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# Occurrence of the Earthworms *Pontodrilus litoralis* (Grube, 1855), *Metaphire houlleti* (Perrier, 1872), and *Eiseniella tetraedra* (Savigny, 1826) from Taiwan

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**ABSTRACT:** This paper describes two megascolecid earthworms *Pontodrilus litoralis* (Grube, 1855) and *Metaphire houlleti* (Perrier, 1872), and a lumbricid earthworm *Eiseniella tetraedra* (Savigny, 1826) as the species newly recorded to Taiwan. *P. litoralis* is a small, euryhaline earthworm dwelling in the intertidal zone along coasts of the Penghu island and the southwestern Taiwan. *M. houlleti* is a medium, sexthecal earthworm from Pingtung of the southern Taiwan. It belongs to the *houlleti*-group of the genus *Metaphire* Sims and Easton, 1972. *E. tetraedra* is an earthworm dwelling in the torrents or damp habitat in mountain streams of the central Taiwan.

**KEY WORDS:** ***Pontodrilus litoralis, Metaphire houlleti, Eiseniella tetraedra*, earthworm, Taiwan.**

## INTRODUCTION

In recent years we have conducted earthworm surveys in various parts of Taiwan with discoveries of many new and unrecorded species (Tsai *et al*., 1999, 2000a, 2000b, 2001, 2002, 2003, 2004; Shen and Tsai, 2002; Shen *et al*., 2002, 2003, 2005). This paper adds two megascolecid earthworms, *Pontodrilus litoralis* (Grube, 1855) and *Metaphire houlleti* (Perrier, 1872), and a lumbricid earthworm *Eiseniella tetraedra* (Savigny, 1826) as the species newly recorded to Taiwan. With an addition of these three species, there are a total of 59 known species and subspecies of megadrile oligochaetes in Taiwan.

*P. litoralis* is from the coasts of the Penghu island and the southwestern Taiwan. It is a small, euryhaline earthworm dwelling in the intertidal zone along the shore, and widely distributed in warm beaches throughout the world (Blakemore, 2002). *M. houlleti* is from Pingtung. It is a medium, sexthecal earthworm belonging to the *houlleti*-group of the genus *Metaphire* Sims and Easton, 1972, and possibly originates from Southeast Asia (Gates, 1972). *E. tetraedra* is from mountain streams of central Taiwan. It is an earthworm dwelling in torrents or damp habitat and originates from the temperate zone (Gates, 1972). Its present cosmopolitan distribution has largely influenced by human transportation (Gates, 1972).

The earthworms collected were fixed in a 10% formalin-water solution and preserved in a 70% ethyl alcohol-water solution. The following description is based on 49 specimens of *P. litoralis*, six specimens of *M. houlleti*, and 15 specimens of *E. tetraedra* deposited at the Taiwan Endemic Species Research Institute, Chichi, Nantou, Taiwan.

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## TREATMENTS

### ***Pontodrilus litoralis*** (Grube, 1855)

*Lumbricus litoralis* Grub, 1855: 127.
*Pontodrilus marionis* Perrier, 1874: 1582. – Perrier, 1881: 176.
*Pontodrilus bermudensis* Beddard, 1891: 96. – Michaelsen, 1910a: 84; 1921: 12. – Gates, 1926a: 150; 1942: 90; 1943: 99; 1954a: 240; 1961: 57; 1972: 47. – Stephenson, 1931: 51. – Chen, 1938: 379.
*Pontodrilus matsushimensis* Iizuka, 1898: 21. – Beddard, 1899: 192. – Michaelsen, 1900: 179; 1910a: 91. – Lee, 1969: 352; 1985: 66. – Easton, 1981: 45.
*Pontodrilus litoralis* – Michaelsen, 1900: 180; 1910a: 89. – Easton, 1984: 114.

Diagnosis: Slender worm. Clitellum XIII-XVII, saddle-shaped. Setae lumbricin. Male pores paired in XVIII, each on inner wall of a longitudinal depression, median to a longitudinal ridge. Female pores paired, medio-ventral in XIV. Spermathecal pores in 7/8 and 8/9. Spermathecae tubular. Testis sacs paired in X and XI. Seminal vesicles paired in XI and XII. Prostate glands tubular, paired in XVIII. Nephridia avesiculate, absent in I-XII and XIV.

