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A re-examination of the pheretimoid earthworms reported in James *et al.* (2005), false synonymy between *Drawida barwelli* (Beddard, 1886) and *Drawida beddardi* (Rosa, 1890) and comments on recent publications on East and Southeast Asian earthworms

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Abstract. A re-examination of the "known species" of the pheretimoid earthworms reported in James *et al.* (2005) from southern Taiwan results in the discovery of four new species of the genus *Amynthas*, namely *A. chungchi* sp. nov., *A. kendingensis* sp. nov., *A. jioupengensis* sp. nov. and *A. lilis* sp. nov. All these new species were wrongly identified as *A. corticis* (Kinberg, 1867). Additionally, five specimens of *A. nanrenensis* James, Shih & Chang, 2005 and three specimens of *Metaphire houlleti* (Perrier, 1872) are found to be misidentified as *A. corticis* and *M. californica* (Kinberg, 1867), respectively, by James *et al.* (2005). *Drawida beddardi* (Rosa, 1890) is a false synonym of *D. barwelli* (Beddard, 1886), as the former has simple and straight sperm ducts and spermathecal ducts, while the latter has long and coiled ones. Both *Amynthas triastriatus usualis* Dong, Jiang, Yuan, Zhao & Qiu, 2020 and *Metaphire remanens* Jin, Jiang, Li & Qiu, 2022 are nomenclaturally unavailable names, since they were published in electronic journals without ZooBank registration, and there is no explicit statement on the deposition of the type material for each of the taxa. *Metaphire guillelmi* (Michaelsen, 1895) listed in Nguyen *et al.* (2016, 2020) is a misidentification and needs to be re-examined. Errors and problems identified in recent publications on East and Southeast Asian earthworms are discussed.

Keywords. Earthworm, *Amynthas*, new species, taxonomy, Taiwan.

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Introduction

James *et al.* (2005) described seven new earthworm species of the genus *Amynthas* from southern Taiwan. On 3 February 2005, HPS inspected the holotypes of these species deposited at the National Museum of Natural Science, Taichung, Taiwan. The record of this visit is traceable in the guestbook of the museum. It was found that among these species, five should be transferred to the genus *Metaphire* and furthermore, only three are valid, while the others are synonyms of other species (Tsai *et al.* 2009; Shen *et al.* 2016, 2019).

Recently, HPS examined the remaining pheretimoid earthworm specimens reported in James *et al.* (2005) under the following names: *Amynthas corticis* (Kinberg, 1867), *A. gracilis* (Kinberg, 1867), *A. incongruus* (Chen, 1933), *A. robustus* (Perrier, 1872), *Metaphire houlleti* (Perrier, 1872), *M. californica* (Kinberg, 1867), and *Polypheretima elongata* (Perrier, 1872). All these are peregrine species. The examination resulted in the discovery of four new species of the genus *Amynthas*, namely *A. chungchi* sp. nov., *A. kendingensis* sp. nov., *A. jioupengensis* sp. nov. and *A. lilis* sp. nov. All of them were wrongly identified as *A. corticis* by James *et al.* (2005). With the addition of these four new species in the genus *Amynthas* (this study) and the recently described *Amynthas popi* Shen & Chang, 2025 from northern Taiwan (Shen & Chang 2025), and confirmation of the validity and of the occurrence of *A. masatakae* (Beddard, 1892) in Taiwan (Chang *et al.* 2024), the number of earthworm species in Taiwan increases to 121.

As stated in Shen (2018a) and as illustrated above, earthworm taxonomy is confusing and chaotic. This is mainly due to the overwhelming numbers of species, synonyms, misidentifications and false synonymies. For example, *Drawida beddardi* (Rosa, 1890) from Myanmar has long been erroneously considered synonymous with *D. barwelli* (Beddard, 1886) from the Philippines (Beddard 1895; Michaelsen 1900; Stephenson 1923; Blakemore *et al.* 2014; Misirlioğlu *et al.* 2023). Gates (1929) included *D. beddardi* in *D. barwelli*, but later (Gates 1962) maintained these two species separated and stated that *D. barwelli* had never been found in Burma (Myanmar). Also, Easton (1984) excluded *D. beddardi* as a synonym of *D. barwelli*. Shen *et al.* (2015: 434–435) indicated that the sperm ducts of *D. barwelli* are thin, delicate and much coiled, but those of *D. beddardi* are quite short and not twisted. Shen (2018b) further indicated that *D. barwelli* has long, slender, coiled and contorted spermathecal ducts, while those of *D. beddardi* are simple and quite straight. Shen (2018b) also elaborated how Beddard (1888, 1891) mistook *D. beddardi* for *D. barwelli*, which led to false synonymy afterward.

The cases mentioned above are just some examples of the errors and improper taxonomic treatments we noticed when reviewing the recent literature regarding earthworms in East and Southeast Asia, specifically James *et al.* (2005), Nguyen *et al.* (2016, 2020, 2023), Dong *et al.* (2019, 2020), Yuan *et al.* (2019), Sun *et al.* (2021) and Jin *et al.* (2022). These examples demonstrate an urgent need for correct information and a document that summarizes it. Thus, the main objective of this study is to serve as such a document for future research and to describe the new species that emerged from re-inspecting some of the specimens involved.

Material and methods

Repository and morphological examination

The specimens with the following catalogue numbers as reported in James *et al.* (2005) and deposited at the National Museum of Natural Science, Taichung, Taiwan (NMNS) were investigated with a Leica MZ6 stereo microscope: NMNS 4054-003, NMNS 4054-012, NMNS 4054-031, NMNS 4054-032, NMNS

4054-033, NMNS 4054-034, NMNS 4054-035, NMNS 4054-036, NMNS 4054-037, NMNS 4054-038, NMNS 4054-039, and NMNS 4054-040. Four of the seven specimens in the bottle labeled with catalogue no. NMNS 4054-003, one of the six specimens in the bottle labeled with catalogue no. NMNS 4054-031, two of the 12 specimens in the bottle labeled with catalogue no. NMNS 4054-032, and the single specimen in the bottle labeled with catalogue no. NMNS 4054-033 had been dissected prior to this examination. The remaining three specimens under catalogue no. NMNS 4054-003, one of the other five specimens under catalogue no. NMNS 4054-031, and two of the six specimens under catalogue no. NMNS 4054-034 were dissected dorsally by HPS. All figures were edited using Adobe Photoshop CC 2019 ver. 20.0.6.

DNA barcoding analyses

COI sequences used in Dong *et al.* (2020) and Sun *et al.* (2021) were compared with available sequences via BLAST (Camacho *et al.* 2009; https://blast.ncbi.nlm.nih.gov).

Abbreviations used in text and figures

Morphology

ag = accessory gland
amp = ampulla
dv = diverticulum
gp = genital papilla
mp = male porophore
pd = prostatic duct
sp = spermathecal pore

Institutions

BMNH = Natural History Museum, London, UK
NMNS = National Museum of Natural Science, Taichung, Taiwan

Results

On recent publications on East and Southeast Asian earthworms

In Nguyen *et al.* (2016) and in the "Introduction" section of Nguyen *et al.* (2022: 42), five species of *Drawida*, including *D. beddardi* but not *D. barwelli*, were listed from Vietnam. The type locality of *D. beddardi* is somewhere in Myanmar (Rosa 1890), not Manila, Philippines as noted in Nguyen *et al.* (2016: 77). Also, the type material of *D. beddardi* is missing (Gates 1972; Blakemore 2010), and is not at the Natural History Museum in London as mentioned in Nguyen *et al.* (2016: 77). Actually, Manila, Philippines is the type locality of *D. barwelli* (Beddard 1886), and types of *D. barwelli* were said to be at the Natural History Museum, London (see Blakemore 2010). Apparently, Nguyen *et al.* (2016) got *D. barwelli* and *D. beddardi* mixed up. According to Gates (1972: 246) and Nguyen *et al.* (2016: 77), *D. beddardi* is distributed in Myanmar and Vietnam. It is possible that this species is found in other Southeast Asian countries. Regarding *D. barwelli*, it is a peregrine earthworm and has been reported from Southeast Asia, Pacific Islands, Central America and Australia (see Shen 2018b). The distributional range of *D. barwelli* has been confounded with that of *D. beddardi* by Blakemore (2010), Blakemore & Kupriyanova (2010) and Blakemore *et al.* (2014), since the two species were wrongly synonymized by these authors. Both are tropical species and neither has been recorded from Japan (Easton 1981; Ishizuka 1999; Blakemore 2003, 2012; Blakemore *et al.* 2014). The record of "*Drawida* cf. *barwelli*" from Japan reported by Blakemore *et al.* (2010) was a misidentification of *D. eda* Blakemore, 2010 as indicated in Blakemore (2012). As to "*Drawida* cf. *barwelli*" found in Korea (Blakemore *et al.* 2012, 2014), Shen *et al.* (2018: 306) pointed out that it is a misidentification of *D. eda* based on morphological and molecular evidence. Blakemore (2010), Blakemore & Kupriyanova (2010) and Blakemore *et al.* (2010, 2014) also erroneously synonymized *D. glabella* Chen, 1938 from Hainan Island, China with *D. barwelli*. Shen

