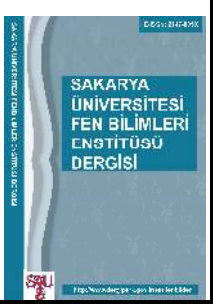
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Review of earthworm (Clitellata: Lumbricidae, Criodrilidae, Acanthodrilidae) biodiversity of thrace in Bulgaria, Turkey and Greece

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ABSTRACT

In this study, earthworm biodiversity of the Thrace which is a historical and geographic region in Southeastern Europe, centered on the modern borders of Bulgaria, Turkey and Greece were presented. The study underlines earthworm diversity of Thrace and provides a general overview of their distribution and zoogeographical position. We establish the first list of all known earthworm taxa (Lumbricidae; Criodrilidae; Acanthodrilidae) of Thrace. Currently, 40 species, belonging to 16 genera, are registered from the whole territory of the Thrace region. The earthworm fauna of Thrace is dominated by peregrine species. The degree of endemism is relatively high: 20%. Autochthonous species take part with 38% of all earthworm taxa.

Key words: Thrace, Earthworms, Clitellata, Bulgaria, Turkey, Greece.

Bulgaristan, Türkiye ve Yunanistan'da bulunan Trakya (Clitellata: Lumbricidae, Criodrilidae, Acanthodrilidae) bölgesinin topraksolucanı çeşitliliğinin gözden geçirilmesi

ÖZ

Bu çalışmada, Güneydoğu Avrupa'da tarihi ve coğrafik bir bölge olan ve Bulgaristan, Türkiye ve Yunanistan'ın modern sınırları içinde yer alan Trakya bölgesinin topraksolucanı çeşitliliği sunulmuştur. Çalışma, Trakya'daki topraksolucanı çeşitliliğinin altını çizmekte ve türlerin dağılımı ve zoocoğrafik durumuna genel bir bakış sağlamaktadır. Çalışmada, Trakya bölgesinin bilinen tüm topraksolucanı (Lumbricidae; Criodrilidae; Acanthodrilidae) taksonlarının ilk listesi oluşturulmuştur. Şu ana kadar, Trakya bölgesinin tüm alanlarından 16 cinse ait 40 tür kaydedilmiştir. Trakya topraksolucanı faunasında peregrin türler hakimdir. Endemizm derecesi nispeten yüksektir: % 20. Otokton türler, tüm topraksolucanı taksonlarının % 38'ini kapsar.

Anahtar Kelimeler: Trakya, Topraksolucanları, Clitellata, Bulgaristan, Türkiye, Yunanistan.

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1. INTRODUCTION

Thrace is situated in the eastern part of the Balkan Peninsula, in European Turkey, Bulgaria, and Greece (Fig. 1). The areas it comprises are southeastern Bulgaria (Northern Thrace), northeastern Greece (Western Thrace), and the European part of Turkey (Eastern Thrace). Northern Thrace is located in Southern Bulgaria and refers to the whole territory south of the Balkan Mountains and east of the Mesta River, to the Greek and Turkish borders in the south and the Black Sea in the east. It encompasses Sredna Gora Mountain, the Upper Thracian Lowland and the Rhodopes, Sakar and part of Istranca (Strandza) Mountains. The portion of Thrace that is now part of Greece is bounded by the Néstos River to the west, the Rhodope Mountains to the north, and the Maritsa River to the east. Western Thrace takes part with 8.578 km². The Lower Thracian Lowland, Gallipoli Peninsula, Tekirdağ and Istranca (Strandza) Mountain constitute Turkish side of Thrace. Eastern Thrace is approximately 23.764 km² [1]. About 2/3 of Thrace lies in Bulgaria; 1/4 of Thrace take part in Turkey, and 1/10 is on the territory of Greece. Annual precipitation totals 400–500 mm, and there are summer droughts. The natural vegetation is a deciduous secondary brushwood formation. A Mediterranean climate prevails in southern part and is modified by continental influences in northern part of the region [2].



Figure 1: Map of the Thrace region.