Description: Length 50-130 mm, diameter 1-2 mm. Segment number 81-115. Prostomium epilobous. Dorsal pores absent. Clitellum XIII-XVII, saddle-shaped, setae present. Setae lumbricin (eight setae per segment), ab absent on XVIII, ab < cd, aa > bc, aa = cd, dd < 0.5 body circumferences (setal arrangements, see Edwards and Bohlen, 1996) in the anterior portion of the body. Male pores minute, paired in XVIII, each on inner wall of a longitudinal depression, median to a longitudinal ridge extending the entire segment XVIII (Fig. 1A). Female pores paired, medio-ventral in XIV, each anterior to seta a. Spermathecal pores two pairs in 7/8 and 8/9, ventrolateral, in line with seta b (Fig. 1A). Preserved specimens pale, light brown around clitellum. Genital marking large, medio-ventral, transversely oval across 19/20, center depressed.

Septa 5/6-12/13 muscular. Gizzard absent. Intestine origin in XVII. Esophageal hearts VII-XIII. Nephridia avesiculate, absent in I-XII and XIV, small in XIII, larger from XV. Spermathecae two pairs in VIII and IX, tubular. Diverticulum slender, narrower at the junction with ampulla (Fig. 1B). Accessory glands absent.

Holandry: testis sacs paired in X and XI. Seminal vesicles paired in XI and XII, thin, follicular (Fig. 1C). Prostate glands paired in XVIII, tubular (Fig. 1D). Prostatic duct curved with muscular sheen. Accessory glands absent.

Specimens examined: Nine mature (clitellate) and 18 immature (aclitellate) specimens collected from the beach of Sanshui, Penghu Co., Taiwan on 9 Nov. 1998 by C. Y. Liu and T. J. Lin (coll. no. 1998-64); eight immature specimens collected from the coast of Chitou, Penghu Co., Taiwan on 14 Jun. 1999 by H. P. Chen and C. Y. Chang (coll. no. 1999-6-Shen); 12 immature specimens collected under trees of *Casuarina equisetifolia* along the coast of Haomeiliao, Putai, Chiayi Co., Taiwan on 30 Jul. 1999 by M. L. Hsueh (coll. no. 1999-13-Shen); two immature specimens collected from the sandy beach near the light house of Chiku Lagoon, Chiku, Tainan Co., Taiwan on 16 Feb. 2000 by C. Y. Liu and T. J. Lin (coll. no. 2000-6-Shen). All the above collections except coll. no. 2000-6-Shen were lost in the 21 Sep. 1999 earthquake.

Remarks: *Pontodrilus litoralis* was first described by Grube (1855) based on specimens collected from the Mediterranean coast of southern France. Michaelsen (1910a) listed three littoral *Pontodrilus* species, *Pontodrilus litoralis* (Grube, 1855), *Pontodrilus bermudensis* Beddard, 1891, and *Pontodrilus matsushimensis* Iizuka, 1898, and distinguished them by slight difference in the structure of their prostatic ducts. Chen (1938) suggested that the latter two species are synonymous. Easton (1984) considered that there is but a single littoral *Pontodrilus* species in view of individual variation and sympatric distribution of the above three taxa.

*P. litoralis* is a cosmopolitan species and widely distributed in warm beaches throughout the world (Blakemore, 2002). It dwells in sandy beaches, salty mud, or mangrove swamps of the intertidal zone (Gates, 1972; Blakemore, 2002). According to Lee (1969), this species showed immediate signs of irritation and exuded coelomic fluid from nephridiopores when put into sea water at first. However, instead of death like most other earthworms, it relaxed and then burrowed into the sand on the bottom within about ten minutes.