et al. (2018: 306) listed quite a few morphological differences between these two species and stated that *D. glabella* should be recognized as a valid species, not as a synonym of *D. barwelli*. *Drawida barwelli* has been collected from central, southern and eastern Taiwan, and has never been found in northern Taiwan (Shen 2018b). Shen (2018a, 2018b) concluded that the island of Taiwan should be the northernmost range of *D. barwelli*, since this species is absent from the earthworm fauna of adjacent Kinmen (Chang *et al.* 2012), Matsu (Shen *et al.* 2015), China and Japan. Consequently, records of *D. barwelli* found north of Taiwan should be regarded as misidentifications. As regards *D. beddardi*, it has never been found in Taiwan. Hence, its distribution should be further south than the one of *D. barwelli*. The aforementioned misidentification and mis-synonymization have blurred the actual distributional range of the species, and provoke not only taxonomic but also distributional confusion (Shen 2018a).

On the other hand, errors and problems continue as well in recent publications on pheretimoid earthworms (Nguyen *et al.* 2016, 2020, 2023; Dong *et al.* 2019, 2020; Yuan *et al.* 2019; Sun *et al.* 2021; Jin *et al.* 2022). *Metaphire guillelmi* (Michaelsen, 1895) listed in Nguyen *et al.* (2016, 2020) is a misidentification, as pointed out in Shen (2018a) and confirmed through the key by Nguyen *et al.* (2020). As stated by Shen (2018a), *M. guillelmi* is a warm-temperate species distributed in north and central China and was not found in Matsu (Shen *et al.* 2015), not to mention Taiwan; it is therefore unlikely for *M. guillelmi* to be present in Vietnam. Specimens collected from Vietnam and listed in the checklist of Nguyen *et al.* (2016) should be reinvestigated; they are probably misidentifications (Shen 2018a). Nonetheless, Nguyen *et al.* (2020) continued to include *M. guillelmi* in the Vietnamese earthworm fauna. In the key provided by Nguyen *et al.* (2020: 235), *M. guillelmi* is categorized among species with two spermathecal pores in 6/7/8 (note: "two spermathecal pores" should be corrected to "two pairs of spermathecal pores"). Evidently, these authors misidentified their specimens, since *M. guillelmi* has three pairs of spermathecal pores in 6/7–8/9 (Michaelsen 1895; Shen 2018a: table 6). Also in Nguyen *et al.* (2020), there are no accession numbers for sequences obtained from GenBank. Thus, the source of the material is unknown and the identification is doubtful.

Misidentification is not uncommon in GenBank (see Chang *et al.* 2024). In table 1 of Dong *et al.* (2019), a sequence with accession number LC458750 was claimed to belong to *Amynthas formosae* (Michaelsen, 1922) from India. However, this species is not an *Amynthas* species but a member of the *Metaphire formosae* species group, which is endemic to Taiwan and the Southern Ryukyus (Chang *et al.* 2008, 2014; Shen *et al.* 2022). *Amynthas carnosus* (Goto & Hatai, 1899) with accession number KF205962 from Hainan, southern China listed in table 1 of Dong *et al.* (2019) is also wrongly identified since areas south of Matsu (including Taiwan) should be excluded from the distributional range of *A. carnosus* as detailed in Shen (2018a: 324–325). What is more, the so-called *A. carnosus* with accession number KF205962 appeared throughout all three tables in Sun *et al.* (2021). Actually, we found no sequences similar to these two sequences or to another sequence claimed to belong to *A. corticis* with accession number KF205966 from Hainan, southern China listed in table 1 of Dong *et al.* (2019). These species without comparable DNA barcodes could be new species. Accordingly, subsequent molecular analysis together with genetic or evolutionary inferences drawn from these incorrect data is problematic. Chang *et al.* (2024) revealed that sequences analyzed by Dong *et al.* (2020) do not belong to *A. triastriatus* (Chen, 1946) but to *A. masatakae*. The former is an earthworm endemic to China, while the latter is a peregrine species. The population differentiation, lineage distribution, divergence time estimate and colonization history proposed by Dong *et al.* (2020) are unfounded, since the distribution and dispersal of peregrine species are generally bound up with human intervention. In fact, as indicated by Chang *et al.* (2024), *A. masatakae* has been misidentified as *A. triastriatus* and *A. gracilis* since Huang *et al.* (2007). All the sequences with erroneous identity used by Dong *et al.* (2019) and Sun *et al.* (2021) are summarized in Table 1 in this study.

Table 1. Erroneous sequence identity used in Dong *et al.* (2019) and Sun *et al.* (2021). [1] sequence used in both Dong *et al.* (2019) and Sun *et al.* (2021); [2] sequence used in Dong *et al.* (2019); [3] sequence used in Sun *et al.* (2021); [4] KF205962 is most similar to *Amynthas hainanicus* JX315409 (88.7% identical); [5] KF205966 is most similar to *Metaphire yuhsi* AY739319 (87.1% identical); [6] LC458750 is most similar to five sequences from the same study with the same incorrect identification (99–100% identical).

GenBank accession no.	Locality	Identification in Dong *et al.* (2019) and/or Sun *et al.* (2021)	Result of sequence comparison
KF205962[1]	Hainan, southern China	*Amynthas carnosus* (Goto & Hatai, 1899)	No similar sequences found[4]
KF205966[2]	Hainan, southern China	*Amynthas corticis* (Kinberg, 1867)	No similar sequences found[5]
LC458750[2]	India	*Amynthas formosae* (Michaelsen, 1922)	No similar sequences found[6]
AB542533[3]	Japan	*Amynthas robustus* (Perrier, 1872)	Matches the sequences of *Amynthas masatakae* (Beddard, 1892)
EF077575[3]	China	*Amynthas gracilis* (Kinberg, 1867)	Matches the sequences of *Amynthas masatakae* (Beddard, 1892)
KF179569[3]	China	*Amynthas triastriatus* (Chen, 1946)	Matches the sequences of *Amynthas tralfamadore* Blakemore, 2012, a junior synonym of *A. masatakae*, as reported in Chang *et al.* (2024)

Apart from misidentification, inadequate literature review is rampant in recent publications on earthworms. For example, errors caused by inadequate literature review are ubiquitous throughout Yuan *et al.* (2019). The first reference documenting the earthworms from Yunnan, China is Stephenson (1912) which was then followed by Michaelsen (1927). However, these two papers are missing in Yuan *et al.* (2019). The two new species, *Pheretima browni* and *P. divergens yunnanensis*, described in Stephenson (1912) are actually synonyms of *Metaphire californica* and *Amynthas corticis*, respectively (Gates 1972). The type specimen of *P. browni*, deposited at the Natural History Museum, London (BMNH 1925:5:12:130), was examined by HPS in 2014. Stephenson (1912) also described *Pheretima hawayana* (Rosa, 1891) (= *A. gracilis*) from Yunnan. Michaelsen (1927) characterized the following species collected from Yunnan: *Drawida japonica* (Michaelsen, 1892), *P. hawayana* (= *A. gracilis*), *P. choeina* and *P. modesta*. The latter two species were described by Michaelsen (1927) as new to science, but *P. modesta* is synonymous with *M. californica* (Gates 1972). Yuan *et al.* (2019) listed earthworms recorded in Yunnan, China in their table 1 without citing Stephenson (1912) or Michaelsen (1927). Likewise, by cause of insufficient literature review, *Drawida sulcata* Zhong, 1986 listed in table 1 of Yuan *et al.* (2019) should be replaced with *D. zhongi* Blakemore, 2006 since it is a primary homonym of *D. sulcata* Michaelsen, 1907, and a replacement name has been given (Blakemore *et al.* 2014). Additionally, *Amynthas parvus* (Chen & Xu, 1977) listed in table 1 of Yuan *et al.* (2019) should be substituted with *Metaphire mediparva* (Nakamura, 1999). This species, described in Chen & Xu (1977) as having small penes, should belong to the genus *Metaphire* instead of *Amynthas*. As a result, *Pheretima parva* Chen & Xu, 1977 is a junior homonym of *Perichaeta parva* Ude, 1893, since the latter was assigned to *Metaphire* by Sims & Easton (1972). Nakamura (1999) substituted *Pheretima mediparva* for *P. parva* Chen & Xu, 1977. Other than being short of literature review, the specific name, *Metaphire areniphilus* (Chen & Xu, 1975), listed in table 1 of Yuan *et al.* (2019), should be corrected to *M. areniphila*. Acccording to Chen *et al.* (1975), this species

Table 2. Errors in table 1 of Yuan *et al.* (2019).

