Description of the first endemic earthworm species from Cyprus (Oligochaeta: Lumbricidae)

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(Received 16 November 2015; accepted 19 March 2016; first published online 4 May 2016)

New earthworm samples from Cyprus are assessed and discussed. A re-evaluation of specimens previously relegated to the Southern Alpine species Perelia nematogena (Rosa, 1903), revealed two independent species: Perelia phoebea (Cognetti, 1913), described originally from Rhodes Island, (Greece) and an undescribed species Perelia makrisi sp. n. The new species is similar also to the Levantine Pe. galileana Csuzdá & Pavlíček, 2005 and corroborates the hypotheses that the autochthonous earthworm fauna of Cyprus is of Levantine origin.

http://www.zoobank.org/urn:lsid:zoobank.org:pub:FD1996DC-2FFC-42D5-A1D2-005B50E6FC64

Keywords: Earthworms; Cyprus; new species; the Levant; Messinian period; endemism

Introduction
The first earthworm records from Cyprus were presented in 1993 by K. Michalis. This material was collected mostly in urban environments and altogether displayed six, mainly peregrine, earthworm species. From this material, Michalis (1993) concluded that the earthworm fauna of the island was poor, lacking a diversity of species. Later, Pavlíček & Csuzdi (2006, 2008, 2016) refuted this statement by adding 14 new species records, mainly from the environs of the Troodos Mts. This effort raised the number of earthworm species recorded from Cyprus to 20. By taking into account the East Mediterranean climate, and the size of the island it was concluded that the earthworm fauna of Cyprus is in fact rich (Pavlíček & Csuzdi, 2016). However, up till now no endemic earthworm species had been recorded on the island.

In the present paper, we clarify the taxonomic status of the Perelia nematogena specimens recorded earlier from Cyprus and described the first endemic earthworm species; Perelia makrisi sp. n. Some additional earthworm records from the Troodos Mts. and the southern part of the island are also presented.

Material and Methods
Earthworms were collected by the diluted formaldehyde method (Raw, 1959), complemented with digging and hand-sorting. The specimens were killed and fixed in 96% ethanol, then trans-
ferred into 75% ethanol and deposited in the earthworm collection of the Hungarian Natural History Museum (HNHM). For molecular studies, some specimens were placed into 96% ethanol.

Family Lumbricidae Rafinesque-Schmaltz, 1815

**Perelia makrisi** sp. n. (Figures 1a–2a)

*Allolobophora nematogena* Pavlíček & Csuzdi 2006: S114 (part.).

*Perelia nematogena* Pavlíček & Csuzdi 2016: 11 (part.).

**Material.** Holotype. HNHM/14792 Cyprus, River Xeros Potamos near the monastery Agios Marina, riverside, 34°51′N 32°37′E, leg. T. Pavlíček, 10.iv.2004. – Paratypes. HNHM/14866 4 ex., Cyprus, between Lythrodontos and Makheros, pine forest with a small creek, 34°57′03″N 33°14′27″E, leg. T. Pavlíček, 17.i.2003. HNHM/14872 2 ex., Cyprus, Fikardon & Klirou, 567 m, 34°59′43″N 31°11′33″E, leg. T. Pavlíček, 17.i.2003.

**Etymology.** The new species is named in honour of Christodoulos Makris, who helped us in conducting field work in Cyprus.

**Diagnosis.** Length 44–66 mm, diameter 3–4 mm, setae closely paired. Colour brownish. Clitellum on 24, 25–34, tubercles on 30–½34. Male pore on 15, large. Two pairs of vesicles in 11, 12; two pairs of spermathecae in 9/10, 10/11 open in setal line cd. Calciferous glands with lateral diverticula in 10. Nephridial bladders S-shaped with cephalad bent ental limb and an ectal vesiculum.

**External characteristics.** Holotype: length 49 mm, diameter just after the clitellum 4 mm. Number of segments: 126. Paratypes: 44–66 mm long and 3–3.5 mm wide. Number of segments: 110–131. Colour brownish. Prostomium epilobous ½ closed. First dorsal pore at the intersegmental furrow 4/5. Setae strictly paired. Setal arrangement behind clitellum: \(aa:ab:bc:cd:dd = 11.2:1.2:8.7:1:19.2\) (Figure 1a). Male pores on segment 15, surrounded by glandular crescents, protruding into the neighbouring segments. Nephridial pores irregularly alternate between \(b\) and above \(d\). Clitellum on segments 24, 25–34. Tubercula pubertatis on segments 30–½ 34. Glandular tumescences on10, 11 ab (Figure 2a).

