EARTHWORM FAUNA of TAIWAN
Biota Taiwanica

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Earthworm Fauna of Taiwan
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Preface

For the first time, I met Sam James in 2007 in Cyprus where the 3rd IOTM was held. It is not possible for me to forget the word that he said at that time: “Taiwan is probably the country that has the highest density of earthworm taxonomists in the world.” What he said is definitely the truth. Taiwan is among the countries where the greatest numbers of new earthworm species were described in the past decade, and there are three teams working on earthworm systematics, one in National Taiwan University, one in Endemic Species Research Institute, and one in National Chung Hsing University.

However, these are not enough. With the current pace, it will still need around 20 more years before most earthworms in Taiwan are described. But in 20 years, many of the habitats may be destroyed, and some earthworm species may become extinct before they are discovered. This is very likely to be the case since economic growth is given the first priority by the politicians currently in power, and there is much evidence that they still take environmental conservation as unimportant as their predecessors did in the past decade.

But there is still hope. The progress of DNA analysis of Taiwanese earthworms in recent years promised an integrative approach that, already underway, accelerates the discovery of new species. In addition, more and more graduate students emphasize their studies on the ecology of earthworms, improving our understanding of these animals. I hope the publishing of Earthworm Fauna of Taiwan can reduce the load for taxonomic paper collection in earthworm ecological studies, and then encourage more students and young scientists to devote themselves to earthworm-related studies.
This work can not be done without the help from many persons. I am grateful to Hsi-Te Shih and Yu-Hsin Wang for their help on examining type specimens. The copy editor and photographer, Wen-Jay Chih, contributed a lot during the processing of the manuscript. I owe a great deal to Shu-Chun Chuang for the pictures she provided and drawings she made, and feel immense gratitude to Sam James for his encouragement and suggestions. I also thank Yong Hong, Jia Hsing Wu and Hsin-I Hsieh for letting me use the pictures they took, and Tin-Yam Chan and Sharon Horng for their kindly giving me their published books in the series of *Biota Taiwanica* as references for this book. This work was funded by National Science Council to J.-H. Chen.

C.-H. Chang
July, 2009
Introduction

Excluding a few aquatic species, earthworms are terrestrial oligochaetes (Annelida: Clitellata) composed of around 5,000 species within 18 families (Blakemore, 2002). Most earthworms are megadriles, which, by definition, have multilayered clitellum, and belong to Lumbricina within Haplotaxida. Some microdriles (oligochaetes with single-layered clitellum) that are also called earthworms belong to Moniligastridae within Moniligastrida. However, the family Moniligastridae may be transferred to Haplotaxida if its sister group relationship with Lumbricina is supported by future phylogenetic analyses, which, if happening, will render “earthworms” a monophyletic group composed of Lumbricina plus Moniligastrina.

Historical review of earthworm taxonomic studies in Taiwan

The earthworm taxonomic studies in Taiwan started when Goto and Hatai (1898) described the first endemic species from Taiwan, *Amynthas candidus* (described as *Perichaeta candida*), in 1898. After that, surveys in human-inhabited plain and low elevation regions were conducted by Michaelsen (1922), Kobayashi (1938, 1939a, b, 1940a, b, c, 1941), Gates (1959), Tsai (1964), Kuo (1993, 1995) and Chen and Shih (1996). By the middle of the 1990s, 26 species were reported (Shih et al., 1999), but only five are endemic, including *Amynthas candidus*, *Metaphire formosae* (Michaelsen, 1922) (described as *Pheretima formosae*), *Metaphire yuhsii* (Tsai, 1964) (described as *Pheretima yuhsi*), *Amynthas swanus* (Tsai, 1964) (described as *Pheretima swanus*), and *Amynthas polyglandularis* (Tsai, 1964) (described as *Pheretima polyglandularis*).

The understanding of earthworm fauna of Taiwan progressed rapidly in the past decade. Between 1999 and 2009, 34 papers describing 47 new species or new records were published (Chang, 2005; Chang and Chen, 2004, 2005a, b; Chang et al., 2001, 2007b, 2008a; Chen and Chuang, 2003; Chen et al., 2002, 2003, 2004; Chuang and Chen, 2002; Chuang et al., 2002; James et al., 2005; Shen and Tsai, 2002a, b, 2007; Shen et al., 2002, 2003a, b, 2005a, b, 2008a, b; Tsai et al., 1999, 2000b, c, 2001, 2002, 2003, 2004a, b, 2007; Tsai S.-C. et al., 2000). Accompanying the fast-growing number of literatures, several reviews or checklists were published (Blakemore et al., 2006; Chang and Chen, 2008b; Chang et al., 2008b; Chuang et
Table 1. Numbers of earthworm species within different genera and families in Taiwan.

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species nos. within genera</th>
<th>Species nos. within families</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glossoscolecidae</td>
<td>Pontoscolex</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lumbricidae</td>
<td>Aporrectodea</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Bipastos</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eiseniella</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ocnerodrilidae</td>
<td>Eukerria</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Octochaetidae</td>
<td>Dichogaster</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Megascolecidae</td>
<td>Amynthas</td>
<td>40</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Metaphire</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perionyx</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pithemera</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polypheretima</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pontodrilus</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Moniligastridae</td>
<td>Drawida</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2. A comparison of the earthworm fauna from Taiwan, Japan, Korea, China and Burma.

<table>
<thead>
<tr>
<th>Country</th>
<th>No. of species</th>
<th>No. of endemic species</th>
<th>Endemism</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiwan</td>
<td>73</td>
<td>42</td>
<td>58 %</td>
<td>Tsai et al., 2009</td>
</tr>
<tr>
<td>Japan</td>
<td>82</td>
<td>38</td>
<td>46 %</td>
<td>Blakemore, 2006</td>
</tr>
<tr>
<td>Korea</td>
<td>94</td>
<td>70</td>
<td>74 %</td>
<td>Blakemore, 2006</td>
</tr>
<tr>
<td>China</td>
<td>248</td>
<td>161</td>
<td>65 %</td>
<td>Blakemore, 2006</td>
</tr>
<tr>
<td>Burma</td>
<td>195</td>
<td>130</td>
<td>67 %</td>
<td>Blakemore, 2006</td>
</tr>
</tbody>
</table>

al., 2005; Tsai et al., 2000a, 2009), including those in the first edition of the official biodiversity species checklist (Chang and Chen, 2008b; Chang et al., 2008b). Type specimens designated during this period were deposited in the Taiwan Endemic Species Research Institute (Nantou), Institute of Zoology, National Taiwan University (Taipei), and National Museum of Natural Science (Taichung) in Taiwan.