Taxon name	Correction
Amynthas choeinus (Michaelsen, 1927)	Michaelsen (1927) first published this species from Yunnan, China and should be added in the references
Amynthas corticis (Kinberg, 1867)	Stephenson (1912) first reported the occurrence of this species in Yunnan, China and should be added in the references
Amynthas gracilis (Kinberg, 1867)	Both Stephenson (1912) and Michaelsen (1927) should be added in the references
Amynthas parvus (Chen & Xu, 1977)	The name should be substituted with *Metaphire mediparva* (Nakamura, 1999)
Metaphire areniphilus (Chen & Xu, 1975)	The name should be corrected to *Metaphire areniphila* (Chen & Xu, 1975)
Metaphire californica (Kinberg, 1867)	Both Stephenson (1912) and Michaelsen (1927) should be added in the references
Aporrectodea trapezoides (Dugès, 1828)	The paper of Yuan *et al.* (submitted) is missing in the references section and should be added
Bimastos rubidus (Savigny, 1826)	The paper of Yuan *et al.* (submitted) is missing in the references section and should be added
Drawida japonica (Michaelsen, 1892)	Michaelsen (1927) first reported the occurrence of this species in Yunnan, China and should be added in the references
Drawida sulcata Zhong, 1986	The name should be replaced with *Drawida zhongi* Blakemore, 2006
Pontoscolex corethrurus (Müller, 1857)	The paper of Yuan *et al.* (submitted) is missing in the references section and should be added

has small penes and was originally published as "*Pheretima areniphila*". All the errors in table 1 of Yuan *et al.* (2019) are summarized in Table 2 in this study.

Meanwhile, both *Amynthas triastriatus usualis* Dong, Jiang, Yuan, Zhao & Qiu, 2020 and *Metaphire remanens* Jin, Jiang, Li & Qiu, 2022 are nomenclaturally unavailable names since the original descriptions of the two taxa fail to meet the criteria for electronic publication: to be considered published, a work issued and distributed electronically must be registered in the *Official Register of Zoological Nomenclature* (ZooBank) and contain evidence in the work itself that such registration has occurred (ICZN 2012: amended Article 8.5.3.). Moreover, there is no explicit statement on the deposition of the type material for each of the taxa (ICZN 1999: Article 16.4.2.). In addition, as mentioned previously, specimens described under this unavailable name, *A. triastriatus usualis*, actually belong to *A. masatakae* (Chang *et al.* 2024). Also, *Amynthas scaberulus* Sun & Jiang, 2021 has been proved to be a junior synonym of *A. masatakae* (Chang *et al.* 2024). As demonstrated in Chang *et al.* (2024), misidentification together with inadequate literature review resulted in the publication of a peregrine species, *A. masatakae*, as a taxon new to science by Dong *et al.* (2020) and Sun *et al.* (2021). Furthermore, GenBank accession numbers are entirely lacking for sequences analyzed in Jin *et al.* (2022), and thus their results are not reproducible.

Nguyen *et al.* (2023) revised the *Metaphire peguana* species group (Sims & Easton 1972) through molecular analysis and included seven species and subspecies in this species group. However, the distribution of *M. peguana* and *M. bahli* (members of the *M. peguana* species group) in Japan reported in Nguyen *et al.* (2023) is an error. Both are tropical species and none of them occurred in Taiwan, let alone Japan. Figure 3 in Nguyen *et al.* (2023) also shows that *M. peguana* and *M. bahli* are absent from China

Table 3. Misidentifications of the "known species" of the pheretimoid earthworms reported in James *et al.* (2005).

Catalogue no. in James *et al.* (2005)	Identification by James *et al.* (2005)	Correct identity
NMNS 4054-003	*Amynthas corticis* (Kinberg, 1867)	*Amynthas chungchi* sp. nov.
NMNS 4054-031	*Amynthas corticis* (Kinberg, 1867)	*Amynthas nanrenensis* James, Shih & Chang, 2005 (5 specimens) *Amynthas chungchi* sp. nov. (1 specimen)
NMNS 4054-032	*Amynthas corticis* (Kinberg, 1867)	*Amynthas kendingensis* sp. nov.
NMNS 4054-033	*Amynthas corticis* (Kinberg, 1867)	*Amynthas jioupengensis* sp. nov.
NMNS 4054-034	*Amynthas corticis* (Kinberg, 1867)	*Amynthas lilis* sp. nov.
NMNS 4054-039	*Metaphire californica* (Kinberg, 1867)	*Metaphire houlleti* (Perrier, 1872)

and Taiwan. The Japanese record of *M. peguana* was from Ohfuchi (1956), which documented this species found in Ishigaki Island, southern Ryukyus. Easton (1981), Ishizuka (1999) and Blakemore (2003, 2012) simply followed Ohfuchi (1956) although Gates (1972) questioned Ohfuchi's (1956) identification. Shen (2018a) pointed out that *Pheretima peguana* sensu Ohfuchi (1956) is a misidentification and named it *Amynthas ishigakiensis*. As to *M. bahli*, Gates (1972) considered that its homeland should be in Myanmar and/or Thailand or in some adjacent region. This species has never appeared in the checklist of Japanese earthworms (Easton 1981; Ishizuka 1999; Blakemore 2003, 2012). Blakemore (2016: fig. 10) also shows no record of this species in Japan, albeit his figure 10 is not 100% correct, as indicated in Shen (2018a: 327). It was stated in the "Distribution" section of *M. bahli* (Nguyen *et al.* 2023: 126): "Bangladesh, Japan, Philippines, Indonesia (Michaelsen 1922; Blakemore 2006)". Actually, Michaelsen (1922) did not mention *M. bahli* at all, and Blakemore (2006) did not include Bangladesh and Japan in the domain of *M. bahli*. The occurrence of *M. peguana* and *M. bahli* in the mainland of Japan marked in Nguyen *et al.* (2023: fig. 3) is a manifest error resulting from inadequate literature review, misquotation and lack of awareness of the concept of biogeography.

Misidentifications of the "known species" of the pheretimoid earthworms reported in James et al. (2005)

The original catalogue numbers listed in James *et al.* (2005) corresponding to the four new species, namely *Amynthas chungchi* sp. nov., *Amynthas kendingensis* sp. nov., *Amynthas jioupengensis* sp. nov. and *Amynthas lilis* sp. nov., found in this study are provided in Table 3. Besides, in the bottle labeled with catalogue no. NMNS 4054-031, one of the six specimens is found to be *A. chungchi* sp. nov., while the true identity of the other five specimens is *Amynthas nanrenensis* James, Shih & Chang, 2005 (Table 3). In conclusion, all the *A. corticis* specimens identified by James *et al.* (2005: 1023) are misidentifications. In addition, in the bottle labeled with catalogue no. NMNS 4054-039, all three specimens have three conspicuous pairs of spermathecal pores in 6/7–8/9 and C-shaped secondary male pores, which are characteristics of *M. houlleti*. However, they were misidentified as *M. californica* (Table 3). *Metaphire*

californica has two pairs of spermathecal pores in 7/8/9 and its secondary male pore is a horizontal slit (perpendicular to the anterior-posterior body axis).

Taxonomy

Class Clitellata Michaelsen, 1919
Order Opisthopora Michaelsen, 1930
Family Megascolecidae Rosa, 1891
Genus *Amynthas* Kinberg, 1867

Amynthas chungchi Shen sp. nov.
urn:lsid:zoobank.org:act:A0D05C2F-ABD1-4FC2-8D41-50360A01195D
Fig. 1

Amynthas corticis – James *et al.* 2005: 1023 (partim).

Diagnosis

Length (clitellates) 72–116 mm. Segments numbering 95–113. Setae 33–42 in VII, 43–52 in XX, 10–13 between male pores. First dorsal pore in 11/12. Clitellum XIV–XVI. Spermathecal pores four pairs in 5/6–8/9, 0.30–0.31 body circumference ventrally apart. Male pores 0.23–0.30 body circumference ventrally apart in XVIII, each with an anteromedial and a posteromedial genital papilla. Genital papillae widely paired in presetal VIII–IX or VII–IX. Additional papillae often widely paired in postsetal VIII and occasionally present in postsetal VII. Spermathecae four pairs in VI–IX. Seminal vesicles large, two pairs in XI and XII. Prostate glands large, occupying four to six segments in XV–XX. Prostatic ducts long, U-shaped in XV–XVIII or XVI–XVIII. Accessory glands sessile in preclitellar region and absent in postclitellar region.