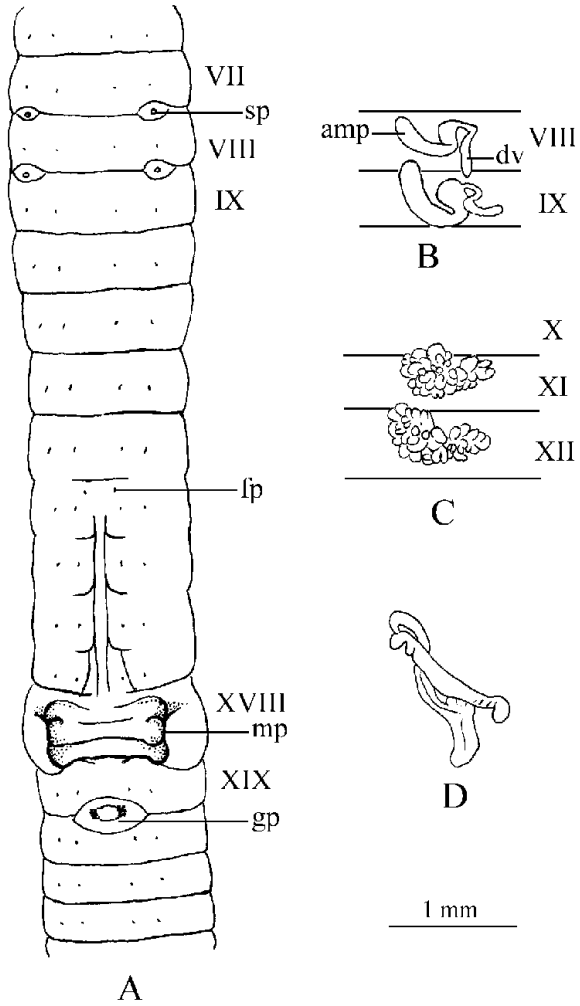


Fig. 1. *Pontodrilus litoralis* (Grub, 1855). A: Ventral view of preclitellar, clitellar, and male pore regions (sp: spermathecal pore; gp: genital papilla; fp: female pore; mp: male pore). B: Dorsal view of left spermathecae (amp: ampulla; dv: diverticulum). C: Dorsal view of right seminal vesicles. D: Dorsal view of right prostate gland.

Gates (1972) considered that the agent for the circumtropical distribution of *P. litoralis* seems unlikely to have been man. It has been speculated that this species is dispersed naturally by ocean currents (Lee, 1969, 1985).

### ***Metaphire houlleti*** (Perrier, 1872)

*Perichaeta houlleti* Perrier, 1872: 99. – Beddard, 1887: 389. – Horst, 1893: 64. – Michaelsen, 1897: 234 (part).

*Perichaeta campanulata* Rosa, 1890: 115.
*Amyntas houlleti* – Beddard, 1900: 613 (part).
*Pheretima houlleti* – Michaelsen, 1900: 273 (part); 1909: 110 (part) and 187; 1910b: 11 (part) and 83. – Stephenson, 1922: 434; 1929: 237 (part). – Gates, 1926a: 156; 1926b: 450; 1931: 389; 1932: 464; 1933: 529; 1936: 419; 1939: 94; 1954b: 87; 1961: 57; 1972: 190.
*Pheretima wimberleyana* Stephenson, 1925: 62.
*Pheretima houlleti typica* – Gates, 1926a: 157; 1926b: 450; 1930: 311.
*Pheretima houlleti tortuosa* Gates, 1926a: 157. – Gates, 1926b: 454.
*Pheretima houlleti rugosa* Gates, 1926a: 157. – Gates, 1926b: 459; 1930: 311.
*Pheretima campanulata* – Gates, 1930: 307; 1931: 373; 1936: 406; 1954b: 84; 1961: 57.
*Pheretima rugosa* – Gates, 1932: 398.
*Pheretima campanulata* var. *typica* – Gates, 1932: 452; 1933: 511.
*Pheretima campanulata* var. *meridiana* Gates, 1932: 457. – Gates, 1933: 511.
*Pheretima campanulata* var. *penetralis* Gates, 1932: 460. – Gates, 1933: 511.
*Pheretima campanulata* var. *rugosa* – Gates, 1933: 512.
*Pheretima campanulata* f. *rugosa* – Gates, 1936: 409; 1939: 83.
*Pheretima meridiana* – Gates, 1936: 434; 1961: 57.
*Pheretima yapensis* Ohfuchi, 1941: 283.
*Metaphire houlleti* – Sims and Easton, 1972: 238.
*Metaphire wimberleyana* – Sims and Easton, 1972: 238.

