

**Occurrence of the Luminous Earthworm *Microscolex
phosphoreus* (Dugès, 1837) in Taiwan**

台灣新紀錄種發光蚯蚓燐微蠕蚓

***Microscolex phosphoreus* (Dugès, 1837)**

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Abstract

This paper describes the luminous earthworm *Microscoclex phosphoreus* (Dugès, 1837) as a new record from Taiwan. Its bioluminescence is only visible in the dark. Now distributed globally, the species is a small earthworm probably originated from southern South America.

Key words: *Microscoclex phosphoreus*, bioluminescence, earthworm, Taiwan

摘要

本文描述一新紀錄種發光蚯蚓磷微蠕蚓*Microscoclex phosphoreus* (Dugès, 1837)。其為小型蚯蚓，屬於棘蚓科 (Acanthodrilidae) 微蠕蚓屬 (*Microscoclex*)，原產地可能為南美溫帶地區。所發出之光微弱，僅於暗處可見。

關鍵詞：磷微蠕蚓、生物發光、蚯蚓、台灣

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Introduction

Types of *Microscoclex phosphoreus*, described by Dugès (1837) as *Lumbricus phosphoreus*, were from greenhouses in Montpellier, France. As stated in Gates (1972), the original home of this species has long been supposed to be in some part of

southern South America. In addition, as late as 1898 in France, the species was said to be present only in the vicinity of gardens with recently introduced, rare plants (Gates 1972). It is believed that the genus *Microscoclex* originates from South America since quite a few species of this genus are endemics there (Beddard 1895, 1899;

Michaelsen 1903, 1911; Lee 1994; Blakemore 2010).

Microscolex phosphoreus is a small earthworm measuring 10–35 mm in length and 1–1.5 mm in width (Gates 1972). It emits a green light only visible in the dark. Skowron (1928) observed great quantities of *M. phosphoreus* in a passage not used for over two years in a coal mine near Cracow, Poland. Skowron (1928) states that "Walking in the darkness, hundreds of luminous points were seen, glowing brilliantly after every step". According to our field observations, *M. phosphoreus* is more easily seen after the rain under a lower temperature (10–19.5 °C). The entire or parts of its body can be luminescent. The worm also exudes a fluorescent fluid and this fluid can be seen in place where the worm has just stayed. Skowron (1926, 1928) called this fluid luminous slime and the slime is discharged on mechanical, chemical or electrical stimulation. The slime is composed chiefly of round cells with numerous light-refracting granules, and if kept moist, the slime continues to glow for about half an hour (Skowron 1926, 1928). Skowron (1928) points out that the granules are of greenish color and are the real luminous material, a disproof of the possibility of infection or symbiosis with luminous microorganisms. It was also found by Skowron (1928) that the

light produced by the granules is fainter and of shorter duration both in higher (40–50 °C) and lower (-5–10 °C) temperatures. Later as reported by Wampler (1982), the luminescent fluid is coelomic fluid and the granule-filled cells are coelomocytes with all of the components of the bioluminescence system packaged within.

It is hypothesized that earthworm bioluminescence is a defense mechanism serving as a warning of unpalatability or as a means of startling subterranean, presumably negatively phototactic predators (Gilchrist 1918; Jamieson and Wampler 1979; Sivinski and Forrest 1983). In Sivinski and Forrest's (1983) experiments, *M. phosphoreus* was palatable to an earwig and a lycosid spider, both were nocturnal predators collected within meters of where the worms were found on the surface after a heavy rain. Although worms managed to smear glowing fluid on their attackers and these predators' "jaws" were frequently alight, worms were consumed without hesitancy (Sivinski and Forrest 1983). However, a subterranean carnivore, the mole cricket, reacted to luminescence. While one cricket quickly ate a *M. phosphoreus*, another dropped its prey as it began to luminesce, rapidly withdrew 2 cm and rubbed its head with the forelegs. The worm managed to crawl 9 cm before being re-attacked and luminous fluid was emitted

whereupon the cricket withdrew 2 cm (Sivinski and Forrest 1983). The results suggest that earthworms are palatable but that a predator can be startled by annelid bioluminescence, particularly if its hunting behaviors evolved underground in darkness (Sivinski and Forrest 1983).

Besides *M. phosphoreus*, there is another luminous earthworm, *Pontodrilus litoralis* (Grube, 1855), reported from Taiwan and its adjacent islands (Shen *et al.* 2005, 2015; Chang *et al.* 2012). The luminescence system of *P. litoralis* is also contained within granule-filled coelomic cells (Wampler and Jamieson 1986). In fact, considerable similarity was found in the physiology and biochemistry of the bioluminescence in all the bioluminescent earthworms examined to date: the bioluminescence system is contained in coelomic cells and is specifically associated with a granule-filled cell type which are morphologically similar in these various species (Benham 1899; Gilchrist 1918; Skowron 1926; Jamieson and Wampler 1979; Wampler and Jamieson 1980, 1986; Wampler 1982). *P. litoralis* and *M. phosphoreus* are two earthworms among a total of 58 luminous terrestrial animals described from Japan (Oba *et al.* 2011). Both are also peregrine species with a difference in distribution. *P. litoralis* inhabits warmer

regions while *M. phosphoreus* dwells in cooler areas.