Etymology

The species is named after Dr. Chung-Chi Hwang who helped extensively with the collection work, as mentioned in James *et al.* (2005).

Type material

Holotype

TAIWAN • clitellate (mature) specimen; Nanrenshan, Kending, Pingtung County; 22°05′03″ N, 120°50′07″ E; 150 m a.s.l.; 13 Jul. 1998; Chung-Chi Hwang leg.; NMNS-8595-001.

Paratypes

TAIWAN • 6 clitellates; same data as for holotype; NMNS 4054-003.

Other material examined

TAIWAN • 1 clitellate; Nanrenshan, Kending, Pingtung County; 22°05′03″ N, 120°50′07″ E; 150 m a.s.l.; 20 Oct. 1996; Chung-Chi Hwang leg.; NMNS-8595-004 (this specimen was separated out from the others stored in the bottle labeled with catalogue no. NMNS 4054-031).

Description

Length (mature) 72–116 mm. Number of segments 95–113. Setae regularly distributed around segmental equators, size and distance regular, numbering 33–42 in VII, 43–52 in XX, 11–16 between spermathecal pores, 10–13 between male pores in XVIII. Prostomium epilobous. First dorsal pore in 11/12. Clitellum XIV–XVI, smooth, setae and dorsal pores absent, length 2.4–2.9 mm and width 2.5–3.7 mm. Spermathecal pores four pairs in 5/6–8/9 (Fig. 1A), paired pores 0.30–0.31 body circumference ventrally apart. Genital

papillae widely paired in presetal VII–IX for four specimens, widely paired in presetal VIII–IX for four specimens, widely paired in postsetal VIII for four specimens, one on left side of postsetal VII for one specimen, and one on right side of postsetal VII for one specimen, each papilla 0.25–0.4 mm in diameter. Female pore single, mid-ventral in XIV.

Male pores paired, ventro-lateral in XVIII, paired pores 0.23–0.30 body circumference ventrally apart. Two small papillae medial to each male pore in XVIII, one anteromedial and the other posteromedial, surrounded by three or four circular folds (Fig. 1B). Each papilla 0.13–0.3 mm in diameter. Preserved specimens brown on dorsum, light greyish brown on venter, dark brown on clitellum.

Septa 5/6–7/8 thickened, 8/9/10 absent, 10/11–13/14 thickened. Nephridial tufts on anterior faces of 5/6/7. Gizzard in VIII–X. Intestine enlarged from XV. Intestinal caeca paired in XXVII, simple, long, surface slightly wrinkled, extending anteriorly to XXIII or XXII. Esophageal hearts paired in XI–XIII.

Spermathecae four pairs in VI–IX. Ampulla large, round, peach- or elongated oval-shaped, surface wrinkled, 1.1–1.8 mm in length and 0.7–1.8 mm in width, with a short, stout stalk 0.3–0.5 mm long. Diverticulum with an oval, iridescent seminal chamber 0.3–0.5 mm in length and a slender stalk 0.4–1.0 mm in length (Fig. 1C). Accessory glands sessile, round, 0.3–0.4 mm in total length, each corresponding to external genital papilla. Ovaries paired in XIII.

Holandric. Testes oval, two pairs in ventrally joined sacs in X and XI. Seminal vesicles large, two pairs in XI and XII, each vesicle occupying 1–2 segments, with a round, prominent dorsal lobe. Prostate glands paired in XVI–XX, XV–XX or XVI–XIX, wrinkled and lobed. Prostatic ducts large, long, U-shaped in XV–XVIII or XVI–XVIII, enlarged in distal half (Fig. 1D). Accessory glands absent.

Distribution

Known only from type locality (Nanrenshan, Kending, Pingtung County, Taiwan).

Remarks

The description of "*A. corticis*" by James *et al.* (2005: 1023–1024) was based on the seven specimens in the bottle labeled with catalogue no. NMNS 4054-003 only. The genital papilla arrangements in the preclitellar and male pore regions of the other specimens assigned to "*A. corticis*" by James *et al.* (2005: 1023), namely NMNS 4054-031, NMNS 4054-032, NMNS 4054-033, and NMNS 4054-034, are completely different from this description. James *et al.* (2005: 1024) mentioned in the "Remarks" section that "The material is very probably *A. corticis*". Obviously, James *et al.* (2005) were not fully sure about the identity of these specimens. *Amynthas chungchi* sp. nov. is most similar to *A. corticis* in the external characters. However, the character of two small papillae with one anteromedial and the other posteromedial to each male pore is consistent among the *A. chungchi* sp. nov. individuals and different from the variable papilla arrangements in the male pore region of *A. corticis* with the number of papillae ranging from zero to two, occasionally three, and the position being posterior, posteromedial, posterolateral, anterolateral and/or anteromedial to each male pore (Chen 1931, 1933; HPS, personal observation). HPS has examined more than 1350 specimens of *A. corticis*, most of which with their identity confirmed by DNA barcode, collected throughout Taiwan and its adjacent islands. In conclusion, *A. corticis* has no postsetal papillae on the ventral side of the preclitellar region except those anterior to each spermathecal pore. This feature agrees with that of *Pheretima heterochaeta* (Michaelsen, 1891) (= *A. corticis*) described by Chen (1931, 1933) and of *A. corticis* described and figured by Blakemore (2013a, 2013b, 2013c). Besides, the prostate glands of *A. corticis* are often absent, and its prostatic duct is always confined to segment XVIII no matter whether the duct is smaller and curved in a "C" shape, or larger and curved in a "U" shape. In contrast, most individuals of *A. chungchi* sp. nov. have postsetal