Diagnosis: Medium-size. Clitellum XIV-XVI with setal rings. Spermathecal pores three pairs in 6/7-8/9, ventrolateral, slit-like. Female pore medio-ventral in XIV. Male porophores paired in XVIII, each in copulatory pouch with C-shaped opening (slit), surrounded by a round swelling area with numerous transverse ridges. Spermathecal diverticulum enlarged and greatly coiled toward distal end. Accessory glands stalked. Testis sacs paired in X and XI. Seminal vesicles paired in XI and XII. Prostate glands large, paired in XVIII.

Description: Length (mature) 107-118 mm, weight 0.595-1.357 g. Segment number 86-102. Prostomium epilobous. First dorsal pore 9/10. Three incomplete annulets per segment in VI-XIII. Setal number 30-36 in VII, 50-52 in XX, 9-10 between male pores in XVIII. Clitellum XIV-XVI, 3.15-4.39 mm long, 2.39-3.6 mm wide, dorsal pores absent, three rings each with about 40 setal pits. Spermathecal pores three pairs in 6/7-8/9, ventrolateral, slit-like, wrinkled at both anterior and posterior margins, buried deeply in intersegmental furrow (Fig. 2A); distance between the paired pores 0.3-0.32 body circumferences ventrally apart. Female pore single, medio-ventral in XIV. Male porophores paired in XVIII, about 0.28 body circumferences ventrally apart, each in copulatory pouch with C-shaped opening (slit), surrounded by a round swelling area with numerous transverse ridges (Fig. 2B). Genital papilla absent in both pre- and post-clitellar regions. Preserved specimens black on dorsum, greyish on ventrum, and dark brown around clitellum.

Septa 5/6-7/8 and 10/11-12/13 thickened, 8/9/10 absent. Gizzard large in IX-X. Intestine enlarged from XV. Intestinal caeca paired in XXVII-XXIV, simple, stocky, wrinkled. Esophageal hearts X-XIII. Meronephridia bush-like mass in intersegmental spaces anterior to septa 5/6 and 6/7. Spermathecae three pairs in VII-IX (Fig. 2C). Ampulla oval, large, surface wrinkled, 1.74-2.57 mm long, 1.06-1.93 mm wide. Spermathecal duct long, stout, 0.77-1.92 mm long, with a swelling basal portion. Diverticulum originating from below the swelling portion of the spermathecal duct; its stalk slender at the proximal end, 0.4-0.6 mm long, enlarged and greatly coiled toward distal end. Accessory glands stalked, stalk length 0.4-1.06 mm, with a round or slightly lobed head, connecting to the swelling basal portion of the spermathecal duct.

Holandry: testis sacs paired in X and XI, round, second pair vestigial. Seminal vesicles paired in XI and XII, small, folliculate, yellowish, posterior pair larger, each with a round or oval dorsal lobe. Pseudovesicles in XIII rudimentary. Prostate glands paired in XVIII, large,

lobed, quite smooth, extending anteriorly to XVI and posteriorly to XXII or XXIII (Fig. 2D). Prostatic duct U-shaped, slender at proximal half and enlarged at distal half. White patches of accessory glands immediately anterior to the bulge at the base of the prostatic duct.

Specimens examined: Six mature (clitellate) specimens collected from the ditch along the road from the Indigenous People's Cultural Park to Haocha (elevation 200-300 m), Pingtung Co., Taiwan on 25 Nov. 1999 by R. C. Jang, J. L. Lai, C. Y. Chang, and S. T. Chang (coll. no. 1999-26-shen).