Microscolex phosphoreus is a cosmopolitan earthworm and has been reported from France (Dugès 1837), Ireland [specimens were discovered some years before 1843 in the bogs of the south of Ireland according to Johnston (1865)], Italy (Rosa 1887; Michaelsen 1910), Argentina (Rosa 1890), Algeria (Beddard 1892), USA (Eisen 1893, 1894, 1900; Smith 1896; Gates 1954), New Zealand (Beddard 1894), Mexico (Eisen 1896, 1900), UK (Beddard 1899; Sherlock 2012), Australia (Michaelsen 1907; Blakemore 2010), India (Stephenson 1914), Southern Europe, Poland (Skowron 1928), Japan (Yamaguchi 1935; Kobayashi 1941), Israel (Černovítov 1940), Turkey (Omodeo 1952; Csuzdi *et al.* 2007; Pavlíček *et al.* 2010), South Africa (Gates 1954, 1972), China (Xu *et al.* 1990), and recently Siberia, Russia (Rota *et al.* 2018). Its distribution suggests a climatic restriction to subtropical and warmer temperate-zone areas (Gates 1972). The combined morphological and genetic evidence presented by Rota *et al.* (2018) based on material and/or COI (barcode) sequences from a total of ten countries suggests cryptic diversity in *M. phosphoreus* since at least four of the found clades should be reclassified as separate species.

The following description is based on seven preserved specimens collected from Sun-Link-Sea Forest Recreation Area, Nantou, Taiwan and deposited at the Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan.

Microsclex phosphoreus
(Dugès, 1837)

- Lumbricus phosphoreus* Dugès, 1837: 17, 24; Johnston, 1865: 62.
Microsclex modestus Rosa, 1887: 1; 1890: 514; Beddard, 1895: 461.
Photodrilus phosphoreus – Giard, 1887: 872.
Microsclex algeriensis Beddard, 1892: 29; 1895: 462.
Deltania troyeri Eisen, 1893: 251; 1894: 33; 1900: 159.
Deltania benhami Eisen, 1893: 252; 1894: 37.
Microsclex novae-zelandiae Beddard, 1894: 33; 1895: 463; Michaelsen, 1900: 139.
Microsclex troyeri – Beddard, 1895: 467; Michaelsen, 1900: 141.
Microsclex benhami – Beddard, 1895: 467; Michaelsen, 1900: 141.
Pontodrilus phosphoreus – Beddard, 1895: 472.
Deltania troyeri var. *crassa* Eisen, 1896: 169.

- Deltania troyeri* var. *lagunae* Eisen, 1896: 170.
Microsclex hempeli Smith, 1896: 407; Michaelsen, 1900: 140.
Microsclex phosphoreus – Michaelsen, 1899: 217; 1900: 141; 1907: 148; 1910: 66; Stephenson, 1914: 338; 1923: 164; Yamaguchi, 1935: 200; Černosvitov, 1940: 440; Kobayashi, 1941: 263; Omodeo, 1952: 2; Gates, 1954: 243; 1972: 35; 1982: 31; Easton, 1981: 45; Csuzdi *et al.*, 2007: 358; Blakemore, 2010: 205; Pavlíček *et al.*, 2010: 1998; Oba *et al.*, 2011: 773, 782; Sherlock, 2012: 40.
Microsclex wuxiensis Xu *et al.*, 1990: 28.

Materials examined. — One mature specimen collected on the 3 May 2016 along the roadside (elevation 1678–1693 m) near Sun-Link-Sea Hotel in the Sun-Link-Sea Forest Recreation Area, Nantou County by C. L. Lin (coll. no. 2016-9); one specimen (head macerated) collected on the 11 July 2016 along Chinglong Trail (elevation 1633–1652 m) in the Sun-Link-Sea Forest Recreation Area, Nantou County by C. L. Lin (coll. no. 2016-31); three mature specimens (one dissected) collected on the 6 December 2019 along Chinglong Trail (elevation 1633–1652 m) in the Sun-Link-Sea Forest Recreation Area, Nantou County by Y. F. Lin (coll. no.