In the 1990s, taxonomists started to use DNA sequences to investigate the systematics, taxonomy, phylology, biogeography and population genetics of animals. However, the study of earthworms in this area started very late, and the first paper had not been published until 2003 (Pop et al., 2003). From 2003 to 2009, 21 papers were published, including three studies in Molecular Phylogenetics and Evolution and Molecular Ecology (Chang et al., 2008a; King et al., 2008; Perez-Losada et al., 2009). During this period, several studies using DNA sequences to investigate earthworms in Taiwan were published by Chang and his colleagues, including the first paper using DNA sequences/DNA barcodes to help the description of new earthworm species (Chang et al., 2007b) and several papers about phylogeography, systematics and DNA barcoding of Taiwanese earthworms (Chang, 2005; Chang and Chen, 2005a; Chang et al., 2008a, 2009b).
Species diversity

Ten years ago, there were only 26 earthworm species belonging to 9 genera within 4 families in Taiwan, but the number has increased dramatically to 73 species belonging to 13 genera within 6 families (Table 1, Fig. 1). Among them, 42 species, or 58%, are endemic. Megascolecidae, which is composed of 63 species in Taiwan, is most abundant in species numbers among all families, and the megascolecid Amynthas and Metaphire, having 40 and 18 species, respectively in Taiwan, comprise 79% of the earthworm fauna on this island.

Compared with the earthworm fauna of surrounding countries, the species number in Taiwan is similar to those of Korea and Japan: all between 70 and 95 species, but is much lower than those of China and Burma. Except Japan, all the above countries have endemism between 55% and 75% (Table 2). There is also evidence that many unrecognized species from Taiwan are still remaining to be described (Chen et al., 2003; Chuang et al., 2002; unpublished data) and most of them may be new species. Therefore, we would say that there are probably 100 or more earthworm species in Taiwan, and the endemism could be 70% or so.

The distribution of earthworms in Taiwan is mainly shaped by the topography and human activity on this island. Around 20 cosmopolitan species are dominant in disturbed areas in the plain regions, and only a few endemic species, such as Amynthas swanus, survive with very low population density. Endemic and cosmopolitan species are both common in mountain regions below 2,000 m in elevation, with the proportion of endemic species increasing in higher elevations. The mountain regions above 2,000 m are dominant by endemic species (Tsai et al., 2004a; unpublished data). Moreover, the numerous mountains, ravines and rivers in
Taiwan are barriers that limit the dispersal and thus gene flow of earthworms. Therefore, most of the endemic earthworms living in the mountains are not widely distributed in Taiwan, resulting in almost no overlap between the native earthworm fauna on the two sides of the Central Mountain Range, and different species compositions in northern, central and southern Taiwan (unpublished data).

Earthworms sold in fishery stores in Taiwan are generally called either “red earthworms” or “black earthworms”. The “red earthworms” refer to *Eisenia andrei* Bouché, 1972 or *Perionyx excavatus* Perrier, 1872, which are the only two species used in vermiculture in Taiwan and are frequently cultured together. The specimens previously claimed to be *Eisenia fetida* (Savigny, 1826) by Blakemore *et al.* (2006) have been double-checked using morphology and DNA sequences and are found to be *E. andrei* (unpublished data). Since *E. andrei* has never been recorded in the wild, it is currently not a member of the Taiwanese earthworm fauna. The “black earthworms” are species collected from the field, which are generally pure *Metaphire posthuma* (Vaillant, 1869) or a mixture of *Amynthas gracilis* (Kinberg, 1867), *A. corticis* (Kinberg, 1867), *M. californica* (Kinberg, 1867) and other local species.

**Pheretima complex**

The *Pheretima* complex is a group of earthworms in the Megascolecidae. It is widely distributed in northeast Australia, Pacific islands, and East and Southeast Asia, including Indonesia and the Philippines. It is composed of approximately 30 cosmopolitan species and more than 900 nominal species within 12 genera, including *Amynthas*, *Metaphire*, *Pheretima s. s.*, *Pitherma*, *Pleionogaster*, *Begemia*, *Metapheretima*, *Polypheretima*, *Planapheretima*, *Archipheretima*, *Dendropheretima* and *Isarogoscolex* (Blakemore, 2006; Easton, 1979, 1982; James, 2005a; Sims and Easton, 1972). However, the generic divisions are mainly based on phenetic studies by Sims and Easton and have many overlapping characters. Moreover, some of these genera have been suggested to be polyphyletic (James, 2005b; James *et al.*, 2009), suggesting an urgent revision of this speciose group.

In Taiwan, the two pheretimoid genera, *Amynthas* and *Metaphire*, comprise 79% of the local diversity. These two genera differ by only one character, the copulatory pouch in the male pore area: *Metaphire* has male pores within copulatory pouches while *Amynthas* has superficial male pores. However, the definition of a true copulatory pouch is now the center of dispute (Chang *et al.*, 2008a; James, 2005b; James *et al.*, 2005): some authors consider only invaginations from body walls into coeloms as copulatory pouches (e.g. James, 2005b; James *et al.*, 2005), but others consider also intramural chambers and even shallow indentations as copulatory pouches (e.g. Tsai *et al.*, 2009). For the former, James cited Gates’ words and commented (James *et al.*, 2005):

> “Gates (1975, p. 7) wrote, “Presence or absence of copulatory chambers is too vague. The really important character is whether the male pores are superficial or invaginate. In the latter case, whether in slight transverse slits or much deeper spaces still confined to the parietes or whether thick-walled copulatory chambers deeply penetrating into coelomic cavity (cf Gates 1972, p. 150)”…….We support
following the suggestion of Gates (1975) to better characterize the status of various types of non-superficial male pores. For now we support restricting Metaphire to those species distinguishable from Pheretima only by the absence of nephridia from the spermathecal ducts (Sims and Easton 1972). This would require the presence of well-developed copulatory pouches protruding into the coelom (as in Pheretima), but leaves unclear what to do with species whose copulatory pouches are entirely intramural and could thus be distinguished from Pheretima.”