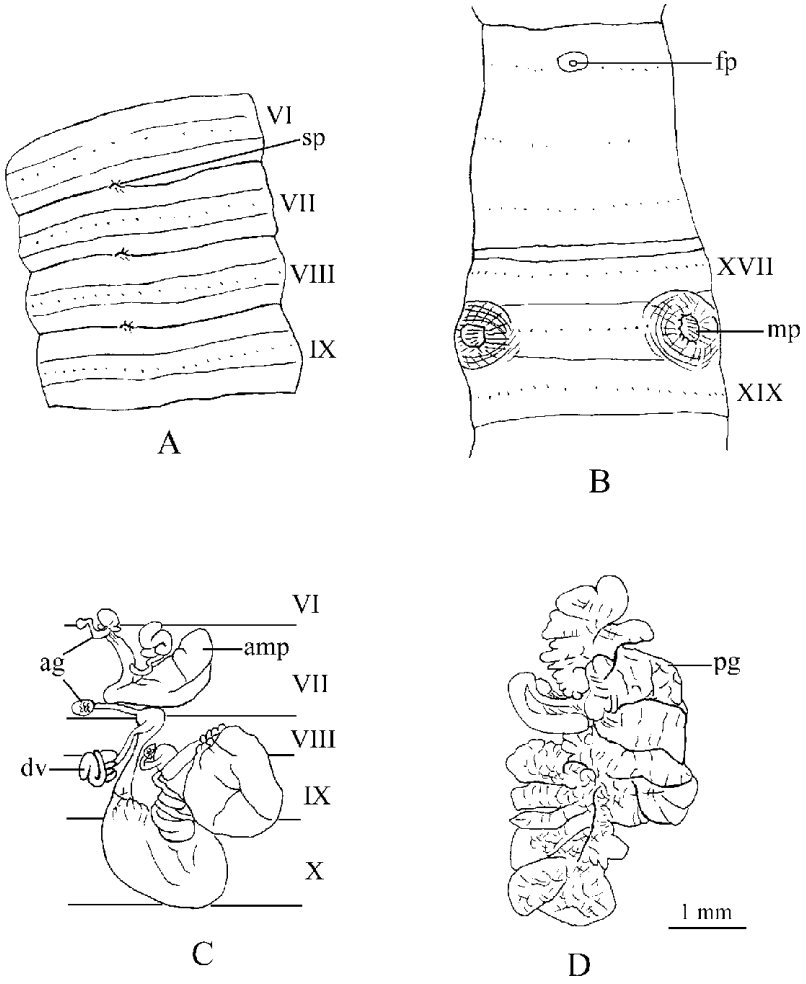


Fig. 2. *Metaphire houlleti* (Perrier, 1872). A: Right lateral view of preclitellar region (sp: spermathecal pore). B: Ventral view of clitellum and male pore region (fp: female porophore; mp: male porophore). C: Dorsal view of right spermathecae (amp: ampulla; dv: diverticulum; ag: accessory gland). D: Dorsal view of right prostate gland (pg).

Remarks: *M. houlleti* complex consists of different morphs distinguishable by somatic and genital characters (Gates, 1972). Its number of spermathecae ranges from three pairs of the normal, original morph to zero of the athecal morph. According to Gates (1972), the differences in the reproductive organs might be attributable to parthenogenetically induced modifications, and moreover, an amphimictic ancestral population could have differentiated into different geographical races.

Michaelsen (1895) described *Perichaeta guillelmi* as a new species from Hupei, China, but later he considered it synonymous to *M. houlleti* (Michaelsen, 1897, 1900). Michaelsen (1931) concluded that *M. guillelmi* was a special variety of *M. houlleti* after a further

examination of the original material. Chen (1933) considered these two species to be specifically different in view of less numerous setae and absence of spermathecal chamber of *M. houlleti*, and their different aspect of the male pore region. Gates (1935) distinguished the two species by their different male pore invaginations. The geographical distribution also varies for the two species. *M. guillelmi* is found in the central China (Michaelsen, 1895; Chen, 1933), while *M. houlleti* is widely distributed in Southeast Asia (Gates, 1972). Accordingly, this study retained *M. guillelmi* as a valid species.