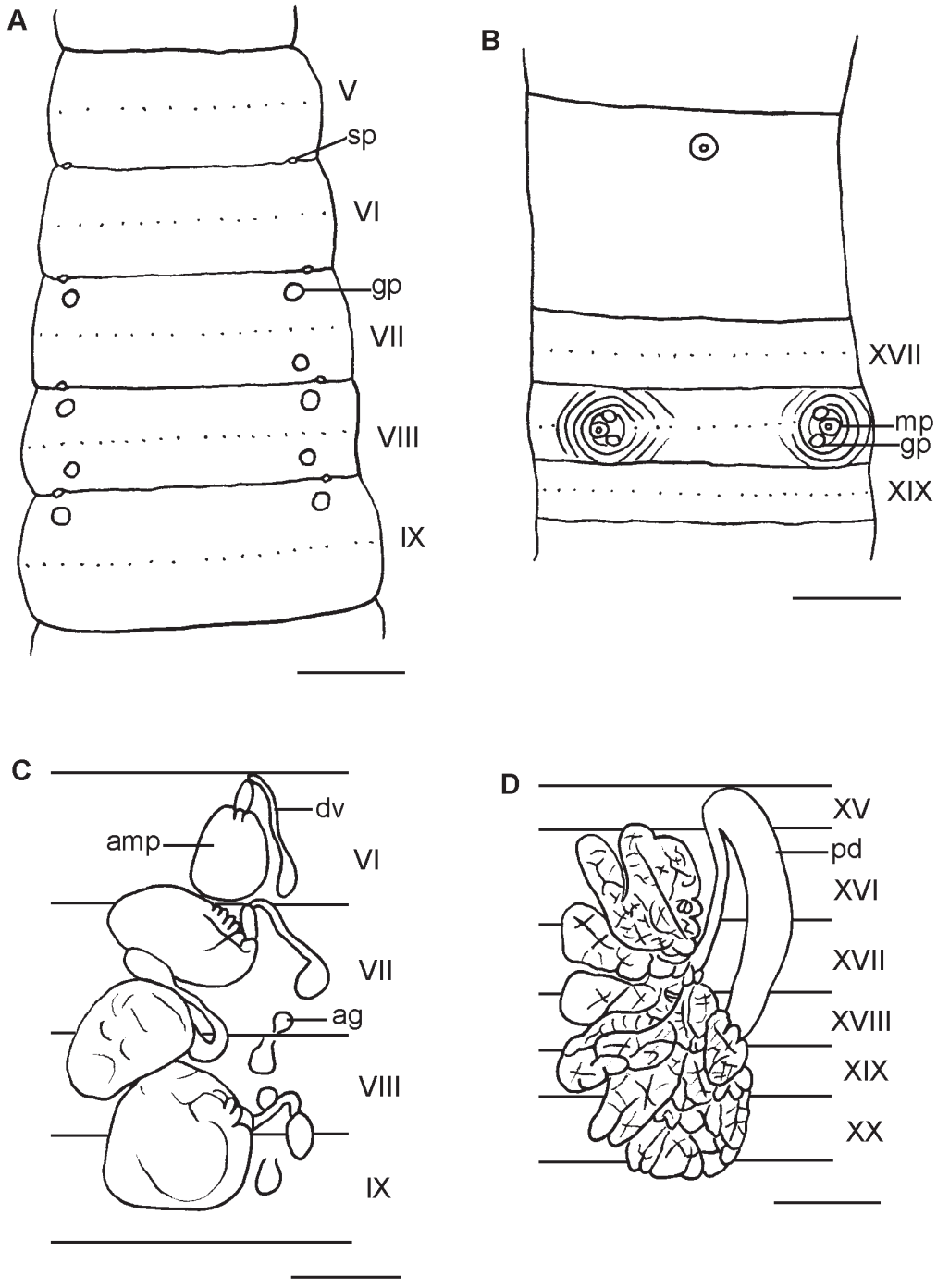

Fig. 1. *Amynthas chungchi* Shen sp. nov., holotype (NMNS-8595-001). **A**. Ventral view of spermathecal pore region. **B**. Ventral view of clitellum and male pore region. **C**. Dorsal view of left spermathecae. **D**. Dorsal view of left prostate gland. Scale bars: 1 mm.

papillae and all of them have large prostate glands occupying four to six segments in XV–XX with large, long, U-shaped prostatic ducts extending in XV–XVIII or XVI–XVIII.

Amynthas chungchi sp. nov. also resembles *Amynthas yizhou* Blakemore, 2013 from northern Taiwan. The latter species was initially misidentified as a new record of *A. carnosus* by Shen *et al.* (2005), and was later named by Blakemore (2013c). Both species are octothecal and have one presetal and one postsetal papilla medial to each male pore. However, *A. yizhou* is larger, with a body length of 130–240 mm and a width of 5.99–8.25 mm, and it has higher setal numbers (42–51 in VII and 54–73 in XX), two or three small papillae ventral to each spermathecal pore near the intersegmental furrow, a diverticulum with an elongated seminal chamber, and a sessile accessory gland associated with each papilla around the male pore (Shen *et al.* 2005).

Amynthas kendingensis Shen sp. nov.
urn:lsid:zoobank.org:act:CEEF533D-FCE6-4054-BD95-AA811531D25D
Fig. 2

Amynthas corticis – James *et al.* 2005: 1023 (partim).

Diagnosis

Length (clitellates) 52–78 mm. Segments numbering 58–87. Setae 28–42 in VII, 36–51 in XX, 10–14 between male pores. First dorsal pore in 4/5, 5/6 or 6/7. Clitellum XIV–XVI. Spermathecal pores four pairs in 5/6–8/9, 0.28–0.35 body circumference ventrally apart. Male pores 0.25–0.29 body circumference ventrally apart in XVIII, each with posterolateral and sometimes with anterolateral genital papillae, surrounded by one or two shallow circular folds. Genital papillae small, 0–6 medial to each spermathecal pore in intersegmental furrow, 1–5 in a row or in a cluster medial to each male disc in presetal XVIII, and widely paired in presetal XIX. Spermathecae four pairs in VI–IX. Seminal vesicles two pairs in XI and XII. Prostate glands paired in XVI–XIX or XVI–XX. Prostatic ducts long, U-shaped in XVI–XVIII. Accessory glands stalked.

Etymology

The species is named after its locality, Kending, Pingtung County, Taiwan.

Type material

Holotype

TAIWAN • clitellate (mature) specimen; Nanrenshan, Kending, Pingtung County; 22°05′03″ N, 120°50′07″ E; 150 m a.s.l.; 24 Aug. 1999; Chung-Chi Hwang leg.; NMNS-8595-002.

Paratypes

TAIWAN • 11 clitellates; same data as for holotype; NMNS 4054-032.

Description

Length (mature) 52–78 mm. Number of segments 58–87. Setae regularly distributed around segmental equators, size and distance regular, numbering 28–42 in VII, 36–51 in XX, 10–16 between spermathecal pores, 10–14 between male pores in XVIII. Prostomium epilobous. First dorsal pore in 4/5, 5/6 or 6/7. Clitellum XIV–XVI, smooth, setae and dorsal pores absent, length 1.7–2.5 mm and width 2.3–2.9 mm. Spermathecal pores four pairs in 5/6–8/9 (Fig. 2A), paired pores 0.28–0.35 body circumference ventrally apart. Genital papillae small, 0–6 medial to each spermathecal pore in intersegmental furrow. Other preclitellar genital markings often absent. Among the 12 specimens examined, papillae widely paired in presetal VIII for one specimen, one on right side of presetal VIII for one specimen, and widely paired

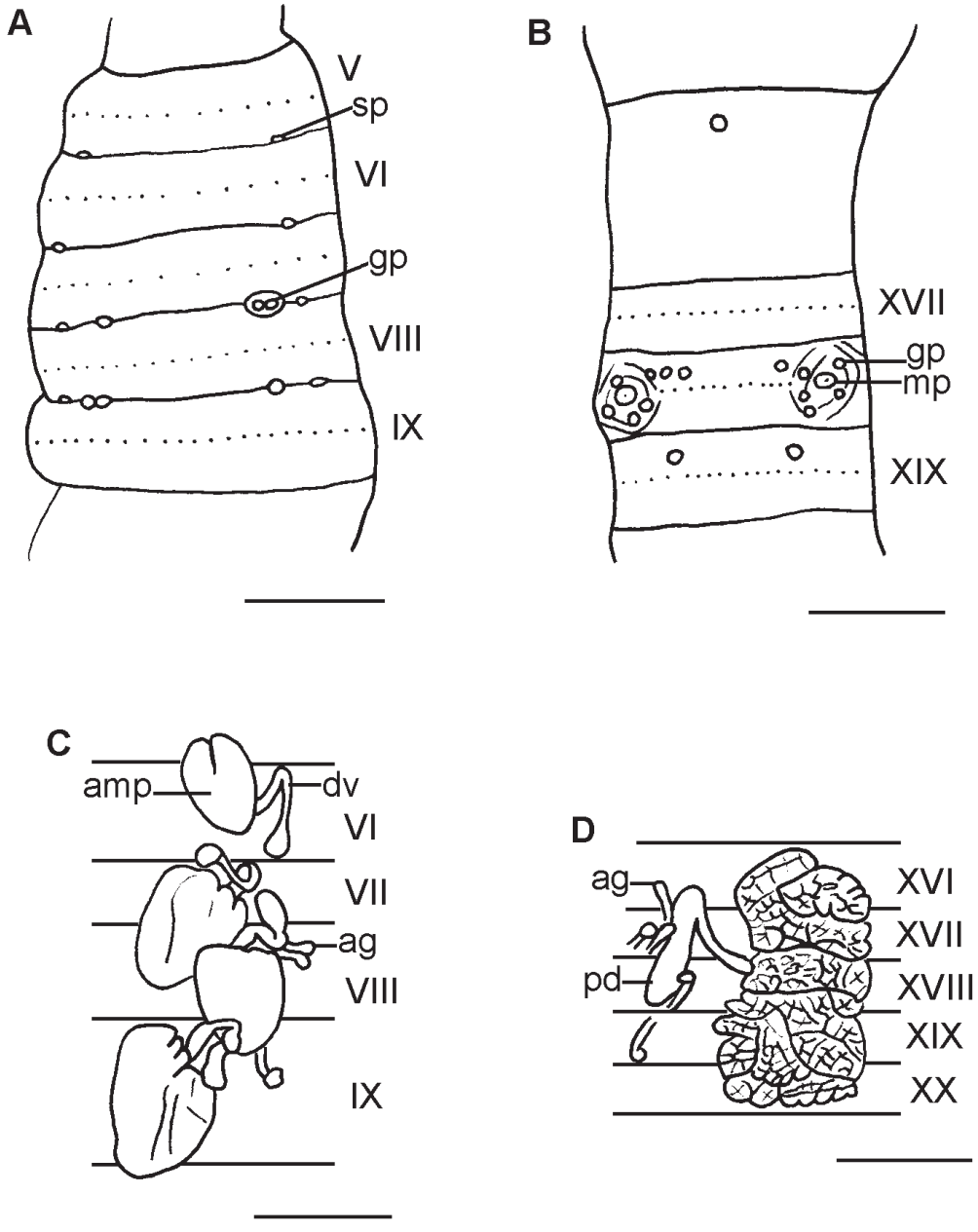

Fig. 2. *Amynthas kendingensis* Shen sp. nov., holotype (NMNS-8595-002). **A**. Ventral view of spermathecal pore region. **B**. Ventral view of clitellum and male pore region. **C**. Dorsal view of left spermathecae. **D**. Dorsal view of right prostate gland. Scale bars: 1 mm.

in presetal IX for one specimen, each papilla 0.15–0.2 mm in diameter. Female pore single, mid-ventral in XIV.