The first study of earthworm fauna of Northern Thrace was published by Černosvitov (1934, 1937) [3, 4]. Since then his work was continued by Plisko (1963) [5], Mihailova (1964, 1966) [6, 7] and Šapkarev (1986) [8]. Recently Uzunov (2010) [9], Valchovski (2012) [10], Szederjesi (2013) [11] and Valchovski, Szederjesi

(2016) [12] added new records to the biodiversity of the Bulgarian side of the region. Western Thrace was investigated by Michalis (1987) [13] and Szederjesi, Csuzdi (2012) [14]. The intensive exploration of earthworm populations in Eastern Thrace was launched by Omodeo (1952) [15]. The explorations of the European part of Turkey were followed by Zicsi (1973) [16], Omodeo, Rota (1989) [17] and Szederjesi *et al.* (2014) [18].

The aim of the study is to present earthworm fauna of Thrace in Bulgaria, Turkey, and Greece.

2. RESULTS AND DISCUSSION

According to the previous studies, altogether 40 species established the first list of the Thrace region from the territory of Bulgaria, Turkey and Greece (Table 1). The highest biodiversity is registered in Northern Thrace - 32 species. The Bulgarian part of Thrace is biggest, so it is expected to have huge earthworm fauna. Approximately 82% of the taxa of the region occurs in Bulgarian Thrace. Despite this many parts of Rhodopes and Istranca (Strandza) Mountains of Bulgarian side of Thrace needs more detailed investigations. In Western Thrace are registered 20 taxa. Nevertheless, it is little size; Greek Thrace is a territory of considerable species richness. Eastern Thrace takes part with 15 earthworm species. In spite of the some exploratory works, European part of Turkey remained an unexplored, especially Istranca (Strandza Mountain) is a white spot on the Balkan Peninsula. Western Thrace earthworm fauna hasn't been studied so far; there are only sporadic data from this region. Some common peregrine species like *Allolobophora chlorotica*, *Aporrectodea caliginosa*, *Aporrectodea rosea* and *Octolasion lacteum* have not been recorded from Turkish part of Thrace. These cosmopolitan earthworms are widely distributed in the other parts of the Thrace region and most probably they will also be recorded on the European side of Turkey in the future. Neither any members of Spermophorodrilinae (*Healyella* and *Spermophorodrilus*) nor Criodrilidae and Megascolecidae species were not recorded on Turkish Thrace until now.

Table 1. List of earthworm species of Thrace from Bulgaria, Turkey and Greece.