James further stated in the same paper:

“The male pores [of A. huangi] are clearly not within intra-coelomic copulatory pouches, such as characterize Pheretima s.s. and perhaps Metaphire. ...... the male pores are within slight folds of the body wall. In the absence of additional evidence supporting transfer to Metaphire, we assign this species to Amynthas. Sims and Easton (1972) stated that in the absence of spermathecae, it is not possible to distinguish a Pheretima from a Metaphire. In light of the fact that Pheretima all have intracoelomic copulatory pouches appearing as domes of tissue (usually muscular in appearance) partially separable from the body wall, this must also be a characteristic of Metaphire, or Sims and Easton (1972) were wrong. We are open to both possibilities, but to date no one has adequately addressed this question. In our experience, there exist species with large intramural copulatory pouches within a thickened body wall of xviii, and these consistently fall in Metaphire. Such structures appear to us not homologous to the intracoelomic pouches of Pheretima, but we could be mistaken. Based on this we prefer to restrict Metaphire to those species with well-characterized copulatory pouches and no nephridia on the spermathecal ducts (Sims and Easton 1972), excluding those whose pores lie within wrinkles or seminal grooves, under small flaps, or within shallow indentations.”

In a similar case, James (2005b) wrote:

“The Sims & Easton (1972) stated that it is impossible to assign athecal morphs to either Metaphire or Pheretima, because one cannot check for nephridia on the spermathecal ducts, the definitive character of Pheretima. This implies that the copulatory bursae are of the same form in the two genera, but this is not the case for Taiwan Metaphire. In light of these observations, ......those working on Amythas and Metaphire should seek new characters enabling stable, phylogenetically informative genus definitions.”

Therefore, James et al. (2005) assigned their huangi, hengchunensis, kaopingensis, ailiaoensis and chaishanensis to Amythas. However, Tsai et al. (2009) argued that these species were misplaced under the genus Amythas and belong to the genus Metaphire because they have copulatory pouches. Among the 18 Metaphire species listed by Tsai et al. (2009) and in this study, the 12 species of the Metaphire formosae species group (see below) do not have intracoelomic copulatory pouches
and thus would have to be transferred to *Amynthas* if James’s idea of copulatory pouches is followed.

**Metaphire formosae** species group

The *M. formosae* species group is a monophyletic group endemic to Taiwan and locally nicknamed “snake earthworms” for their large body size. It is a member of the *Pheretima* complex and is the first species group supported by molecular phylogenetic analyses in this complex (Chang *et al.*, 2008a). Currently, a total of 15 taxa, including species and subspecies, have been discovered, and their identities have been confirmed by DNA barcode analyses. These taxa are the holandric species (species with two pairs of testes in segments 10 and 11) *M. trutina* Tsai *et al.*, 2003 and *M. tahanmonta* Chang and Chen, 2005, and the proandric species (species with one pair of testes in segment 10) *M. formosae* (Michaelsen, 1922), *M. yuhsii* (Tsai, 1964), *M. paiwanna paiwanna* Tsai *et al.*, 2000, *M. Paiwanna liliumfordi* Tsai *et al.*, 2000, *M. paiwanna hengchunensis* (James *et al.*, 2005), *M. bununa* Tsai *et al.*, 2000, *M. glareosa* Tsai *et al.*, 2000, *M. taiwanensis* Tsai *et al.*, 2004, *M. feijani* Chang and Chen, 2004, *M. nanaoensis* Chang and Chen, 2005, and an undescribed species and two undescribed subspecies of *M. taiwanensis* and *M. nanaoensis* (Chang and Chen, 2008a; Chang *et al.*, 2008a).

The *M. formosae* species group have large body sizes exceeding 30 cm in length and 1 cm in width, bluish-gray body coloration, male pores within copulatory pouches with one or two oval pads or one vestige of oval pads (Fig. 2), and four pairs of spermathecae in segments 6–9. Their burrowing behaviors and casts are also very similar. Morphologically, these species differ only in the condition of the testes, the distance between the paired spermathecal pores, and the structure of the male pores (Chang and Chen, 2004, 2005a, b; Chang *et al.*, 2008a; James *et al.*, 2005; Tsai *et al.*, 2000c, 2003, 2004b).

The study of the *M. formosae* species group started from 1922 when *Pheretima formosae* was described from southern Taiwan (Michaelsen, 1922). After that, *Pheretima yuhsii* was described from Taipei in 1964 (Tsai, 1964). In the phenetic revision of the *Pheretima* complex, Sims and Easton (1972) assigned *formosae* and *yuhsii* to *Amynthas*. In 2000, *M. paiwanna* *paiwanna*, *M. paiwanna* *liliumfordi*, *M. bununa* *bununa* and *M. bununa glareosa* were described from Pingtung, Hualien, Nantou, and Taitung, respectively in 2000 (Tsai *et al.*, 2000c). In 2003, *M. trutina* was described from northeastern Taiwan based on two specimens with three pairs of spermathecae (Tsai *et al.*, 2003). In 2004, *M. taiwanensis* was described from central Taiwan, and a new species group, the *M. stephensoni* species group, was proposed to include *M. paiwanna*, *M. bununa*, and *M. taiwanensis* (Tsai *et al.*, 2004b). Another species, *M. feijani* was later described from southern Taiwan and assigned to the *M. stephensoni* species group (Chang and Chen, 2004). *A. yuhsii* was regarded as a junior synonym of *A. formosae* in the review of Taiwanese earthworms (Tsai *et al.*, 2000a). However, in 2005, this species was corrected to *A. yuhsii* and was re-evaluated as a valid species instead of a synonym of *A. formosae* by using both morphological and molecular data. In addition, the two species were reassigned to *Metaphire* because of the presence of intramural copulatory pouches.
Fig. 2. Male pores of the Metaphire formosae species group. (A) Metaphire bununa; (B) M. feijani; (C) M. formosae; (D) M. glareosa; (E) M. nanaoensis; (F) an undescribed subspecies of M. nanaoensis; (G) M. paiwanna paiwanna; (H) M. paiwanna hengchunensis; (I) M. paiwanna liliumfordi; (J) M. tahanmonta; (K) M. taiwanensis; (L) an undescribed subspecies of M. taiwanensis; (M) M. trutina; (N) M. yuhsii; (O) an undescribed species.
(Chang and Chen, 2005a). In the same year, *A. ailiaoensis* James et al., 2005, *A. kaopingensis* James et al., 2005, *A. chaishanensis* James et al., 2005 and *A. hengchunensis* were described from southern Taiwan. Because of different opinions regarding copulatory pouches mentioned above, the authors assigned these species to *Amynthas* (James et al., 2005). The first three names were later regarded junior synonyms of *M. feijani*, *M. paiwanna paiwanna*, and *M. formosae*, respectively in the checklist of Taiwanese oligochaetes (Tsai et al., 2009). Later in 2005, *M. yuanpowa*, *M. tahanmonta* and *M. nanaoensis* were described from Taipei, Pingtung and Ilan (Chang and Chen, 2005b). The first two species were assigned to the *M. ignobilis* species group and the last species was assigned to the *M. stephensoni* species group. In addition, the monophyly of *M. formosae*, *M. paiwanna*, *M. bununa*, *M. taiwanensis*, *M. nanaoensis*, *M. yuanpowa*, and *M. tahanmonta* was first hypothesized based on morphological similarities (Chang and Chen, 2005b). In the checklist of Taiwanese earthworms (Blakemore et al., 2006), *M. yuanpowa* is regarded as a junior synonym of *M. trutina*.

