td>10, 11</td>
</tr>
<tr>
<td>A. mehadiensis oreophila</td>
<td>Cylindrical</td>
<td>143-270mm</td>
<td>280-316</td>
<td>34, 35-49, 50</td>
<td>39, 40-45-47</td>
<td>Brown-violet</td>
<td>Epilobous 1/3</td>
<td>9/10</td>
<td>15</td>
<td>ab on 16 to 19 (13 to 15), 31 to 33, 34 (49, 51)</td>
<td>9-12</td>
<td>10, 11</td>
</tr>
</tbody>
</table>

Romania and the western Carpathians (Csuzdi et al. 2011). The subspecies A. mehadiensis voivodiensis Šapkarev (1989) appears only in the eastern part of Vojvodina (Šapkarev 1989). Based on our investigation, A. mehadiensis voivodiensis is registered in the same locality in the Vojvodina Province (Vršac, eastern Vojvodina) as it was in the study of Šapkarev (1989). The mentioned subspecies differ from each other by the position of the clitellar organs. On the other hand, all of them possess a lot of common characteristics (number of seminal vesicle, position and number of spermathecae, position of the first dorsal pore, thickened septae, calciferous glands, form of prostomium and sexual pores, and position and form of sexual pores) (Table 2). Based on these facts, Csuzdi & Zicsi (2003) have taken a standpoint that the validity of some of these subspecies comes into question because the characteristics could vary during maturation.

Ooctodrilus gradinescui is another endemic species of Dacian origin and it occurs in Romania (Pop 1938, 1949, Csuzdi et al. 2011), Slovakia (Zajcova 1981), Ukraine, and Hungary (Csuzdi & Zicsi 2003).

One of the Balkanic endemic species is Aporrectodea macvensis. Up to now, throughout Serbia this species has been reported from two distant localities, one occurring in the western Serbia (Šapkarev 2002) and one known in the central Serbia (Stojanović et al. 2008). Unfortunately, collection attempts have so far yielded a very small number of individuals. Based on our study, Pančevo in the southeastern part of Vojvodina Province is the third known locality of Ap. macvensis. This is it first observation outside of the Balkans. Its area of occupancy has been estimated to be less than 500 km². Allolobophora kosowensis kosowensis is a restricted Balkan endemic subspecies, distributed in a small part of the Peninsula, in the state of Serbia. It is an exclusively endemic to Serbia. It was first described from the southern part of Serbia (Karaman 1968). Later on, it has been registered in several localities in the southern, southeastern, central and southwestern parts of Serbia (Šapkarev 1972, Šapkarev 1989, Karaman & Stojanović 1996, Stojanović 1996, Stojanović & Karaman 2005, Stojanović & Karaman 2007, Stojanović et al. 2008). However, A. kosowensis kosowensis is also found in the Vojvodina Province, on the border between the Pannonian region and the Balkans (Milutinović et al. 2013), extending its known distribution area more than 300 km to the northeast. According to the data from Fauna Europaea (Rota 2005), this subspecies inhabits Serbia and Montenegro. But, this subspecies has never been registered in Montenegro whatsoever (Stojanović et al. 2008). According to our data Pančevo (the Vojvodina Province) is the northernmost point of occurrence of this subspecies while Priština represents the southernmost limit of its distribution. The distribution map of this subspecies indicates that the high mountain ranges of the Dinarides in the west, the Carpatho-Balkan Mountains in the east, as well as Macedonian mountains (which belong to the Rhodope massif) in the south limit this subspecies’ extent by forming a barrier (Fig. 2).
Apart from its endemic earthworm species, the fauna of Vojvodina Province includes several other species belonging to a different zoogeographical type. The most important elements are Central European and Trans-Aegean taxa. It is not surprising that the wider Central European range species are found in the earthworm fauna due to the fact that the area of Vojvodina Province borders the Carpathian Basin, which almost reaches the Alps. For example, *Lumbricus polyphemus*, *Proctodrilus antipai* and *F. platyura depressa* show a typical Central-European distribution. Over the last forty years, *F. platyura depressa* has been recorded from Macedonia (Šapkarev 1978a), Bosnia, Serbia, Croatia (Mršić 1991), Slovenia (Mršić 1991), Romania (Csuzdi et al. 2011) and Czechia (Rota 2005). Also, it is recorded in Greece (Mršić 1991, Zici & Michalis 1993), Serbia (Stojanović et al. 2008) and Albania (Szederjesi & Csuzdi 2012), as well.