Gates (1972) considered *M. houlleti* to be primarily a lowland tropical species. The original home of *M. houlleti* is probably in Southeast Asia (Gates, 1939, 1972). Up to date, the southern Taiwan is the northernmost distributional limit of this earthworm in East Asia. It has never been recorded in either central or northern Taiwan despite years of surveys by different research groups.

***Eiseniella tetraedra*** (Savigny, 1826)

*Enterion tetraedrum* Savigny, 1826: 184.
*Allurus tetraedrus* – Michaelsen, 1892: 251.
*Allurus hercynius* Michaelsen, 1892: 251.
*Eiseniella tetraedra* – Michaelsen, 1900: 471. – Gates, 1972: 108. – Reynolds, 1973: 108; 1974: 95. – Lee, 1985: 64.
*Eiseniella tetraedra* (Savigny) f. *typica* – Michaelsen, 1935: 40. – Muldal, 1952: 59.
*Eiseniella tetraedra* mut. *hercynia* (Michaelsen) – Muldal, 1952: 59.
*Eiseniella tetraedra tetraedra* – Easton, 1983: 481.

Diagnosis: Body reddish brown in color with yellowish orange clitellum, squarish toward posterior end. Setae lumbricin. First dorsal pore 4/5 or 5/6. Clitellum XXII-XXVII, saddle-shaped. Tubercula pubertatis XXIII-XXVI. Male clefts paired in lateral margin of XIII. Female pores paired, medio-ventral in XIV. Spermathecal pores two pairs in 9/10 and 10/11, dorsolateral. Spermathecae small, adiverticulate. Calciferous sacs in X. Nephridia holoic.

Description: Length 44-63 mm, diameter 2-4 mm. Segment number 79-95. Body squarish toward posterior end. Tail easily broken off. Prostomium epilobous or zygolobous. First dorsal pore 4/5 or 5/6. Clitellum XXII-XXVII, saddle-shaped, setae present. Tubercula pubertatis XXIII-XXVI. Setae lumbricin (eight setae per segment), closely paired, ab < cd, aa = bc, dd about 0.5 body circumferences. Male clefts paired in lateral margin of XIII (Fig. 3A). Female pores paired, medio-ventral in XIV, each medial to seta a. Spermathecal pores two pairs in 9/10 and 10/11 (Fig. 3B), dorsolateral, distance between paired pores shorter than dd. Preserved specimens reddish brown, yellowish orange around clitellum.

Septa not especially thickened. Calciferous sacs in X. Crops large in XV-XVII. Gizzard small in upper half of XVIII. Intestine origin in XVIII. Esophageal hearts VII-XI. Extra-esophageal vessels joining dorsal vessel in XII. Nephridia holoic. Spermathecae small, two pairs in X and XI (Fig. 3C). Ampulla round, sessile, white, about 0.53 mm wide, adiverticulate. Accessory glands absent. Holandric. Seminal vesicles paired in XI and XII (Fig. 3C), small. Ovaries in XIII. Prostate glands absent.

Specimens examined: Fifteen mature (clitellate) specimens collected from Shalihsien Stream at an elevation of around 700 m, Tungpu, Nantou Co., Taiwan on 24 Mar. 2000 by M. H. Shen, R. C. Jang and H. P. Chen (coll. no. 2000-32-Shen).

Remarks: According to Gates (1972), atypical mitoses in testes of *E. tetraedra* were recognized as early as 1894. Also, sperm are phagocytized by lymphocytes in the seminal vesicles and/or the coelom. Its chromosome number, $2n = 72$, is presumably tetraploid, and

the reproduction is obligatory parthenogenetic (Muldal, 1952). This species is highly polymorphic due to parthenogenetic degeneration (Gates, 1972).

