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Remarks on the earthworm genus *Helodrilus* Hoffmeister, 1845 with new epigean and subterranean records (Oligochaeta, Lumbricidae)

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Abstract. The earthworm genus *Helodrilus* Hoffmeister, 1845 is shortly reviewed. Its special semi-aquatic and subterranean way of life and its consequences to the taxonomy of the genus is discussed. Several new occurrences of some little-known *Helodrilus* species are given including new country records of *H. oculatus* for Hungary and *H. putricola putricola* for Portugal. Examining a topotype of *H. hachiojii* revealed presence of saccular nephridial bladders consequently, here we propose its transposal to the genus *Eisenia* as *E. hachiojii* (Blakemore, 2007) comb. nov.

Keywords. *Helodrilus*, new records, nephridial system, distribution, phylogeny

INTRODUCTION

The genus *Helodrilus* was described by Hoffmeister (1845) with the type species *Helodrilus oculatus* Hoffmeister, 1845 and defined by characters such as a thin body, strong setae, and the absence of a clitellum which clearly indicates that the specimens examined by Hoffmeister were either juvenile or aclitellate adults. Later Michaelsen (1900) created a large catch-all genus from the original *Helodrilus* by merging the genera *Allolobophora* Eisen, 1873, *Dendrobaena* Eisen, 1873, and *Bimastos* Moore, 1893 into it as independent subgenera. Pop (1941) in his revision of the family Lumbricidae transposed all unpigmented species with closely paired setae, from *Helodrilus* to the genus *Allolobophora* and furthermore elevated *Dendrobaena* to genus rank resulting in exterminating the former genus *Helodrilus*.

Omodeo (1953) resurrected the genus *Helodrilus* with the following characteristics: setae strictly paired, calciferous glands without lateral diverticula, pigmentation lacking, two pairs of seminal vesicles in segment 11, 12, spermathecal pores in setal line cd, small or medium size, medium number of segments. It is worth mentioning that the *Helodrilus* species usually possess lateral calciferous diverticula in segment 10, but these are sometimes hardly recognizable (Csuzdi & Zicsi 2003).

Perel (1976a) was among the first earthworm taxonomists who thoroughly examined the morphology of the nephridial bladders in the family Lumbricidae and highlighted the absence of nephridial bladders in case of the *Helodrilus* species, as an important distinguishing character. Following a similar train of thought Zicsi (1985) separated the genus *Proctodrilus* from *Helodrilus* by differences in the excretory system. The nephridial bladders are lacking in both cases, but in the genus *Helodrilus* each nephridium opens in its own segment (exonephric system). In the *Proc-*

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todrilus species each nephridium discharges in a collecting canal (enteronephric system).

Up to now the genus *Helodrilus* comprises ca. 20 species and subspecies (Appendix 1) showing holarctic distribution, from the Iberian Peninsula (Trigo *et al.* 1988) to Anatolia (Csuzdi *et al.* 2006), Levant (Pavlícek *et al.* 2003) and the Caucasus (Kvavadze 1985).

The species have special habitat preferences; most of them prefer highly moist soils or can be found in the banks of streams, swamps and caves, and because of their narrow range many species are considered as endangered or critically endangered (Stojanović & Karaman 2006). However, this conservation status may also be attributed to undersampling in these habitats and more research should be carried out in these areas to accurately assess their conservation status and distribution.

A typical example for this is the first records of *Helodrilus oculatus* Hoffmeister, 1845 from Hungary and *Helodrilus putricola putricola* (Bouché, 1972) from Portugal presented here.

MATERIAL AND METHODS

Earthworms were collected by digging and hand-sorting. The specimens were killed and fixed in 96% ethanol, then transferred into 75% ethanol and deposited in the earthworm collection of the Hungarian Natural History Museum (HNHM). For later molecular studies, tail parts of specimens of taxonomic importance were placed into 96% ethanol.

RESULTS

Helodrilus cernosvitovianus (Zicsi, 1967)

Allolobophora cernosvitoviana Zicsi, 1967: 248.
Helodrius cernosvitovianus: Zicsi 1985: 282., Mršić 1991: 115., Csuzdi & Zicsi 2003: 170.

Material examined. HNHM/16511, 1 ex., Hungary, Kömörő, leg. Cs. Csuzdi, 16.04.2007.

Remarks. This species was described from Hungary (Zicsi 1967) and later was found in Ukraine (Perel 1976b), Poland (Rosen & Kostecka 1988), Serbia (Mršić 1991, Karaman & Stojanović 2002, Stojanović & Karaman 2005) and Greece (Zicsi & Michalis 1981). The real distribution of this species is still unknown (Csuzdi *et al.* 2011).