Widely distributed Trans-Aegean species group (*Allolobophora leoni*, *Aporrectodea dubiosa*, *A. jassyensis*, *Octodrilus transpadanus* and *Proctodrilus tuberculatus*) shows a range of distribution extending from Italy to Turkey (Misrulüğlu 2008, Csuzdi et al. 2011). Over the last 90 years, *Aporrectodea dubiosa* has been recorded from Slovakia to the northern Turkey (Zajonc 1970, Omodeo 1989, Mršić 1991, Zici 1991, Csuzdi & Zicsi 2003, Csuzdi et al. 2006, Stojanović et al. 2012). In the Vojvodina Province it was discovered in several localities in the northern (Michaelsen 1900, Černosvitov 1938, Šapkarev 1978b, 1986), northeast (Šapkarev 1986) and central (Stojanović et al. 2008) part of Serbia and recently recognized again at the same localities in Vojvodina, with the low number of individuals and a clear reduction in population size over the last 22 years.

On the other hand, there is only one southern element in the earthworm fauna in the Province belongs to the Moesian (the East Balkans) element, namely, *Allolobophara robusta robusta*, spreads from the Balkan area and has reached the Carpathian Basin (Csuzdi et al. 2011).

Instead of the fact that about fifty *Octodrilus* species living in the Carpatho-Balkan-Alpine region, in the Vojvodina Province we registered only two nonendemic species, *Octodrilus complanatus* typical circum-Mediterranean (Csuzdi & Pavliček 2005) species and *Octodrilus transpadanus*. An analogous situation is that of the genera *Octolasion*, *Eisenia*, *Proctodrilus* and *Lumbricus*, represented by
widely distributed species. One of them is peregrine species Octolasion cyaneum which was found for the first time in the area of Vojvodina. Octolasion cyaneum has been widely introduced by humans. So, its present range includes America, India and Australia (Rota 2005). Up to now, this species has been found in the southwest part of Serbia (Šapkarev 1989) and only one species in the central area of Serbia (Stojanović et al. 2008). Its last locality (only one exemplar) we found in the Zasavica reserve (Appendix 1).

Most of the present earthworm species in the area of Vojvodina Province are found in preserved areas. However, in Vojvodina there are still natural areas which deserve protection, which would maintain functioning of natural ecosystems, act as refuges for species, and maintain ecological processes that cannot survive in most intensely managed landscapes. Unfortunately, the neighboring territories of preserved areas are distinctly uniform agrobiotopes. Characteristic anthropogenic factors (agriculture intensification and extensification, drainage, irrigation, river regulation, deforestation, etc.) result in the unification of living conditions in the simplified landscape structure where the ecological network was weakened, and represent a force that endangers biodiversity (Paoletti 1999, Ducić et al. 2008, Nedeljković et al. 2009).

Consequently, due to the agriculture impacts, the earthworm fauna of the Vojvodina Province is relatively poor and monotonous. Peregrines species are predominant. The number of endemic species is quite low (5 taxa) compared with the 12 species is quite low (5 taxa) compared with the 12 endemic taxa recorded from the eastern territory of Serbia, situated on the area of the Balkan Peninsula (Stojanović et al. 2008). To sum up, the three eastern territories of preserved areas are distinctly uniform agrobiotopes. Characteristic anthropogenic actions in the simplified landscape structure where the ecological network was weakened, and represent a force that endangers biodiversity (Paoletti 1999, Ducić et al. 2008, Nedeljković et al. 2009).

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The earthworms (Oligochaeta: Lumbricidae) of the Vojvodina Province

Appendix I. A list of collected earthworms from Vojvodina Province

Aliolaimus chlorisicis chlorisicis (Savigny, 1826) Location(s): 1 exp., Frka Gora, 02.11.1990; 1 exp., Karsavakovo, 04.1993; 1 exp., Tamiš, 01. 02. 2008; 1 exp., Plätvözo, 07. 04. 2010.


Aliolaimus melanopus retrodenticus (Skaparot, 1989) Location(s): 1 exp., Frka Gora, 15. 10. 1990.