Species	Bulgaria	Turkey	Greece
Family LUMBRICIDAE RAFINESQUE-SCHMALTZ, 1815			
<i>Allolobophora chlorotica</i> (SAVIGNY, 1826)	MİHAİLOVA 1966; ŠAPKAREV 1986	-	MİCHALIS, 1987
<i>Allolobophoridella eiseni</i> (LEVINSEN, 1884)	MİHAİLOVA 1966	-	SZEDERJESI & CSUZDI 2012
<i>Aporrectodea caliginosa</i> (SAVIGNY, 1826)	MİHAİLOVA 1966; ŠAPKAREV 1986; VALCHOVSKI & SZEDERJESI 2016	-	MİCHALIS 1987
<i>Aporrectodea handlirschi</i> (ROSA, 1897)	MİHAİLOVA 1966	-	-
<i>Aporrectodea jassyensis</i> (MICHAELSEN, 1891)	MİHAİLOVA 1966; ŠAPKAREV 1986; SZEDERJESI 2013; VALCHOVSKI & SZEDERJESI 2016	SZEDERJESI et al. 2014	MİCHALIS 1987; SZEDERJESI & CSUZDI 2012
<i>Aporrectodea trapezoides</i> (DUGÈS, 1828)	MİHAİLOVA 1966; ŠAPKAREV 1986	OMODEO & ROTA 1989	MİCHALIS 1987
<i>Aporrectodea longa</i> (UDE, 1885)	MİHAİLOVA 1966	-	-
<i>Aporrectodea rosea</i> (SAVIGNY, 1826)	MİHAİLOVA 1964; 1966; ŠAPKAREV 1986; VALCHOVSKI & SZEDERJESI 2016	-	MİCHALIS 1987
<i>Cernosvitovia biserialis</i> (ČERNOSVITOV, 1937)	MİHAİLOVA 1966	-	-
<i>Cernosvitovia bulgarica</i> (ČERNOSVITOV, 1934)	ČERNOSVITOV 1934; MİHAİLOVA 1968	-	-
<i>Cernosvitovia rebeli</i> (ROSA, 1897)	ČERNOSVITOV 1934; MİHAİLOVA 1966; SZEDERJESI 2013	-	-
<i>Dendrobaena alpina alpina</i> (ROSA, 1884)	ČERNOSVITOV 1937; MİHAİLOVA 1966; SZEDERJESI 2013	-	SZEDERJESI & CSUZDI 2012
<i>Dendrobaena attemsi</i> (MICHAELSEN, 1902)	ČERNOSVITOV 1934; MİHAİLOVA 1966; SZEDERJESI 2013	-	-
<i>Dendrobaena byblica byblica</i> (ROSA, 1893)	SZEDERJESI 2013	ZICSI 1973; SZEDERJESI et al. 2014	-
<i>Dendrobaena cognettii</i> (MICHAELSEN, 1903)	-	SZEDERJESI et al. 2014	-
<i>Dendrobaena hauseri</i> ZICSI, 1973	-	ZICSI 1973	-
<i>Dendrobaena hortensis</i> (MICHAELSEN, 1890)	SZEDERJESI 2013	OMODEO & ROTA 1989; SZEDERJESI et al. 2014	-
<i>Dendrobaena hrabei</i> (ČERNOSVITOV, 1934)	ČERNOSVITOV 1934	-	-
<i>Dendrobaena michalisi</i> (KARAMAN, 1972)	-	-	MİCHALIS 1987

<i>Dendrobaena octaedra</i> (SAVIGNY, 1826)	UZUNOV 2010; SZEDERJESI 2013	-	-
<i>Dendrobaena rhodopenis</i> (ČERNOSVITOV, 1937)	ČERNOSVITOV 1937; PLİSKO 1963	-	-
<i>Dendrodriilus rubidus rubidus</i> (SAVIGNY, 1826)	ČERNOSVITOV 1934; MİHAİLOVA 1966; VALCHOVSKI & SZEDERJESI 2016	SZEDERJESI et al. 2014	MİCHALIS 1987
<i>Dendrodriilus rubidus subrubicundus</i> (EISEN, 1874)	PLİSKO 1963; MİHAİLOVA 1966; ŠAPKAREV 1986	-	MİCHALIS 1987
<i>Dendrobaena veneta veneta</i> (ROSA, 1884)	-	ZICSI 1973, SZEDERJESI et al. 2014	-
<i>Eisenia andrei</i> BOUCHÉ, 1972	VALCHOVSKI & SZEDERJESI 2016	-	-
<i>Eisenia fetida</i> (SAVIGNY, 1826)	MİHAİLOVA 1966; ŠAPKAREV 1986; VALCHOVSKI & SZEDERJESI 2016	OMODEO & ROTA 1989; SZEDERJESI et al. 2014	MİCHALIS 1987
<i>Eisenia lucens</i> (WAGA, 1857)	ČERNOSVITOV 1937; PLİSKO 1963; MİHAİLOVA 1964; SZEDERJESI 2013	-	SZEDERJESI & CSUZDI 2012
<i>Eiseniella tetraedra</i> (SAVIGNY, 1826)	ČERNOSVITOV 1934; MİHAİLOVA 1966; ŠAPKAREV 1986; UZUNOV 2010; SZEDERJESI 2013 VALCHOVSKI & SZEDERJESI 2016	OMODEO & ROTA 1989	MİCHALIS 1987; SZEDERJESI & CSUZDI 2012
<i>Fitzingeria loebli</i> Zicši, 1985	-	-	SZEDERJESI & CSUZDI 2012
<i>Lumbricus rubellus</i> HOFFMEISTER, 1843	ČERNOSVITOV 1934; MİHAİLOVA 1966; ŠAPKAREV 1986; UZUNOV 2010	OMODEO & ROTA 1989; ZICSI 1973	MİCHALIS 1987
<i>Lumbricus terrestris</i> LINNAEUS, 1758	SZEDERJESI 2013	-	-
<i>Octodrilus complanatus</i> (DUGÈS, 1828)	MİHAİLOVA 1966; VALCHOVSKI 2012; SZEDERJESI 2013	ZICSI 1973, SZEDERJESI et al. 2014	MİCHALIS 1987; SZEDERJESI & CSUZDI 2012
<i>Octodrilus transpadanus</i> (ROSA, 1884)	SZEDERJESI 2013	OMODEO & ROTA 1989; ZICSI 1973	MİCHALIS 1987; SZEDERJESI & CSUZDI 2012
<i>Octolasion lacteum</i> (ÖRLEY, 1881)	ČERNOSVITOV 1937; MİHAİLOVA 1966; ŠAPKAREV 1986; SZEDERJESI 2013	-	MİCHALIS, 1987
<i>Proctodrilus antipai</i> (MICHAELSEN, 1891)	MİHAİLOVA 1966	-	-