Helodrilus deficiens Zicsi, 1985

Helodrilus deficiens Zicsi, 1985: 282., Mršić 1991: 126., Csuzdi & Zicsi 2003: 172.

Material examined. HNHM/14880, 1 ex., Hungary, Püski, Salamon Isle, leg. S. Mahunka, 23.06.2004.

Remark. This species is known only from Hungary and Austria (Zicsi 1994) from a narrow area, and all the specimens were collected from the bank of the Danube.

Helodrilus kratochvili (Černosvitov, 1937)

Eophila kratochvili Černosvitov, 1937: 130.
Helodrilus kratochvili: Zicsi 12985: 280., Mršić 1991: 114.

Material examined. HNHM/16960, 2 ex., Bosnia-Herzegovina, Žira Cave, leg. G. Balázs, 01. 08.2014.

Remarks. Zicsi (1985) examining the type material recognized that it contains only a single adult specimen, the other four specimens in the vial were praeadult or juvenile. Our specimens are also juvenile with only developing tubercles present on 29–31.

This troglobiont species lives solely in the Žira Cave and was found only two times after the original description. The samples were collected in the terminal siphon of the cave. The siphon is filled with fine mud. The cave is considered as a fossil sinkhole. Its morphology suggests that it used to consume huge quantities of water, but now the entrance is situated 7–8 meters higher

than the present polje level, therefore normally it collects only percolating water from the surface which is just enough to keep the mud wet throughout the year, and floods can only occur in the cave when the water level on Popovo polje is high. Although this area of the Dinaric Karst is well researched due to the close position of Vjetrenica Cave, *H. kratochvili* has only been found in this single cave. The unique hidrology of the locality might serve as explanation for this phenolmenon.

Helodrilus mozsaryorum (Zicsi, 1974)

Allolobophora mozsaryorum Zicsi, 1974: 230.
Helodrilus mozsaryorum: Zicsi 1985: 282., Mršić 1991: 125., Csuzdi & Zicsi 2003: 173.

Material examined. HNHM/16134, 2 ex., Hungary, Jósvafő, Baradla Rövid-Alsó Cave, siphon 4, leg. G. Balázs, 07.07.2011.

Remarks. This troglobiont species is endemic to Hungary, found only in the Baradla Rövid-Alsó Cave, NE Hungary, where it lives under water in the mud of siphons and secures its oxygen needs by the circular moves of its tail (Csuzdi & Zicsi 2003).

The cave is one of the active lower spring caves of the Baradla-Domica Cave System. Since the siphons, where these animals lived, were dried up by intensive pumping, this species was thought to be extinct (Zicsi *et al*. 1999).

New research in the Baradla-Domica Cave System proved that *H. mozsaryorum* specimens are still found in their type locality and they occur not only in the siphons but probably along the whole cave stream, as they were observed in the water of the artificial tunnel at the beginning of the cave, in a distance of about 30–40 meters from the entrance.

It worth noting, that the species have been found only in this branch of the Baradla-Domica Cave System although, since its discovery, numerous attempts were made to find it in other parts of the cave with similar conditions, as well as in surrounding caves.

Helodrilus oculatus Hoffmeister, 1845

Helodrilus oculatus Hoffmeister, 1845: 39., Zicsi 1985: 279., Mršić 1991: 118., Zicsi 1994: 43., Zicsi & Csuzdi 1999: 991.

Material examined. HNHM/11855, 1 ex., Germany, Rolfshagen, leg. A. Zicsi, 17.06.1963. HNHM/16133, 1 ex., Hungary, Mecsek, Abaliget Cave, leg. D. Angyal, L. Dányi, 14.01.2012. HNHM/16961, 1 ex., Hungary, Mecsek, Spirál Sinkhole, beginning of streamy branch, leg. D. Angyal, 23.02.2013.

Remarks. *H. oculatus* is the most widely distributed *Helodrilus* species. It is recorded from the Iberian peninsula (Trigo *et al.* 1998) to the Caucasus (Perel 1979, Kvavadze 1985). Consequently it shows a rather large morphological variability which resulted in describing many synonym names (Csuzdi 2012).

Our specimens with the clitellum on 22–31 and tubercles on 29–1/2 31 agrees well with the modern concept of the species (Michaelsen 1900: 497.).