By using DNA sequences of the mitochondrial cytochrome *c* oxidase subunit 1 (COI) gene, the animal DNA barcode, and other mitochondrial genes, Chang et al. (2008a) proposed a *M. formosae* species group to include the above species, provided evidence for their monophyly, revised their taxonomy and hypothesized their phylogeny. In that study, *M. bununa glareosa* was elevated to a specific status, *M. hengchunensis* was recognized as the third subspecies of *M. paiwanna*, and a cryptic species morphologically similar to *M. paiwanna* was reported. The authors also made phylogeographical inference to discuss the biogeography of earthworms in Taiwan (see Biogeography).

When the overall morphological similarity is taken into consideration, the closest relative of these Taiwanese species may be *M. riukiensis* (Ohfuchi, 1957) from Iriomote of the Ryukyu Islands. *M. riukiensis* is an octothecate, holandric species with large body size. Unlike male pores of the *M. formosae* species group, its male pores have no genital pads, and its copulatory pouches are better developed. This species may also be included in the *M. formosae* species group if supported by future molecular phylogenetic studies. According to our DNA sequence analysis (unpublished data), the second closest relative of these species might be *A. sexpectatus* Tsai et al., 1999 from central Taiwan or *M. tschiliensis* (Michaelsen, 1928) from eastern China; both are sexthecate and holandric. The latter also has C-shaped male pores and copulatory pouches.

**Intraspecific variations & synonyms**

With the growth of species numbers in Taiwan, some newly proposed names were regarded as junior synonyms (Blakemore et al., 2006; Tsai et al., 2009). Although the species checklist by Tsai et al. (2009) is followed in this study, it should be noted that some synonyms are probably a matter of opinion regarding the range of intraspecific morphological variations. For instance, *A. monsoonus* James et al., 2005 is regarded as a junior synonym of *A. tungpuensis* Tsai et al., 1999 (Tsai et al., 2009). As we know, the latter is a species with great intraspecific morphological and genetic variations and has a widespread distribution in western Taiwan (unpublished data). However, it is also possible that the morphological and
genetic variations are concordant, and the different morpho-groups are indeed different subspecies or even species. In fact, high intraspecific morphological and/or genetic variations have been observed in some other Taiwan earthworms, such as *M. paiwanna*, *M. formosae*, *M. yuhsii*, *M. glareosa*, and *A. lini*. This phenomenon suggests the urgent need for further studies on these species.

**Biogeography**

The earthworm fauna of Taiwan is similar to that of southeast China, which has the highest number of endemic species of *Amynthas* and *Metaphire*, two major genera among Taiwanese earthworms (Tsai *et al.*, 2000a, 2009). Accordingly, Tsai *et al.* (2000a, 2001) hypothesized that the ancestors of earthworms in Taiwan were mainly from southeast China, a region on the other side of the Taiwan Strait and connected with Taiwan through land bridges for several times in the past (Voris 2000; Lin *et al.*, 2002). The land bridges formed during glaciations provided opportunities for the dispersal of earthworms from China to Taiwan. Recently, our finding that the Taiwanese *M. formosae* species group and the Chinese *M. tschiliensis*, which has three subspecies, may be sister groups (unpublished data) provides further evidence to support this hypothesis.

Taiwan is a mountainous island about 170 km off the southeast coast of China. The Central Mountain Range runs north-south throughout the center of the island, with more than 200 mountain peaks exceeding 3000 m. The main island of Taiwan is the result of a collision between the Luzon Volcanic Arc and the Eurasian Continental Margin between 5 and 2.5 million years ago (Ma), a geological event known as Penglai Orogeny (Huang *et al.*, 1997, 2000; Teng, 1990), and is still rising at present. The complex topography and geological history greatly affect the distribution and diversification of the earthworm fauna on this island.

The mountains and the rivers in the Central Mountain Range have long been considered as major factors resulting in intraspecific genetic differentiation of many terrestrial and freshwater animals in Taiwan, such as mice (Hsu *et al.*, 2001), lizards (Liu, 1995), frogs (Yang *et al.*, 1994; Toda *et al.*, 1997), spiders (Lin *et al.*, 1999), and crabs (Shih *et al.*, 2006), and also earthworms. Take *M. yuhsii*, a member of the *M. formosae* species group, for example. The formation of the ancient Tamsui River about 2.5 Ma in northern Taiwan has been hypothesized to cause the divergence between its north and south populations (Chang and Chen, 2005a). Similar genetic divergences caused by the formation of rivers can also be seen in other members of this species group, such as *M. nanaoensis*, which has two populations isolated from each other by the Heping River in northeastern Taiwan, and *M. formosae* (Chang, 2005; Chang and Chen, 2005a; Chang *et al.*, 2008a). Other species that have been proved to have geographic genetic divergences include *M. paiwanna*, *M. glareosa*, *M. taiwanensis* and *A. lini* Chang *et al.*, 2007b (Chang, 2005; Chang *et al.*, 2007b, 2008a). All together, this genetic structure is clear evidence that the mountains and rivers in Taiwan are important factors in shaping intraspecific genetic differentiation in earthworms.

Recently, molecular phylogeographic studies regarding the endemic *M. formosae* species group showed the impacts of vicariance events on speciation of earthworms during the rapid uplift of the Taiwan Island (Chang, 2005; Chang *et al.*, 2008a).
This species group distributes throughout the mountain regions of Taiwan, from hills to an elevation as high as 3,000 m. Most members of it have an allopatric distribution (Fig. 3). According to those studies, the ancestors of the *Metaphire formosae* species group arrived in Taiwan before the rapid uplift of this island, probably during the late Miocene, and then dispersed throughout this island. During the period of Penglai Orogeny between 5.0 and 2.5 Ma, different populations of the ancestral species were rapidly isolated by the mountains and the rivers that formed as a result of orogenesis. This vicariance event resulted in genetic differentiation and ultimately caused speciation of the *M. formosae* species group. Similar
speciation events not only happened in the gigantic *M. formosae* species group, but also are the origin of species diversity in some small-sized earthworm groups (unpublished data). These phenomena suggest that the vicariance events caused by Penglai Orogeny are influential on the earthworm diversity in Taiwan.