<i>Proctodrilus tuberculata</i> (ČERNOSVITOV, 1935)	MİHAİLOVA 1966	OMODEO & ROTA 1989	-
<i>Spermophorodrilus antiquus</i> (ČERNOSVITOV, 1938)	-	-	SZEDERJESI & CSUZDI 2012
Family CRİODRİLİDAE VEJDOVSKY, 1884			
<i>Criodrilus lacuum</i> HOFFMEISTER, 1845	UZUNOV 2010	-	-
Family ACANTHODRİLİDAE CLAUS, 1880			
<i>Microscolex phosphoreus</i> (DUGES, 1837)	-	OMODEO 1952	-
<i>Microscolex dubius</i> (FLETCHER, 1887)	-	-	MİCHALIS 1987

The most common species in Thrace are: *Aporrectodea jassyensis*, *Aporrectodea trapezoides*, *Lumbricus rubellus* and *Octodrilus transpadanus*. Eight taxa were registered both to the Northern, Western and Eastern parts of Thrace - *Aporrectodea jassyensis*, *Aporrectodea trapezoides*, *Dendrodrilus rubidus rubidus*, *Eisenia fetida*, *Eiseniella tetraedra*, *Lumbricus rubellus*, *Octodrilus complanatus* and *Octodrilus transpadanus*. The genus *Dendrobaena* with ten species is the one of the dominant faunal components of earthworm fauna of Thrace. Seven taxa of genus *Dendrobaena* are registered from Northern Thrace; five of them occurs in Eastern Thrace, and only two are recorded from Western Thrace. The richness of *Dendrobaena* species is not surprising because one of the distribution centers of the genus is the Carpatho-Balkan area. Another important component of earthworm biodiversity of Thrace is genus *Aporrectodea*. It is comprised six taxa in the region, mainly widely distributed Peregrines, and Trans-Aegean species. All of them are registered from Bulgarian Thrace, four taxa occur in Greek Thrace, and only two species are recorded from the European part of Turkey. *Aporrectodea* species are dominant in the agriculture regions of the Thracian Lowlands. Earthworm fauna of Thrace is enriched by 14 other genus: *Cernosvitovia* (3 taxa), *Eisenia* (3 taxa), *Dendrodrilus* (2 taxa), *Lumbricus* (2 taxa), *Octodrilus* (2 taxa), *Proctodrilus* (2 taxa), *Microscolex* (2 taxa), *Allolobophora* (1 taxon), *Allolobophoridella* (1 taxon), *Eiseniella* (1 taxon), *Fitzingeria* (1 taxon), *Octolasion* (1 taxon), *Spermophorodrilus* (1 taxon) and *Criodrilus* (1 taxon).