Both the Abaliget Cave and the Spirál Sinkhole are situated in the Mecsek Mts. in SW Hungary. The former is the longest (about 2000 meters) and the later is the deepest (with 86 vertical metres extension and 1600 metres length) cave in that karstic region. Both caves have been developed in Triassic limestone and provide various microhabitats for some eutroglophile and troglobiont macroinvertebrate species. The collected *H. oculatus* specimens were found on clay in a wet environment approximately 70 meters deep in the Spirál Sinkhole and in a small puddle on the top of a large rock about 470 meters deep in the Abaliget Cave.

Helodrilus oculatus is new to the fauna of Hungary. As it was found in Slovenia (Mršić 1991) and Austria (Zicsi 1994) its presence in

Hungary was to be expected. The fact that it could have remain undiscovered till now in one of the biologically best investigated Hungarian caves– the Abaliget Cave – may indicates the rarity of the species.

Helodrilus patriarchalis (Rosa, 1893)

Allolobophora patriarchalis Rosa, 1893: 9.
Helodrilus patriarchalis: Zicsi 1985: 280., Csuzdi & Pavlíček 2005: 92., Szederjesi *et al*. 2013: 398., 2014: 566.

Material examined. HNHM/16624, 6 ex., Greece, Crete, Chania regional unit, Georgioupoli, swamp E of the village, 5m, N35°21.112' E24°17.442', leg. J. Kontschán, D. Murányi, T. Szederjesi, 01.04.2013. HNHM/16667, 2 ex., Jordan, Wadi Hassa, leg. T. Pavlíček, 14.05.1996. HNHM/16925, 2 ex., Turkey, Akyaka Mts. region, near stream, pine forest, leg. P. Cardet, T. Pavlíček, 13.04.2014. HNHM/16931, 3 ex., Turkey, Akyaka, mount slopes, pine forest, leg. P. Cardet, T. Pavlíček, 15.04.2014.

Remarks. *H. patriarchalis* shows a typical East Mediterranean distribution with its range stretching from Crete through Anatolia and the Levant (Csuzdi *et al*. 2006, Pavlíček *et al*. 2003) to the Transcaucasus (Perel 1967, Kvavadze 1985). It becomes completely adult only for a short period in the year which results in high variability of the clitellar and tubercular positions. In case of full development, the tubercles stretch from the hind end of segment 30 to the beginning of segment 34. Between this maximal extension large variations can be seen during development which have resulted in the description of several synonymised names such as *Helodrilus colchicus* Kvavadze, 2000 and *Helodrilus zicsianus* Kvavadze 2000 with data cl: 21,22–33,34 tb: ¼30,31–¼33,½34 and cl: 23–33,34 tb: ¼30,31–32,¼33 respectively.

Helodrilus putricola putricola (Bouché, 1972)

Allolobophora putricola Bouché, 1972: 442.
Helodrilus putricola putricola: Zicsi 1985: 282., Zicsi & Csuzdi 1999: 991.

Material examined. HNHM/16414, 1 ex., Portugal, Cal de Bois, N41°21.53 W7°29.219, leg. T. Pavlíček, 05.09.2011. HNHM/16428, 1 ex., Portugal, Palmeira de Faro, stream in a farm, 89 m, leg. T. Pavlíček, 01–05.09.2011. HNHM/16470, 1 ex., France, Midi-Pyrénées, after Paréac, forest, 404 m, N43°06.736' E00°00.736', leg. Cs. Csuzdi, 07.07.2004.

Remarks. Our specimen with a clitellum on 23– 29, tubercula on 23–28, four pairs of vesicles in 9–12 and spermatheca in 9/10, 10/11 *cd* agrees well with the original description. *H. putricola putricola* was previously known only from France and it is new to the fauna of Portugal.

Helodrilus putricola orionense (Zicsi, 1977)

Allolobophora orionense Zicsi, 1977: 682.
Helodrilus putricola orionensis: Zicsi & Csuzdi 1999: 991.

Material examined. HNHM/16413, 1 ex., France, Aquitaine, Pyrenees Mts., 21 km after Combo les Bains, before St. James Pied de Port, forest, stream bank, 63 m, N43°19.517' W01°22.963', leg. Cs. Csuzdi, 06.07.2004.

Remark. This subspecies is only known from the French part of the Pyrenees.

Eisenia hachiojii (Blakemore 2007) comb. nov.

Helodrilus hachiojii Blakemore, 2007: 17., Blakemore & Grygier 2011: 276.

Material examined. HNHM/15531, 1 ex., Japan, Komiga Park, Hachioji, West Tokyo, leg. R.J. Blakemore, 05.09.2010.