*E. tetraedra* dwells in springs, lakes, mountain torrents, and swampy soil (Gates, 1972). This species is mainly distributed in the temperate zone. Gates (1972) considered that the colonization by this earthworm has largely paralleled colonization by Europeans, such as the cases of hill resorts of India, Australia, and New Zealand, and islands such as the Hebrides. However, further investigation is needed to find whether human transportation or some other means such as by migratory birds (J.-H. Chen, personal communication) might be involved in the occurrence of this temperate species in the mountain streams of subtropical Taiwan.

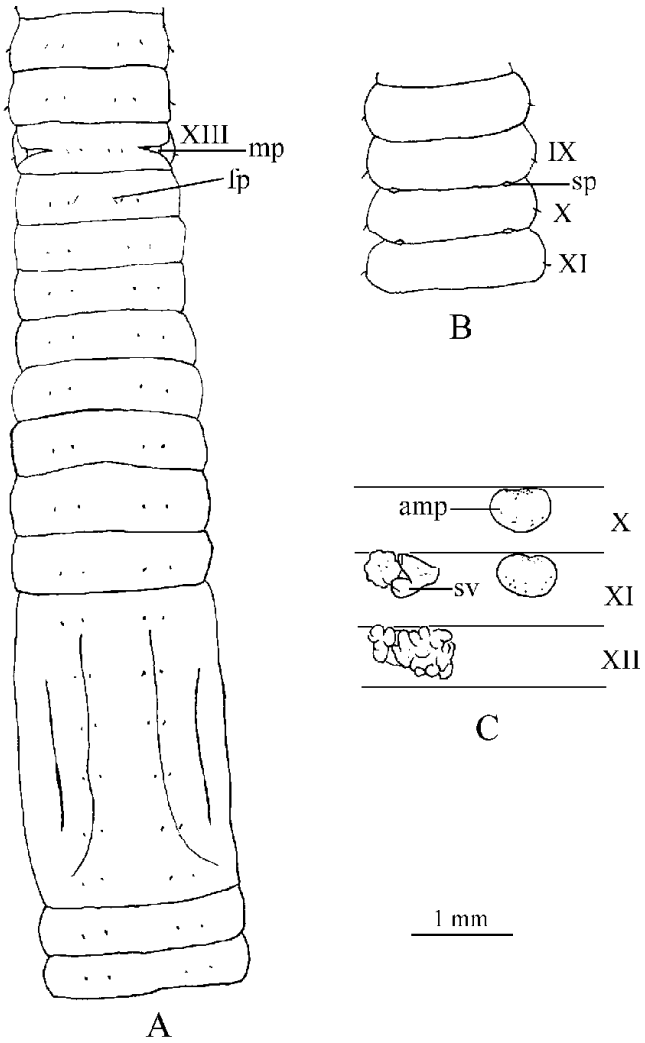


Fig. 3. *Eiseniella tetraedra* (Savigny, 1826). A: Ventral view of preclitellar and clitellar region (fp: female pore; mp: male pore). B: Dorsal view of spermathecal pore region (sp: spermathecal pore). C: Dorsal view of right spermathecae (amp: ampulla) and seminal vesicles (sv).

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# 台灣三種新紀錄蚯蚓：潮間泮蚓 *Pontodrilus litoralis* (Grube, 1855)，霍氏腔環蚓 *Metaphire houlleti* (Perrier, 1872) 以及紅釣蚓 *Eiseniella tetraedra* (Savigny, 1826)

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## 摘　　要

本文描述三種台灣新紀錄蚯蚓：潮間泮蚓 *Pontodrilus litoralis* (Grube, 1855)，霍氏腔環蚓 *Metaphire houlleti* (Perrier, 1872)，以及紅釣蚓 *Eiseniella tetraedra* (Savigny, 1826)。*P. litoralis* 採自澎湖及台灣西南海岸，其為小型蚯蚓，棲息於潮間帶。*M. houlleti* 採自屏東，其為中型蚯蚓，具三對受精囊，屬於 *Metaphire* 屬之 *houlleti* 種群。*E. tetraedra* 採自台灣中部沙里仙溪，其為源於溫帶之蚯蚓，棲息於水域或潮濕環境。

關鍵詞：潮間泮蚓、霍氏腔環蚓、紅釣蚓、蚯蚓、台灣。

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