**Internal characteristics.** Septa 6/7–9/10 strongly thickened, 10/11–13/14 thickened. Free testes and funnels paired in segments 10–11. Two pairs of seminal vesicles in segments 11, 12. Two pairs of spermathecae in 9/10, 10/11 with external openings in the setal line cd. Calciferous glands in 10–13 with well-developed diverticula in segment 10. Paired lateral hearts appear in segments 6–11, with a pair of small extraesophageal vessels in 12. Nephridial bladders S-shaped with cephalad bent ental limb and an ectal vesiculum. Crop in segments 15–16, and gizzard in segments 17–18. Typhlosolis tri-lobed. Longitudinal muscle layers transitional.

**Remarks.** Comparison of the Cypriot specimens with *Perelia nematogena* collected from Italy (HNHM/12830, 12811, 12805, 6801, 6805, 6841, 6863), Slovenia (HNHM/6743), Croatia (HNHM/6494, 6495), Hungary (HNHM/4136, 4122, 4132, 4135, 9120), Serbia (HNHM/7642, 12799) and Bosnia-Herzegovina (HNHM/6673) exposed remarkable differences. The position of the clitellum of *P. makrisi* sp. n. is mostly constant on 24, 25–34, while in the case of *P. nematogena* it varied in having a wider range: \(½ \) 24, \(½ \) 25, 25, \(½ \) 26, 26, 27–33, \(½ \) 34, 34, 35. Similar pattern was observed in the position of tubercula pubertatis (exclusively \(30–½ \) 34 vs. \(½ \) 29, 29, 30–\(½ \) 33, 33). There are also differences in size: the new species is smaller in length (44–66 mm) and diameter (3–4 mm) than *nematogena* (48–81 mm and 4–5 mm respectively). Furthermore, the new species differs from *P. nematogena* in the coloration (brownish
Figure 1. Setal arrangements in the *Perelia nematogena* species group. 1a = *P. makrisi* sp. n., 1b = *P. nematogena* (Rosa, 1903) HNHM/6805 Italy, 1c = *P. phoebea* (Cognetti, 1913). a, b, c, d = setal lines.

vs. unpigmented), setal ratio (Figures 1a, 1b), type of longitudinal muscle layer (transitional vs. fasciculated) (Csuzdi & Zicsi, 2003) and also in the form of the tail (Figures 2a, 2b).

With its characteristic cut-tail (Figure 2a.), the new species also resembles *Pe. phoebea*, and *Pe. galileana* Csuzdi & Pavliček, 2005 but differs from both in the position of the clitellum, tubercula and from *Pe. phoebea* in the number of vesicles (2 vs. four pairs) (Table 1).

**Perelia phoebea** (Cognetti, 1913) **comb. n.** (Figures 1c–2c)

*Helodrilus* (*Allolobophora*) *phoebeus* Cognetti, 1913: 2.
*Allolobophora jassyensis* *phoebea* Zicsi & Michalis 1981: 250.
*Allolobophora nematogena* Rosa, 1903: Pavliček & Csuzdi 2006: S114 (part.).
*Perelia nematogena* Pavliček & Csuzdi 2016: 11 (part.).

**Material.** HNHM/14867 2 ex., Cyprus, between Lazanias and Gourri/Fikardou, maquis with pine, 34°54’N 33°01’E leg. T. Pavliček, 17.i.2003. HNHM/16368 1 ex., Cyprus, between Lythrodontos and Makheros, pine forest with a small creek, 34°57’03”N 33°14’27”E, leg. T. Pavliček, 17.i.2003.

**Diagnosis.** Length 46–50 mm, diameter 2–5 mm, setae closely paired. Setal arrangement behind the clitellum: $aa:ab:bc:cd:dd = 11:1.5:8.5:1:23$ (Figure 1c). Colour brownish. Clitellum on ½ 25–35, tubercles on 31–34. Male pore on 15, large (Figure 2c). Four pairs of vesicles in 9–12; two pairs of spermathecae in 9/10, 10/11 open in setal line cd. Calciferous glands with lateral diverticula in 10. Nephridial bladders S-shaped with cephalad bent ental limb and an ectal vesiculum.