According to published studies, the endemic terrestrial fauna diversity in Taiwan was generally attributed to be consequences of multiple dispersal-isolation events between Taiwan and the surrounding regions (Asia continent and Festoon Islands) (Lin et al., 2002; Ota, 1997; Ota et al., 2002; Tu et al., 2000; Yeh et al., 2004). On the contrary, although within-island speciation of animals through vicariance events caused by orogenesis in Taiwan is a familiar idea, or even regarded as cliché, only a few studies provided evidence for this hypothesis, such as the phylogeographic study of the grass lizard *Takydromus formosanus* species complex (Lin, 2003) and the case of the *M. formosae* species group. This fact demonstrates the urgent need for more studies on within-island speciation to understand the mechanisms shaping the diversity of animals in Taiwan.

**Specimen voucher & database**

The major institutions for preserving specimens of earthworms in Taiwan are the Department of Life Science in National Taiwan University and the Taiwan Endemic Species Research Institute, which collectively have a collection of more than 20,000 specimens, including most of the described species. In addition, there are also specimens deposited at the National Museum of Natural Science, National Chung Hsing University, and some other institutions.

Currently, there are two databases concerning the earthworms of Taiwan. The Database of Earthworms of Taiwan (earthworm.zo.ntu.edu.tw/earthworm/) has information of most described species, including their biology and morphology. In addition, TaiBNET (taibnet.sinica.edu.tw) has a full list of described species, including information concerning the taxonomy. The information presented in the two databases is also updated accompanying the publishing of the present study.

**Challenges & perspectives**

With the growth of understanding about earthworm diversity in Taiwan, there are also some challenges; for instance, morphological ambiguity. In earthworms, some species are morphologically very similar, but on the other hand, some species are intraspecifically highly variable. This phenomenon makes it sometimes very difficult to distinguish if two specimens belong to different or the same species, and greatly impedes the description of new species and thus our understanding of earthworm diversity. Recently, the application of DNA barcoding provides a supporting method to solve this problem. Extensive sampling has confirmed the usefulness of DNA barcodes in species identification in earthworms (Chang et al., 2007a, 2009a, b; Rougerie et al., 2009). With the aid of DNA barcodes, we are now able to know if the observed morphological variations are intraspecific or interspecific, and thus the description of new species can be accelerated, and the possibility that the same species are repeatedly described and named can be reduced.

In addition to the discovery of new species, the revision of current taxonomy, the
understanding of intraspecific morphological and genetic variations and the investigation of ecology are all important aspects of earthworm biodiversity studies, but, compared with new species description, are less studied in Taiwan. We hope that Earthworm Fauna of Taiwan can help people who are interested in earthworm biology and soil ecology avoid being bombarded by a sea of taxonomic literatures, and provide both taxonomists and amateurs a reference book for their researches.

About this catalog…

In Earthworm Fauna of Taiwan, we follow Tsai et al. (2009) for species list. The morphological data presented were compiled from published studies, especially those describing specimens from Taiwan. The data sources are listed in Reference at the end of each species description. Instead of using drawings, we made our first attempt to use pictures to present anatomical characters. Although, for earthworm taxonomists, pictures may not be as clear as drawings, they are much easier for non-specialists, such as soil ecologist and amateurs, to follow and understand. On the other hand, after being preserved in alcohol, anatomical structures usually share the colors from light brown to white, which makes it almost useless to present colors in the pictures. Therefore, pictures of anatomical characters are presented as black-and-white, which, to tell the truth, also helps for saving money! For species that are not as large as those in the *M. formosae* species group, species identification are usually not able to be done with naked eyes unless the specimens are fixed, preserved, dissected and examined under the microscope. Since live specimens are often unidentifiable, we are unfortunately not able to present pictures of live specimens for many species.
**Pontoscolex corethrurus** (Müller, 1856)

**Type locality**  Itajahy, Brazil.

**Distribution**  Cosmopolitan. This species is originally endemic to tropic America. At present it has pantropical distribution caused by human activity and is one of the most widely spread earthworms in the world. In Taiwan, this species is widely distributed throughout the island at elevations below 1,000 m. It is also recorded in the Lanyu, Siaoliouciou, Turtle and Kinmen Islands.

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Fig. 4. *Pontoscolex corethrurus.* (A) Lateral view; (B) dorsal view of clitellum and anterior body; (C) spermathecae.
**Morphology**

**External characters**

Length 92-128 mm, clitellum width 3.5-4.3 mm, segment number 167-220. Number of annuli (secondary segmentation) two in the middle portion of body, including a narrow anterior non-setal annulus and a wide posterior setal annulus. Prostomium prolobous. Setae lumbricine. Dorsal pore absent. Clitellum 14,15-21,22 (usually seven segments), length 6.5-8.8 mm, segmented, saddle-shaped, setae absent. Tubercula pubertatis 15-21. Spermathecal pores invisible. Female pore invisible. Male pores paired in 17, ventral, 0.06 circumference apart ventrally. Male pores invisible in some specimens. Nephridiopores distinct, paired, in intersegmental furrows, two longitudinal rows at the latero-ventral sides of body in the anterior segments. Live specimens pigmentless, head portion pink to light purple, clitellum orange or grayish pink, body light bluish pink, tail white. Three pairs of bright yellow spots (calciferous glands) observable externally in front of clitellum. Preserved specimens white in color, clitellum light grayish brown.

**Internal characters**


**Remarks**

*P. corethrurus* is a dominant earthworm in disturbed environments, such as parks and school campuses in cities, agricultural lands, and ditches along mountain roads in Taiwan. Its invasion occurred probably in the past five decades (Chen *et al.*, 2004), and is now causing serious problems to the soil ecosystems. For instance, *P. corethrurus* can be found in 28% of 1607 collection sites in northern Taiwan (Taipei, Ilan, Taoyuan, Hsinchu and Miaoli), and up to 8% among all the 1607 sites have only this earthworm (Chen *et al.*, 2004). It can tolerate a variety of environmental changes, has high fertility, and is capable of both sexual and parthenogenetic reproductions. These factors contribute to its dominance in many localities (eg. ~100 individuals/m² in the main campus of National Taiwan University) and make this species a strong competitor against indigenous species. In addition, it reduces the porosity and thus compacts the soil (Barros *et al.*, 2001; Chauvel *et al.*, 1999), making the soil a bad habitat for other soil-dwelling animals.