Male pores paired, ventro-lateral in XVIII, paired pores 0.25–0.29 body circumference ventrally apart. Number and arrangement of papillae in male pore region highly variable. Among the 12 specimens examined, each male pore with a posterolateral papilla for three specimens, with a posterolateral and an anterolateral papilla for four specimens, with 2–3 posterolateral papillae for four specimens, and with 2 posterolateral and 1–2 anterolateral papillae for one specimen. Holotype with additional two posteromedial papillae for each male pore and an anteromedial papilla for left male pore (Fig. 2B). Each papilla small, about 0.1 mm in diameter. These papillae together with the male pore surrounded by one or two shallow circular folds. In addition, 1–5 papillae in a row or in a cluster medial to each male disc in presetal XVIII. In XIX, presetal papillae widely paired for 10 specimens, one on left side of presetal XIX for one specimen, and one on left side of postsetal XIX for one specimen. Preserved specimens brown on dorsum, light greyish brown on venter, dark brown on clitellum.

Septa 5/6–7/8 thickened, 8/9/10 absent, 10/11–13/14 thickened. Nephridial tufts on anterior faces of 5/6/7. Gizzard in VIII–X. Intestine enlarged from XV. Intestinal caeca paired in XXVII, simple, surface slightly wrinkled, extending anteriorly to XXV. Esophageal hearts paired in XI–XIII.

Spermathecae four pairs in VI–IX. Ampulla peach- or elongated oval-shaped, surface wrinkled, 1.1–1.5 mm in length and 0.8–1.1 mm in width, with a short, slender stalk 0.2–0.3 mm long. Diverticulum with a round or oval, iridescent seminal chamber 0.2–0.4 mm in length and a short, slender stalk 0.3–0.4 mm in length (Fig. 2C). Accessory glands stalked, 0.4–0.5 mm in total length, each corresponding to external genital papilla. Ovaries paired in XIII.

Holandric. Testes oval, two pairs in ventrally joined sacs in X and XI. Seminal vesicles two pairs in XI and XII, each with a round, prominent dorsal lobe. Prostate glands paired in XVI–XIX or XVI–XX, lobed, follicular. Prostatic ducts long, U-shaped in XVI–XVIII or XVII–XVIII, enlarged in distal half (Fig. 2D). Accessory glands stalked, 0.3–0.4 mm in total length.

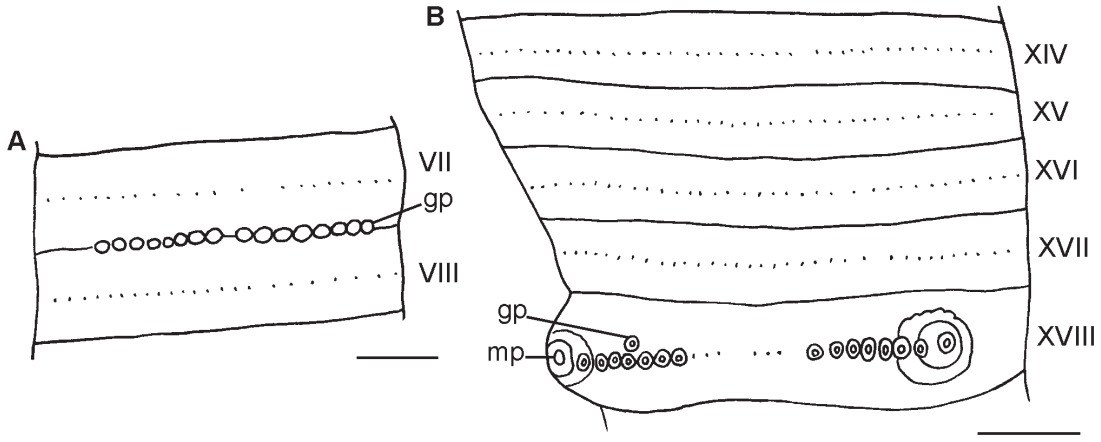

Fig. 3. *Amynthas evansi* (Beddard, 1900), syntype (BMNH 1904.10.5.37). **A**. Ventral view of segments VII–VIII. **B**. Ventral view of male pore region. Scale bars: 1 mm.

Distribution

Known only from type locality (Nanrenshan, Kending, Pingtung County, Taiwan).

Remarks

The unique genital papilla arrangements in the preclitellar and male pore regions together with the anteriorly placed first dorsal pore in 4/5, 5/6 or 6/7 in *A. kendingensis* sp. nov. clearly distinguishes it from *A. corticis*. The papilla arrangements in *A. kendingensis* sp. nov. are somewhat like those in *A. evansi* (Beddard, 1900) from Biserat, Malay Peninsula. *Amynthas evansi* also has four pairs of spermathecae in VI–IX, a row of genital papillae in the intersegmental furrow of 7/8 (eight papillae on each side), and 7 papillae in a row medial to each male disc in XVIII (Fig. 3). However, *A. evansi* is larger (body length 120 mm and segments numbering 120 for an aclitellate specimen), and has the first dorsal pore in 11/12 or 12/13, a short prostatic duct and a coiled diverticular stalk (Beddard 1900; Stephenson 1932). The type specimen of *A. evansi* is deposited at the Natural History Museum, London (BMNH 1904.10.5.37) and was examined by HPS in 2014.

Amynthas jioupengensis Shen sp. nov.
urn:lsid:zoobank.org:act:EFFBE568-8136-4E35-9BF3-FB8685FBA3F8
Fig. 4

Amynthas corticis – James *et al.* 2005: 1023 (partim).

Diagnosis

Length 40 mm. Segments numbering 85. Setae 38 in VII, 44 in XX, 12 between male pores. First dorsal pore in 12/13. Clitellum XIV–XVI. Spermathecal pores invisible. Male pores 0.34 body circumference ventrally apart in XVIII, each with an anterolateral genital papilla. Genital papillae small, widely paired in presetal VII–VIII, and 7 or 8 in a row, closely along setal lines in presetal XVIII–XIX. Spermathecae four pairs in VI–IX. Seminal vesicles two pairs in XI and XII. Prostate glands paired in XVI–XIX. Prostatic ducts small, C-shaped in XVIII. Accessory glands stalked.

Etymology

The species is named after its locality, Jioupeng, Pingtung County, Taiwan.

Type material

Holotype

TAIWAN • clitellate (mature) specimen; Jioupeng, Pingtung County; 22°06′18″ N, 120°50′56″ E; 149 m a.s.l.; 29 Apr. 1999; Hsi-Te Shih leg.; NMNS 4054-033.

Description

Length (mature) 40 mm. Number of segments 85. Setae regularly distributed around segmental equators, size and distance regular, numbering 38 in VII, 44 in XX, 12 between male pores in XVIII. Prostomium epilobous. First dorsal pore in 12/13. Clitellum XIV–XVI, smooth, setae and dorsal pores absent, length 1.8 mm and width 3.0 mm. Spermathecal pores invisible. Genital papillae small, widely paired in presetal VII–VIII (Fig. 4A), each papilla about 0.1 mm in diameter. Female pore single, mid-ventral in XIV.

Male pores paired, ventro-lateral in XVIII, paired pores 0.34 body circumference ventrally apart, each pore with an anterolateral genital papilla. In addition, genital papillae 7 or 8 in a row, closely along setal lines in presetal XVIII–XIX (Fig. 4B). Each papilla small, about 0.1 mm in diameter. Preserved specimens brown in color.

Septa 5/6–7/8 thick, 8/9/10 absent, 10/11–13/14 thick. Nephridial tufts on anterior faces of 5/6/7. Gizzard in VIII–X. Intestine enlarged from XV. Intestinal caeca paired in XXVII, simple, surface slightly wrinkled, extending anteriorly to XXV. Esophageal hearts paired in XI–XIII.

Spermathecae four pairs in VI–IX. Ampulla elongated oval-shaped, 0.6–0.9 mm in length and 0.4–0.5 mm in width, with a short, slender stalk about 0.3 mm long. Diverticulum with a round, iridescent seminal chamber about 0.1 mm in length and a short, slender stalk 0.3–0.4 mm in length (Fig. 4C). Accessory glands stalked, about 0.2 mm in total length, each corresponding to external genital papilla. Ovaries paired in XIII.