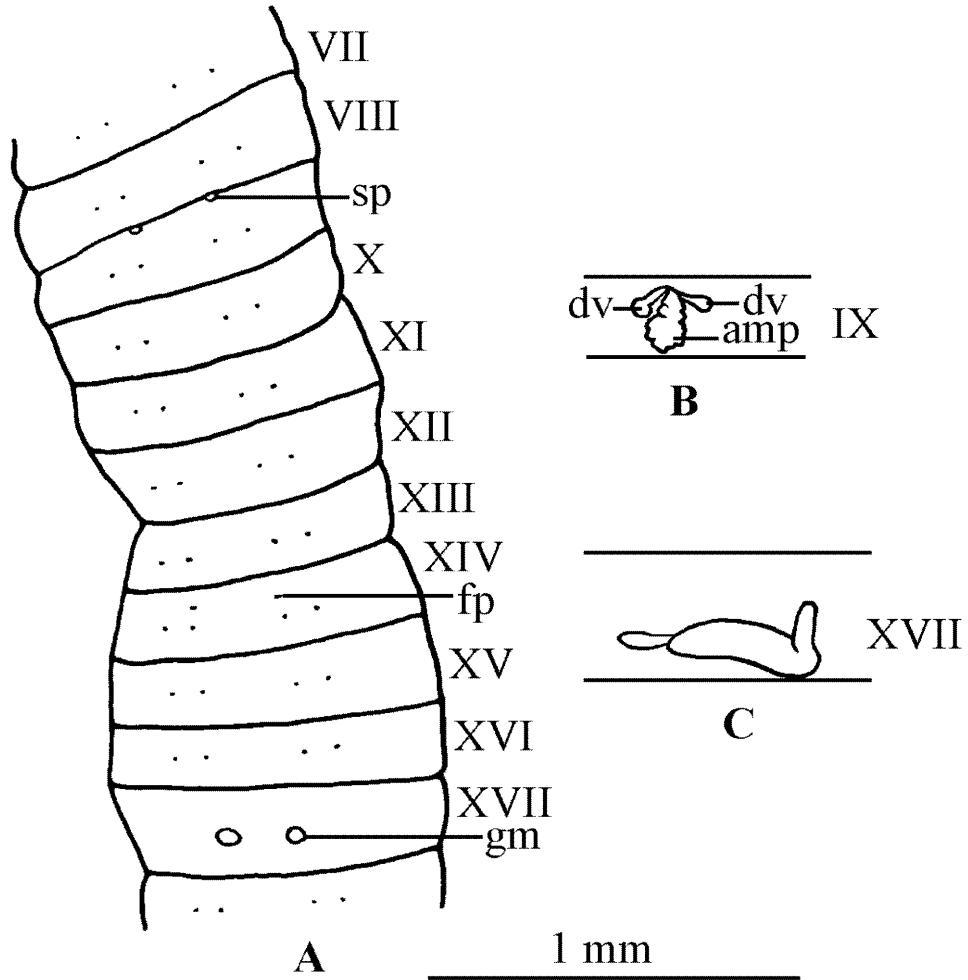


Fig. 1. *Microscolex phosphoreus* (Dugès): A, ventral view of preclitellar and clitellar regions (sp, spermathecal pore; fp, female pore; gm, genital marking); B, dorsal view of right spermatheca (amp, ampulla; dv, diverticulum); C, dorsal view of right prostate gland.

2019-45); one specimen collected on the 14 March 2020 along Chinglong Trail (elevation 1633–1652 m) in the Sun-Link-Sea Forest Recreation Area, Nantou County by J. C. Chen (coll. no. 2020-1); one mature specimen collected on the 15 March 2020 along Chinglong Trail (elevation 1633–1652 m) in the Sun-Link-Sea Forest Recreation Area, Nantou County by J. C. Chen (coll. no. 2020-2).

Description. — Length (clitellates) 14–34 mm, weight 0.01–0.03 g, diameter 0.97–1.28 mm. Segment number 72–76. Prostomium epilobous. Setae lumbricine (eight setae per segment), minute. Nephropores in II–IV in line with seta d, from 4/5 medial to seta c, conspicuous on the clitellum. Dorsal pores absent. Clitellum annular, XIII–XVII. Spermathecal pores one pair in 8/9, in line with seta a. Male pores not visible. Genital markings a pair of small, circular tubercles in XVII (Fig. 1A). Female pores minute, one pair anterior to seta a in XIV (Fig. 1A). Live worms translucent with orange clitellum. Preserved specimens unpigmented with clitellum whiter than rest of the body.

Septa 5/6–11/12 thin, 12/13–15/16 membranous. Gizzard weak in V. Calciferous glands absent. Intestine enlarged from XVI. Hearts paired in X–XII. Nephridia holoic, vesiculate. Spermathecae small, one pair in

IX. Ampulla pear-shaped, 0.18 mm long and 0.13 mm wide, with two small diverticula on opposite sides, each about 0.1 mm in length (Fig. 1B). Ovaries follicular, palmate in XIII. Holandric. Seminal vesicles small, oval in XI–XII. Prostate glands one pair confined to XVII, each elongate, tubular, 0.5–0.7 mm in long axis and about 0.15 mm in short axis (Fig. 1C).

Remarks. — The characters of *Microscolex wuxiensis*, the so-called “a new fluorescent earthworm” from Wuxi, Jiangsu, central China described by Xu *et al.* (1990), agree mostly with the morphology of *M. phosphoreus* and thus, *M. wuxiensis* is a junior synonym. The site where these specimens were found, sewer outside kitchen or pigsty (Xu *et al.* 1990), is an apparent indication of introduction. Xu *et al.* (1990) mentioned that the lower the temperature was, the more active this species was, and the worms disappeared when temperature reached 20 °C. This finding is consistent with our observations.

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