**Reference**

Aporrectodea caliginosa (Savigny, 1826)

**Type locality**  Paris region, France.

**Deposition of types**  Types in Geneva, Switzerland.

**Distribution**  Cosmopolitan, including India, Pakistan, Middle East, Europe, North Africa, South Africa, Americas, Hawaii, Japan, China, Taiwan, New Zealand, Australia. In Taiwan, it is a rare introduced species recorded at only a few localities.

**Etymology**  The specific name “*caliginosa*” literally means “foggy or misty”.

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**Fig. 5.**  Aporrectodea caliginosa. (A) Dorsal view of clitellum and anterior body; (B) male and female pores; (C) ventral view of clitellum and tubercula pubertatis; (D) spermatheca.
Morphology

*External characters*
Length 35-200 mm, clitellum width 3.5-4 mm, segment number 117-246. Prostomium epilobous. Setae lumbricine. First dorsal pore 6/7-14/15. Clitellum 27,28,29,30-34,35, saddle-shaped. Spermathecal pores two pairs in 9/10/11, lateral in cd lines. Female pores paired in 14, lateral to seta b, small slits. Male pores paired in 15, large slits, between setae b and c. Tubercula pubertatis in bc in 31 and 33, interrupted in 32, as two pairs of protuberances. Genital tumescences around ab in 9-11, 27, 30, 32-34,35. Live specimens pink to light brownish red, clitellum darker.

*Internal characters*

Remarks
This species is a member of the *A. caliginosa* species complex.

References  Blakemore, 2002; Tsai et al., 2009.
Aporrectodea trapezoides (Dugès, 1828)

Fig. 6

Aporrectodea trapezoides - Shih et al., 1999: 436; - Blakemore et al., 2006: 231; - Tsai et al., 2009: 37.

Allolobophora trapezoides - Tsai et al., 2000a: 286.

**Type locality** Montpellier, France.

**Deposition of types** Types are missing.

**Distribution** Cosmopolitan. In Taiwan, it is a very rare introduced species recorded at only a few localities.

**Etymology** The specific name indicates its trapezoid tail region.

Fig. 6. *Aporrectodea trapezoides*. (A) Ventral view of clitellum and anterior body; (B) male and female pores; (C) ventral view of clitellum and tubercula pubertatis; (D) spermathecae.
Morphology

External characters
Length 60-220 mm, clitellum width 3-7 mm, segment number 130-169. Prostomium epilobous. Tail flat or trapezoid. Setae lumbricine. First dorsal pore 6/7-13/14. Clitellum 26,27,28-34,35, saddle-shaped. Spermathecal pores two pairs in 9/10/11, near seta c lines. Female pores paired in 14, lateral to seta b, small slits. Male pores paired in 15, large slits. Tubercula pubertatis in 30,31-33,34, smooth, uninterrupted, occupying bc. Genital tumescences around ab in 9-11, and in 28, 30, 32-34. Live specimens dark gray or grayish brown.

Internal characters

Remarks
This species is a member of the A. caliginosa species complex. The name A. trapezoides has long been considered either a junior synonym of A. caliginosa or a distinct species by different authors (eg. Blakemore, 2002; Csuzdi & Zicsi, 2003 for recent examples). Recently, phylogenetic analyses based on DNA sequences suggested that it is a distinct species (Perez-Losada et al., 2009).

References Blakemore, 2002; Tsai et al., 2009.
Bimastos parvus (Eisen, 1874)

**Type locality** Mt Lebanon, New York., USA.

**Deposition of types** US National Museum, USA.

**Distribution** Cosmopolitan. It is the only cosmopolitan earthworm originally from North America. In Taiwan, it is an introduced species recorded in western Taiwan and the Kinmen Island.

**Etymology** The specific name “parvus” literally means “small or little” in Latin.

![Image](image_url)

**Fig. 7.** Bimastos parvus. (A) Lateral view; (B) ventral view of clitellum and anterior body; (C) male pore and female pore.
Morphology

External characters

Internal characters

References
Blakemore, 2002; Tsai et al., 2009.
Eiseniella tetraedra (Savigny, 1826)

Type locality  Paris, France.
Deposition of types  Paris Museum, France.
Distribution  Cosmopolitan, mainly in the temperate zone. In Taiwan, it is distributed in Shalihsien Creek (around 700 m in elevation) and Cijiawan Creek (around 1,700 m in elevation) in central Taiwan.

Morphology
External characters  Length 44-63 mm. Clitellum width 2-4 mm. Segment number 79-95. Prostomium

Fig. 8. Eiseniella tetraedra. (A) Dorsal view; (B) male pores; (C) ventral view of clitellum and tubercula pubertatis; (D) spermatheca.

**Internal characters**


**Remarks**

This species dwells in springs, lakes, mountain torrents, and swampy soil. It is the only recorded earthworm species living in freshwater habitats in Taiwan. When present, it is abundant.

**Reference**  Shen *et al.*, 2005a; Tsai *et al.*, 2009.
**Amythas aspergillum** (Perrier, 1872)

Fig. 9, PLATE 2 (A)

**Deposition of types** Museum National d’Histoire Naturelle, Paris, France.

**Distribution** China, Taiwan, Vietnam. It is distributed throughout Taiwan at low elevation regions and also recorded in the Lanyu and Kinmen Islands.

**Etymology** The specific name indicates the arrangement of its male pore papillae.

**Morphology**

**External characters**
Length 117-416 mm, clitellum width 8.5-11.3 mm, segment number 109-153. Setae 51-67 in 8, 62-69 in 20, 12-19 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores two pairs in 7/8/9. Genital papillae absent or present, if present, numbering 1-6, small, near spermathecal pores, in transverse rows. Female pore single in 14, medio-ventral. Male pores paired in 18, on top of a small, round papilla. Several papillae in 2-4 transverse rows medial to male pores, number 2-6 or more in each row, higher in the rows closer to setal lines. Male pores and the associated papillae surrounded by several circular folds. Live specimens brownish red or dark gray on dorsum, light brown on ventrum. Preserved specimens purplish brown on dorsum, light gray on ventrum and clitellum.

**Internal characters**
Septa 5/6-7/8, 10/11-13/14 greatly thickened, 8/9/10 absent. Gizzard large in 8 and 9. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 23 or 22. Last hearts in 13. Spermathecae two pairs in 7 and 8, ampulla peach-shaped, stalk short, stout; diverticulum stalk long, slender, coiled, seminal chamber oval, elongated. Accessory glands present. Ovaries paired in 13. Testis sacs two pairs in 10 and 11, ventrally connected. Seminal vesicles paired in 11 and 12, with dorsal lobes. Prostate glands large in 18, extending posteriorly to 22, divided into several pieces. Accessory glands present, corresponding to external papillae in the male pore regions.
Fig. 9. *Amynthas aspergillum*. (A-B) Male pores; (C) spermathecal pore and papillae; (D) spermathecae; (E) prostate gland; (F) caecum.