**Remarks.** *Pe. phoebea* possesses S-shaped nephridial bladders with cephalad bent ental limb and an ectal vesiculum, therefore, belongs to the genus *Perelia* instead of *Allolobophora*, where the simple J- or U-shaped nephridial bladders are typical (Csuzdi & Pavliček, 2005). It is similar to *Perelia nematogena* but differs from it in the position of the clitellum, tubercula pubertatis, length, coloration, and the number of vesicles (Table 1). *Perelia phoebea* was described from Rhodes and this is its first record from Cyprus.
Discussion

Due to its tectonic history and long-time isolation from the mainland, Cyprus is one of the most important biodiversity hotspots identified in the Mediterranean Basin (Médail & Quézel, 1999; Pavlíček & Csuzdi, 2006). Interestingly, the earthworm fauna of Cyprus is still poorly known. Data, especially from the northern part of the island (Kyrenia Mts., Mesaoria Plain) is completely missing. Altogether 21 earthworm species are registered on the island so far belonging to the families Lumbricidae and Acanthodrilidae (19 and two species respectively). This species number, compared to the somewhat smaller Crete (18 species; Szederjesi, 2016) and the approximately twice the size Israel (28 species; Szederjesi, Pavliček, & Csuzdi, 2013) seems to be quite high.

The two acanthodrilid species (*Microscolex phosphoreus* (Dugès, 1837) and *M. dubius* Fletcher, 1887) are well-known circum-Mediterranean peregrines of South American origin (Blakemore, 2008). Out of the 19 lumbricid species recorded 6 (32%) belong to the widely introduced peregrine group and 11 species (58%) possess more
restricted, perhaps autochtonous distribution on the island. The statuses of two further species are uncertain. *Dendrobaena veneta* represents a widely introduced species complex of East Mediterranean origin (Csuzdi & Pavlíček, 1999) its real status in Cyprus needs further considerations. *Dendrobaena pantaleonis* (Chinaglia, 1913) a South Alpine - Mediterranean species has been reported by Michalis (1993) however it has not been found later.

Out of the 11 autochtonous earthworm species recorded for Cyprus only one species shows clear Anatolian affinity: *Dendrobaena pentheri* whose range extends from the Caucasus region through Anatolia to Cyprus. The newly described species together with the clearly Levantine *D. semitica* and in the Levant widely distributed *Helodrilus patriarchalis* (Rosa, 1893) corroborates the hypothesis of the Levantine origin of the Cyprus earthworm fauna (Pavlíček & Csuzdi, 2008). This hypothesis dates back the origin of the native earthworm fauna to the Messinian period (5.96 to 5.33 mya) when several subaerial ridges connected the island with the Levantine coast.

The newly described Cypriot endemic *Perelia makrisi* sp. n. implies that more, still undescribed earthworm species could be found if a thorough survey were conducted.

**Acknowledgements**

Our thanks are due to Mr Christodoulos Makris for his extended help during our several field trips to Cyprus. Ms. Emma Sherlock is sincerely thanked for polishing the text.

**Funding**

This work was supported by the Hungarian Scientific Research Fund (OTKA) No. 100369.

**Disclosure Statement**

No potential conflict of interest was reported by the authors.

**Supplementary Material**

The tables are given as a Supplementary Annex, which is available via the “Supplementary” tab on the article’s online page (http://dx.doi.org/10.1080/09397140.2016.1182778).

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Table 1. Main morphological characters in the *Perelia nematogena* species-group.

| Species                  | Clitellum | Tubercles | Receptacles | Vesicles | Tail     |
|--------------------------|-----------|-----------|-------------|----------|----------|
| *Pe. galileana*           | 23, 24–34 | 31–34     | 9/10, 10/11 | 11, 12   | cut      |
| Csuzdi & Pavlíček, 2005  |           |           | *cd*        |          |          |
| *Pe. makrisi* sp. n.     | 24, 25–34 | 30–½34    | 9/10, 10/11 | 11, 12   | cut      |
| *Pe. nematogena*         | ½24, 25, 26, | ½29, 29, | 9/10, 10/11 | 11, 12   | tapering |
| (Rosa, 1903)             | 27–33, 34, 35 | 30–½33, 33 | *cd*       |          |          |
| *Pe. phoebea*            | ½ 25–35   | 31–34     | 9/10, 10/11 | 9–12     | cut      |
| (Cognetti, 1913)         |           |           | *cd*        |          |          |
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