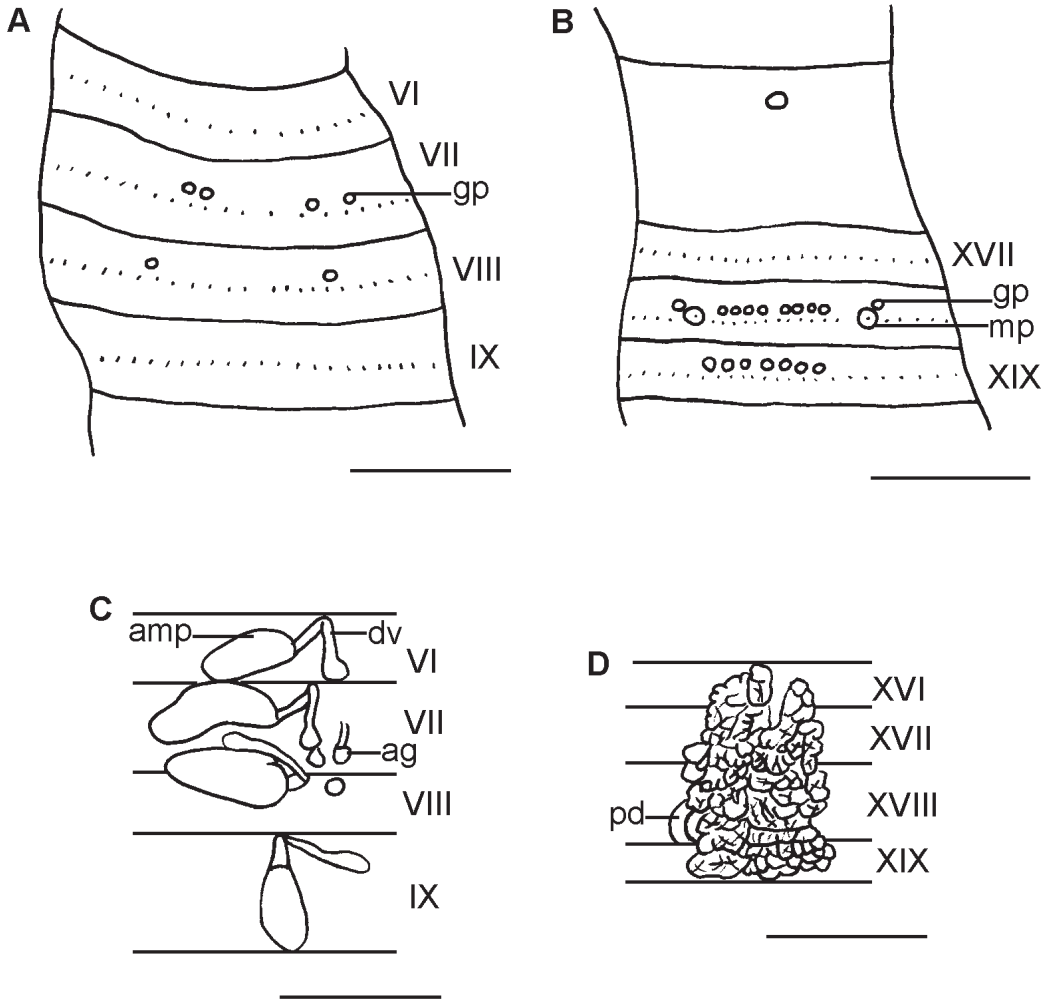

Fig. 4. *Amynthas jioupengensis* Shen sp. nov., holotype (NMNS 4054-033). **A**. Ventral view of segments VI–IX. **B**. Ventral view of clitellum and male pore region. **C**. Dorsal view of left spermathecae. **D**. Dorsal view of right prostate gland. Scale bars: 1 mm.

Holandric. Testes oval, two pairs in ventrally joined sacs in X and XI, first pair large. Seminal vesicles two pairs in XI and XII, each with a round dorsal lobe. Prostate glands paired in XVI–XIX, leafy, follicular. Prostatic ducts small, C-shaped in XVIII (Fig. 4D). Accessory glands stalked.

Distribution

Known only from type locality (Jioupeng, Pingtung County, Taiwan).

Remarks

The character of the rows of genital papillae along the setal lines in presetal XVIII–XIX in *A. jioupengensis* sp. nov. easily separates it from *A. corticis*. The papilla arrangement in *A. jioupengensis* sp. nov. bears a resemblance to that in *A. evansi*. However, *A. evansi* is much larger (body length 120 mm and segments numbering 120 for an aclitellate specimen) and has a coiled diverticular stalk (Beddard 1900; Stephenson 1932). *Amynthas libratus* Tsai & Shen, 2010 from eastern Taiwan also has four pairs of spermathecae in VI–IX and papillae in horizontal rows closely along the setal lines, but the positions of these papillae are in VII–IX, XVII, XIX, and additionally along the intersegmental furrows of 17/18 and 18/19 (Tsai *et al.* 2010). Besides, *A. libratus* has an anteriorly placed first dorsal pore in 5/6 (Tsai *et al.* 2010).

Amynthas lilis Shen sp. nov.
urn:lsid:zoobank.org:act:89141457-A609-429E-9BF5-4054AE69066A
Fig. 5

Amynthas corticis – James *et al.* 2005: 1023 (partim).

Diagnosis

Length (clitellates) 70–85 mm. Segments numbering 74–98. Setae 36–51 in VII, 50–57 in XX, 12–13 between male pores. First dorsal pore in 11/12 or 13/14. Clitellum XIV–XVI. Spermathecal pores four pairs in 5/6–8/9, 0.28–0.30 body circumference ventrally apart. Male pores 0.27–0.31 body circumference ventrally apart in XVIII. Genital papillae small, mid-ventral, 0–5 presetal papillae in a row and 0–3 postsetal papillae in a row on each segment of VII–IX and XVII–XX. Spermathecae four pairs in VI–IX. Seminal vesicles large, two pairs in XI and XII, each occupying 1.5–2 segments. Prostate glands lobed, occupying 3–4 segments in XVI–XX. Prostatic ducts C-shaped in XVIII. Accessory glands stalked.

Etymology

The species is named after the nearby Lili Creek in Chunrih, Pingtung County, Taiwan.

Type material

Holotype

TAIWAN • clitellate (mature) specimen; Nanhe, Chunrih, Pingtung County; 22°26′33″ N, 120°39′03″ E; 133 m a.s.l.; 19 Aug. 1999; Chung-Chi Hwang and Jin-Kuan Yang leg.; NMNS-8595-003.

Paratypes

TAIWAN • 5 clitellates; same data as for holotype; NMNS 4054-034.

Description

Length (mature) 70–85 mm. Number of segments 74–98. Setae regularly distributed around segmental equators, size and distance regular, numbering 36–51 in VII, 50–57 in XX, 13–14 between spermathecal pores, 12–13 between male pores in XVIII. Prostomium epilobous. First dorsal pore in 11/12 or 13/14. Clitellum XIV–XVI, smooth, setae and dorsal pores absent, length 2.7–3.3 mm and width 4.1–5.7 mm.