**Remarks**

*A. aspergillum* is an anecic earthworm, having permanent vertical burrows. It is the largest earthworm species that can be found in big cities in Taiwan, and is frequently seen, with its large casts, on lawns in schools and parks.

**Reference**  
Blakemore, 2006; Tsai, 1964; Tsai *et al.*, 2009.
**Amynthas bilineatus** Tsai & Shen, 2007

Fig. 10


**Type locality** A hill slope along Dongyan Creek (elevation 1,000 m), Jenai, Nantou County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 2000-3-Shen. Paratypes: same collection data as holotype.

**Distribution** Endemic to Taiwan, at elevations around 1,000 m in central Taiwan.

**Etymology**

The name *bilineatus* (*bi* = two, *lineatus* = lines) was given to this species with reference to its unique arrangement of two longitudinal lines (rows) of genital papillae on mid-ventrum of the spermathecal pore region.

Fig. 10. *Amynthas bilineatus*. (A) male pore; (B) preclitellar papillae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 96-153 mm, clitellum width 3.5-5.3 mm, segment number 89-104. Number of incomplete annuli (secondary segmentation) per segment two or three in 6-13, 17, and 18. Prostomium epilobous. Setae 44-52 in 7, 52-56 in 20, 8 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, 2.6-4.6 mm long, setae absent, dorsal pores absent. Spermathecal pores absent. Preclitellar papillae pre-setal, closely paired in two parallel and longitudinal rows on mid-ventrum of 6-9 with numbers variable among specimens and segments: in 6 one on right, one on left or paired; in 7 one on right or paired; in 8 one on left or paired; in 9 paired; in 10 paired or absent. Each papilla round, center concave, 0.3-0.5 mm in diameter, adjacent to setal line. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, 0.23-0.26 circumferences apart ventrally, each pore minute, superficial, on a round or transversely oval porophore surrounded by three or four circular folds. Genital papillae present in 19, pre-setal, each slightly medial to male pores: one pair, one on left, one on right or absent, with structure similar to that of preclitellar papillae. Preserved specimens tinted pink anteriorly, light brown after clitellum, dark brown on clitellum with lighter anterior and posterior edges.

Internal characters
Septa 5/6-7/8, 10/11-13/14 thickened, 8/9/10 absent. Gizzard round in 9 and 10. Intestine from 16. Intestinal caeca paired in 27, simple, short, surface slightly wrinkled, extending anteriorly to 25 or 24. Oesophageal hearts in 11-13, the posterior two pairs enlarged. Spermathecae absent. Accessory glands present, corresponding to external genital papillae, each round, nearly sessile or with stalk to 0.3 mm long. Testis sacs two pairs in 10 and 11, small and round. Seminal vesicles paired in 11 and 12, small, follicular, surface slightly wrinkled, with a small oval dorsal lobe. Prostate glands paired in 18, wrinkled, extending anteriorly to 17 and posteriorly to 19. Prostatic duct U-shaped, occupying 17 and 18, distal end enlarged. Accessory glands present in 19, corresponding to external genital papillae, each slightly divided into two or three round lobes with stalks 0.2-0.3 mm long.

Reference
Tsai et al., 2007, 2009.
**Amythas binoculatus** Tsai, Shen & Tsai, 1999

*Fig. 11*


**Type locality**  Wufong, Taichung County, Taiwan.

**Deposition of types**  Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1998-58.

**Distribution**  Endemic to Taiwan, recorded in northern and central Taiwan.

**Etymology**  The species was named with reference to a pair of large, disc-like genital papillae in segment 8 of this species.

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**Fig. 11. Amythas binoculatus.** (A) male pore; (B) preclitellar papillae; (C) spermathecal pore papillae; (D) prostate gland; (E) spermathecae; (F) caecum.
Morphology

External characters
Length 196 mm, clitellum width 6.3 mm, segment number 113. No secondary segmentation. Prostomium epilobous. Setae 52 in 7, 73 in 20, 16 between male pores. Clitellum 14-16, annular, 7.4 mm long, setae absent, dorsal pore absent. Spermathecal pores three pairs in 6/7/8/9, lateral, 0.53 circumference apart ventrally, with light yellowish creamy white, swollen edge. A pair of large, round, disc-like papillae in 8, occupying the entire space between setal line and 7/8 furrow, distance between the papillae 0.21 body circumference apart ventrally. Each papilla round, flat, 1.5 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, 0.41 circumference apart ventrally. Each male pore region with three large, flat, disk-like papillae surrounded by several circular folds: a lateral triangular papilla, a medio-anterior sandal-shaped papilla, and a medio-posterior sandal-shaped papilla. Each papilla with a slightly concave center. Live specimens yellow. Preserved specimens light yellow on head, dark brown on clitellum, light gray on body.

Internal characters
Septa 8/9/10 absent, 10/11/-13/14 thickened. Gizzard in 9 and 10, round. Intestine from 15. Intestinal caeca paired in 27, smooth, wrinkled, extending anteriorly to 23. Lateral hearts in 11-13. Spermathecae three pairs in 7-9, ampulla large, round or peach-shaped, 2.7 mm long, stalk short, stout; diverticulum with a seminal chamber with folliculated surface, and a straight, stout stalk about 1.2 mm long. Testis sacs two pairs in 11, small, medio-ventral. Seminal vesicles paired in 11 and 12, each with a small dorsal lobe. Prostate glands paired in 18, large, folliculated, extending anteriorly to 15 and posteriorly to 20. Prostatic duct n-shaped, proximal half enlarged. No accessory glands associated with genital papillae in both spermathecal pore and male pore regions.

Reference
Amynthas candidus (Goto & Hatai, 1898)

光澤遠環蚓

Perichaeta candida Goto & Hatai, 1898: 77.
Amynthas candidus - Shih et al., 1999: 436; - Tsai et al., 2000a: 286; - Blakemore et al., 2006: 228; - Tsai et al., 2009: 38.

Type locality  Northern Taiwan.
Deposit of types  The type is missing.
Distribution  Endemic to Taiwan, recorded in northern Taiwan.
Etymology  The specific name “candidus” literally means “shining white” in Latin.