According to zoogeographical position earthworm fauna of Thrace is highly peregrine. From the 40 species 19 taxa (47.5%) belongs to the Peregrine. Endemic species take part with eight

taxa = 20%. Also important components of earthworm biodiversity are Trans-Aegean (3 taxa = 7.5%) and Mediterranean species (3 taxa = 7.5%). Central European (2 taxa= 5%), Balkanic-Alpine (2 taxa = 5%), Levantine (1 taxon = 2.5%), Holarctic (1 taxon = 2.5%) and Palearctic earthworms (1 taxon = 2.5%) are less numerous.

In the studied region are recorded eight endemic species: *Cernosvitovia biserialis*, *Cernosvitovia bulgaricaa*, *Cernosvitovia rebeli*, *Dendrobaena hrabei*, *Dendrobaena michalisi*, *Dendrobaena rhodopensis*, *Spermophorodrilus antiquus* and *Fitzingeria loebli*. The mainly part the endemics in the region belongs to genus *Cernosvitovia*, which spread primarily throughout the Rhodope tectonic plate. Five of endemic species are from the Bulgarian part of Thrace, and three of them are from Greek Thrace. Peregrines are the dominant part of earthworm fauna in the region. They belongs to the genus *Aporrectodea* (4 taxa), *Dendrobaena* (3 taxa), *Dendrodrilus* (2 taxa), *Lumbricus* (2 taxa), *Eisenia* (2 taxa), *Microscolex* (2 taxa), *Allolobophora* (1 taxon), *Eiseniella* (1 taxon), *Octolasion* (1 taxon), and *Criodrilus* (1 taxon). Peregrine species are mainly distributed in secondary forests and agricultural lands. Also, Trans-Aegean (*Aporrectodeahandlirschi*, *Aporrectodea jassyensis* and *Proctodrilus tuberculata*) and Mediterranean (*Dendrobaena byblica*, *Dendrobaena cognettii* and *Octodrilus complanatus*) taxa are an important part of earthworm fauna of Thrace.

Earthworm richness (32 taxa) of Northern Thrace is a major component of Bulgarian earthworm fauna. 50 species are registered from the whole territory of Bulgaria [10], and approximately 2/3 of the taxa are registered from Bulgarian Thrace. Most of the endemic species of the region are recorded from Northern Thrace, especially from Rhodopes and Istanca (Strandza) Mountains. Among Thrace endemics is *Cernosvitovia bulgarica* which is recorded only in Bulgaria.

The analysis of the all published records of Turkish earthworm fauna indicates the presence of 80 species in the country. Approximately 1/3 of them are endemic in Turkey [19, 20, 21, 22]. We are aware of the presence of 14 species of the family Lumbricidae one of family Acanthodrilidae in the European part of Turkey. Eastern Thrace consists about 18.75% of species in Turkey. Some of them are rare like *Dendrobaena hauseri*. It is a unique record of Thracian species which was

recorded only in one locality in Thracian part of Istanbul. This species have Levantine origin.

The estimated number of earthworm fauna of Western Thrace is 20 species. SZEDERJESI (2015) reported 59 earthworm taxa from Greece [23]. It is about 1/3 of species richness of the country. Most of the earthworms of Greek Thrace are peregrines. *Fitzingeria loebli* is an endemic species which is the first record from Greece and for the whole territory of the Balkan Peninsula.

More detailed investigation is needed because large areas of Thrace have not been yet explored properly for earthworm diversity. It is to be expected that in future research new species will be found, especially in Eastern Thrace.

3. CONCLUSION

The present review paper of the earthworm fauna of Thrace performs 40 earthworm species. Eight taxa were registered both to the Northern, Western and Eastern parts of Thrace. Currently, in the studied region are recorded eight endemic species: *Cernosvitovia biserialis*, *Cernosvitovia bulgarica*, *Cernosvitovia rebeli*, *Dendrobaena hrabei*, *Dendrobaena michalisi*, *Dendrobaena rhodopensis*, *Spermophorodrilus antiquus* and *Fitzingeria loebli*. The most common species in Thrace are: *Aporrectodea jassyensis*, *Aporrectodea trapezoides*, *Lumbricus rubellus* and *Octodrilus transpadanus*. Earthworm fauna of Thrace is dominated by peregrine species.

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