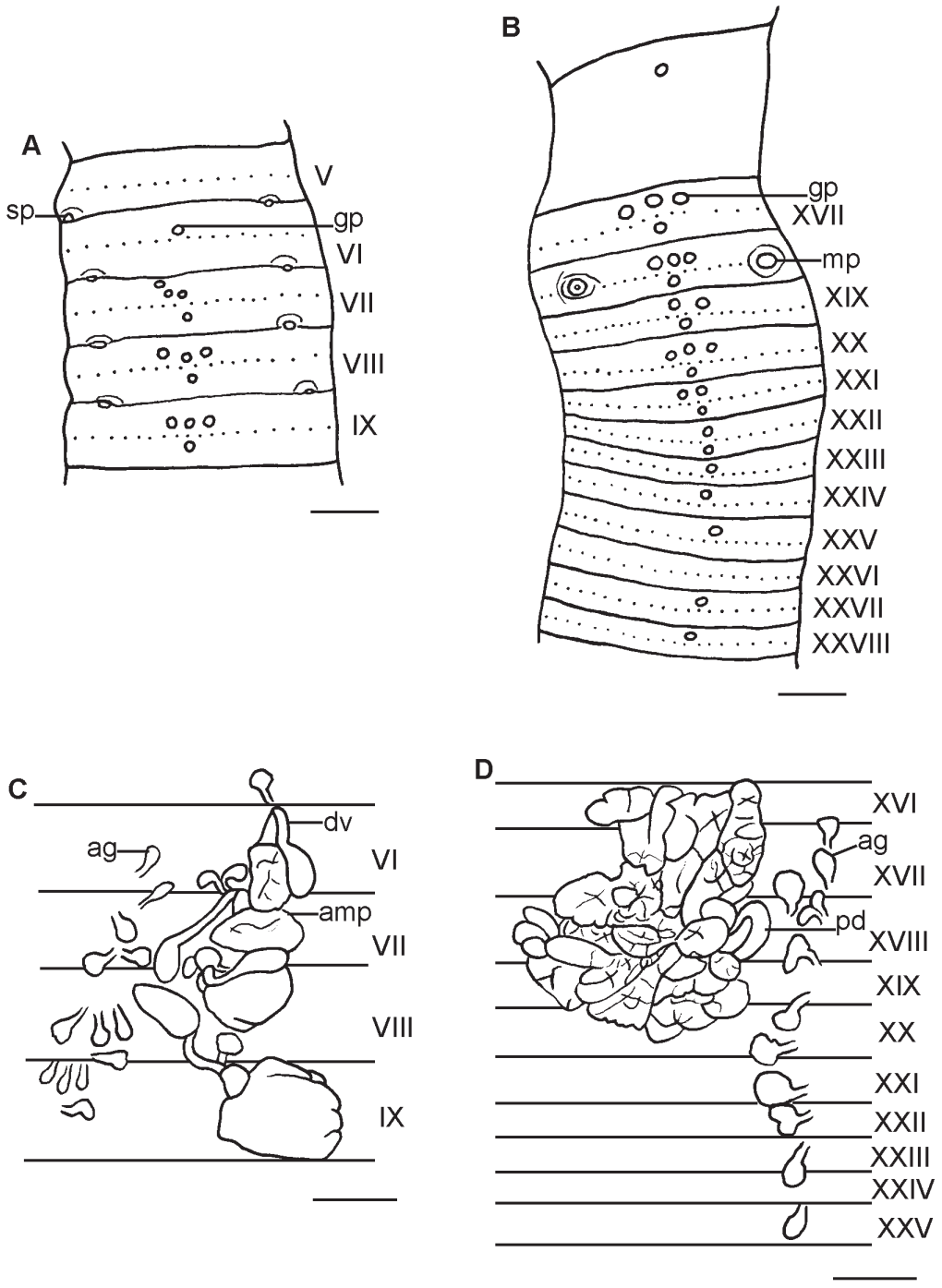

Fig. 5. *Amynthas lilis* Shen sp. nov., holotype (NMNS-8595-003). **A**. Ventral view of spermathecal pore region. **B**. Ventral view of clitellum and male pore region. **C**. Dorsal view of right spermathecae. **D**. Dorsal view of left prostate gland. Scale bars: 1 mm

Spermathecal pores four pairs in 5/6–8/9, paired pores 0.28–0.30 body circumference ventrally apart. Genital papillae small, mid-ventral in VII–IX, number highly variable. In VII, 0–3 presetal papillae in a row and 0–2 postsetal papillae in a row; in VIII, 1–5 presetal papillae in a row and 0–2 postsetal papillae in a row; in IX, 0–3 presetal papillae in a row and 0–3 postsetal papillae in a row; an additional presetal papilla in VI for holotype (Fig. 5A). Each papilla about 0.3 mm in diameter. Female pore single, mid-ventral in XIV.

Male pores paired, ventro-lateral in XVIII, paired pores 0.27–0.31 body circumference ventrally apart, each porophore surrounded by one or two shallow circular folds. Genital papillae small, mid-ventral, often in XVII–XX, number and arrangement highly variable. In XVII, 0–3 presetal papillae in a row and 0–2 postsetal papillae in a row; in XVIII, 0–3 presetal papillae in a row and 0–2 postsetal papillae in a row; in XIX, 0–3 presetal papillae in a row and 0 or 1 postsetal papilla; in XX, 0–3 presetal papillae in a row and 0 or 1 postsetal papilla; additional papillae present in XXI–XXV and XXVII–XXVIII for holotype (Fig. 5B). Each papilla 0.3–0.4 mm in diameter. Preserved specimens brown and dark brown on clitellum.

Septa 5/6–7/8 thickened, 8/9/10 absent, 10/11–13/14 thickened. Nephridial tufts on anterior faces of 5/6/7. Gizzard in VIII–X. Intestine enlarged from XV. Intestinal caeca paired in XXVII, simple, bent, extending anteriorly to XXII or XXI. Esophageal hearts paired in XI–XIII.

Spermathecae four pairs in VI–IX. Ampulla peach- or elongated oval-shaped, surface wrinkled, 0.9–2.1 mm in length and 0.8–1.6 mm in width, with a short, stout stalk 0.3–0.5 mm long. Diverticulum with a large, round or oval, iridescent seminal chamber 0.5–1.1 mm in length and a slender stalk 0.5–0.9 mm in length (Fig. 5C). Accessory glands stalked, 0.4–0.6 mm in total length, each corresponding to external genital papilla. In addition, one or two stalked glands near each spermathecal pore, 0.4–0.6 mm in total length. Ovaries paired in XIII.

Holandric. Testes oval, two pairs in ventrally joined sacs in X and XI. Seminal vesicles large, two pairs in XI and XII, each vesicle occupying 1.5–2 segments, each with a large, round dorsal lobe. Prostate glands paired in XVI–XIX, XVII–XIX or XVII–XX, lobed, wrinkled. Prostatic ducts C-shaped in XVIII, distal end enlarged (Fig. 5D). Accessory glands stalked, 0.6–0.8 mm in total length, each corresponding to external genital papilla.

Distribution

Known only from type locality (Chunrih, Pingtung County, Taiwan).

Remarks

The character of a longitudinal series of genital papillae on the mid-ventral line in *A. lilis* sp. nov. sets it apart from *A. corticis*. This papilla arrangement is akin to that of *A. catenus* Tsai, Shen & Tsai, 2001 from elevations of 2200–3000 m, central Taiwan (Tsai *et al.* 2001; Shen *et al.* 2019). However, *A. catenus* is a parthenogen with spermathecae from absence to three pairs in VI–VIII, small, vestigial seminal vesicles, and prostate glands from absence to large in XVI–XX (Tsai *et al.* 2001). No sperm was found and spermatozoal iridescence was not observed in any of the spermathecae examined for *A. catenus* (Shen *et al.* 2011, 2012).

Discussion

Misidentification of endemic earthworms as peregrine species (Ohfuchi 1956; Easton 1981; Blakemore 2002, 2003, 2010, 2012, 2013a, 2013c, 2016; James *et al.* 2005; Shen *et al.* 2005; Blakemore & Kupriyanova 2010; Blakemore *et al.* 2010, 2012, 2014; Nguyen *et al.* 2016, 2020, 2023) or vice versa (Ohfuchi 1956; Huang *et al.* 2007; Dong *et al.* 2020; Sun *et al.* 2021) is not uncommon in the

studies of earthworm taxonomy (also see Shen 2018a). This phenomenon is also seen in the sequences presented in GenBank as exemplified in this study. Phylogenetic analysis resorting to these sequences with erroneous identities leads to wrong conclusions which exacerbate the problem. Misidentification, mis-synonymization, inadequate literature review, and misquotation presented in the publications on earthworm taxonomy have provoked not only taxonomic but also distributional confusion which hinders the progress of knowledge and distorts the biogeographical picture of the local earthworm fauna.

The four new earthworm species described in this study were initially misidentified as peregrine species. With the discovery of these new species, the total number of earthworm species known from Taiwan and its adjacent islands reaches 121. These new species are from the vicinity of Hengchun Peninsula, the southern tip of Taiwan, where the earthworm fauna is poorly studied. Of particular importance is that they were found at low elevations where habitats are subjected to intensive agricultural activities and human disturbance. The four new species are among the few native earthworms remaining at elevations below 500 m in Taiwan.

Acknowledgments

We are grateful to Mr. Kwen-Shen Lee of the National Museum of Natural Science, Taichung, Taiwan for kindly loaning specimens and cataloguing new species found in this study, and to Emma Sherlock of the Natural History Museum in London for access to earthworm specimens. HPS thanks Mr. Kwen-Shen Lee for his various help during her visit to the National Museum of Natural Science, Taichung, Taiwan on 3 February 2005. This study was supported financially by the National Science and Technology Council, Taiwan (MOST 111-2621-B-002-005-MY3) and the Ministry of Education, Taiwan (Yushan Fellow Program) to CHC, and by the Taiwan Biodiversity Research Institute, Ministry of Agriculture, Taiwan to HPS.

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