Remarks. Blakemore (2007) noted that he observed simple, flask-shaped nephridial bladders in certain segments of a few of the specimens. Examining a topotype we found small, simple, saccular nephridial bladders in all segments which makes it clear that the species *hachiojii* belongs to the genus *Eisenia*. Similar shaped bladders are found in other limicolous *Eisenia* species such as

the Inner Asian *Eisenia colchidica* (Perel, 1967) and the Central European *E. balatonica* (Pop, 1943).

DISCUSSION

As the *Helodrilus* species live mostly in stream banks and caves where earthworm sampling is usually not focused, we still have little information both on the species and also their exact distribution. This might be the reason that, except the two most common species (*H. oculatus* and *H. patriarchalis*), the current known species' ranges for the other *Heliodrilus* taxa are quite limited. Except the truly troglobiont taxa (such as *H. kratochvili* and *H. mozsaryorum*) the other species are likely to have much larger distribution ranges than we currently know. This is highlighted by the recent discovery of *Helodrilus vagneri* Mršić, 1991 in Greece (Szederjesi *et al*. 2012) and also the record of *H. oculatus* in the quite well explored Hungary.

Another problem is that many *Helodrilus* specimens recorded in the literature (including the type specimens of *H. oculatus,* the generotype) are not fully adult because the maturity of these species lasts only for a short period of time in the year. This can lead to misidentifications and also recording high morphological variability which questions the validity of certain species (Omodeo & Rota 2008).

The genus *Helodrilus* is problematic also from phylogenetic point of view. Its most specific character is the lack of nephridial bladders which is the plesiomorphic character state according to Perel (1976a). If we accept this assumption, then *Helodrilus* is considered to be an ancient group of earthworms. The range of this genus totally covers the whole Lumbricidae domain (except North America) which could also imply an ancient origin. However, if we examine the plesiomorphic sister groups of Lumbricidae, e.g. Hormogastridae (James & Davidson 2012), we found nephridial bladders present in all cases. Therefore the absence of bladders seems to be a derived character (Csuzdi 2004) and can be related to the limicolous way of life. Further molecular studies are needed to determine the true phylogenetic position (or even monophyly) of this highly special earthworm taxon.

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Appendix 1.

List of the valid names in the genus *Helodrilus* Hoffmeister, 1845

***Helodrilus balcanicus balcanicus* (Černosvitov, 1931)**

Eiseniella balcanica Černosvitov, 1931: 321.
Allolobophora macedonica Šapkarev, 1971: 150.

***Helodrilus balcanicus plavensis* (Karaman, 1972)**

Eiseniella balcanica plavensis Karaman, 1972: 78.

***Helodrilus cernosvitovianus* (Zicsi, 1967)**

Allolobophora cernosvitoviana Zicsi, 1967: 248.

***Helodrilus deficiens* Zicsi, 1985**

Helodrilus deficiens Zicsi, 1985: 282.

***Helodrilus dinaricus* Mršić, 1991**

Helodrilus dinaricus Mršić, 1991: 108.

***Helodrilus duhlinskae* Zicsi & Csuzdi, 1986**

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Helodrilus serbicus Šapkarev, 1989: 33.

***Helodrilus jadronensis* Šapkarev, 1989**

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***Helodrilus kratochvili* (Černosvitov, 1937)**

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***Helodrilus mozsaryorum* (Zicsi, 1974)**

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***Helodrilus musicus* Qiu & Bouché 2000**

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***Helodrilus oculatus* Hoffmeister, 1845**

Allolobophora hermanni Michaelsen, 1890: 13.
Helodrilus ospensis Mršić, 1991: 113.
Helodrilus cartlicus Kvavadze, 2000: 82.
Helodrilus cortezi Qiu & Bouché, 2000: 9.
Helodrilus phillipei Qiu & Bouché, 2000: 12.
Helodrilus turquini Qiu & Bouché 2000: 10.

***Helodrilus patriarchalis* (Rosa, 1893)**

Allolobophora patriarchalis Rosa, 1893: 9.
Helodrilus colchicus Kvavadze, 2000: 82.
Helodrilus zicsianus Kvavadze, 2000: 83.

***Helodrilus putricola putricola* (Bouché, 1972)**

Allolobophora putricola Bouché, 1972: 442.

***Helodrilus putricola orionense* (Zicsi, 1977)**

Allolobophora orionense Zicsi, 1977: 682.

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Allolobophora oculata v. *dudichi* Pop, 1943: 14.
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***Helodrilus segalensis* (Bouché, 1972)**

Allolobophora segalensis Bouché, 1972: 457.

***Helodrilus slovenicus* Mršić, 1991**

Helodrilus slovenicus Mršić, 1991: 124.

***Helodrilus vagneri* Mršić, 1991**

Helodrilus vagneri Mršić, 1991: 116.