Morphology

External characters
Length 150 mm, clitellum width 6 mm, segment number 95. Setae 44 in 7, 44 in 18, 12 between male pores. First dorsal pore 13/14. Clitellum 14-16, annular, setae absent. Spermathecal pores two pairs in 6/7/8. Genital papillae paired in 6-8, pre-setal. Female pore single in 14, medio-ventral. Male pores paired in 18, between one pre-setal and one post-setal papillae in the same segment. Coloration dark brown on dorsum, light gray on ventrum, with metallic luster.

Internal characters

Remarks
The single missing type specimen is the only record of this species known so far.

Reference  Goto & Hatai, 1898; Tsai et al., 2009.
Amynthas carnosus (Goto & Hatai, 1899)

多肉遠環蚓

Amynthas carnosus - Shen et al., 2005b: 97; - Blakemore et al., 2006: 228; - Tsai et al., 2009: 38.

Type locality  Tokyo, Japan.
Distribution  China, Korea, Taiwan, Japan, and Quelpart Island. It is recorded in Taipei and Ilan in Taiwan.
Etymology  The specific name “carnosus” literally means fleshy.

Fig. 12. Amynthas carnosus. (A) male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 130-240 mm, clitellum width 6.0-8.3 mm, segment number 76-146. Number of annuli (secondary segmentation) per segment three in 7-13. Prostomium epilobous. Setae 42-51 in 7, 54-73 in 20, 12-15 between male pores. First dorsal pore 11/12 or 12/13. Clitellum 14-16, annular, setae absent, dorsal pores absent, 3.7-6.0 mm in length. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, buried deep in intersegmental furrow, 0.26-0.27 circumferences apart ventrally. Each pore with a posterior papilla medial to it, one or two papillae placed further ventrally to each spermathecal pore, one anterior to the intersegmental furrow and the other posterior, the posterior papilla often buried deep in intersegmental furrow, each papilla small, round, 0.2-0.3 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, about 0.27 circumferences apart ventrally, each with a whitish spot in the center or with a shallow transverse slit (depression) at the middle. One pre-setal and one post-setal papillae medial to each male pore, the latter closer to male pore, each papilla 0.3-0.5 mm in diameter, round with a white center. The whole male pore area surrounded by two or three circular folds. Preserved specimens brown on dorsum, greyish on ventrum, slightly whitish around setal rings, and dark brown around clitellum.

Internal characters
Septa 5/6-7/8 and 10/11-13/14 thickened, 8/9 membranous, 9/10 absent. Gizzard large in 9-10. Intestine from 16. Intestinal caeca paired in 27, simple, extending anteriorly to 24. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, ampulla oval, large, surface wrinkled, 3.5-4.5 mm long, 2.4-2.7 mm wide, with a long, stout stalk 0.7-1.7 mm in length; diverticulum with a long, slender stalk 1.1-2.0 mm in length and an elongated seminal chamber 1.5-2.4 mm in length. Accessory glands round or slightly lobed, sessile or stalked, total length 0.4-0.9 mm, corresponding to external genital papillae. Meronephridia bush-like mass in intersegmental spaces anterior to 6/7. Testis sacs two pairs in 10 and 11, round, smooth, second pair larger. Seminal vesicles paired in 11 and 12, large, smooth, yellowish, posterior pair larger, each with a large, round dorsal lobe with a granulated surface. Prostate glands paired in 18, large, lobed, follicular, extending anteriorly to 16 and posteriorly to 20. Prostatic duct large, U-shaped, enlarged at distal half. Accessory glands round, sessile, about 0.5 mm long, corresponding to each genital papilla around male pore.

Reference
Shen et al., 2005b; Tsai et al., 2009.
**Amynthas catenus** Tsai, Shen & Tsai, 2001

**Type locality** Mt. Hohuan near the border between Hualien and Nantou counties in central Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-17-Shen. Paratypes: same collection data as for holotype.

**Distribution** Endemic to Taiwan, recorded in Mt. Hohuan, at elevations around 3,000 m in central Taiwan.

**Etymology** The name “catenus” was given to this species to indicate its “chainlike” arrangement of genital papillae in the medio-ventral portion.

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Fig. 13. *Amynthas catenus*. (A) Male pore; (B-C) male pores and associate papillae; (D) spermathecae; (E) prostate gland; (F) caecum.
Morphology

External characters

Length 61-106 mm, clitellum width 2.7-4.2 mm, segment number 85-103. Number of annuli (secondary segmentation) per segment three in 9-13, occasionally in 10-13 or 8-13. Prostomium epilobous. Setae 29-38 in 7, 41-47 in 20, 7-10 between male pores. First dorsal pore in 11/12 or 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores ventro-lateral, number highly variable: no pore, three pairs in 5/6-7/8, three pairs but lacking a right pore in 7/8, lacking a right pore in 6/7 and a left pore in 7/8, or only a single left pore in 6/7, 0.22 circumferences apart ventrally. Genital papillae medio-ventral in 5-9, in a longitudinal series like a chain, number and position highly variable: three pre-setal papillae in 6-8 and 2 post-setal ones in 7 and 8 or 0 to 9 papillae in 5-9. Generally, one pre-setal papilla and/or one post-setal papilla in a segment, each occupying the entire width of an annulus adjacent to intersegmental furrows. Occasionally, two papillae joined closely in an annulus. Each papilla round with a concave center, associated with a round, stalked accessory gland internally. Female pore single, medio-ventral in 14. Male pores paired, ventral in 18, each porophore round, circular tubercle on setal annulus, 0.23 circumferences apart ventrally. Genital papillae arranged in a longitudinal series, medio-ventral, 3 to 9 papillae from 17 to 21, similar to those in the preclitellar region in size, shape, position and arrangement. Preserved specimens whitish purple on dorsum, whitish gray on ventrum, light grayish tan on clitellum.

Internal characters

Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10, large, cylindrical. Intestine from 16 or 15. Intestinal caeca paired in 27, simple, extending anteriorly to 20 or 22. Esophageal hearts enlarged in 11-13. Spermathecae vestigial or absent, number highly variable in 6-8: six (three pairs), five, four, one, or no spermathecae, if present, size and structure highly variable: ampulla large to small, round to irregular, with or without stalk; diverticulum present, vestigial, or absent, if present, stalk long, straight, with normal seminal chamber, if vestigial, seminal chamber absent with vestigial stalk. Nephridia tufted in 5 and 6. Testis sacs two pairs in 11, large. Seminal vesicles paired in 11 and 12, small, irregular, follicular. Occasionally, small vestigial seminal vesicles (pseudovesicles) in 13. Prostate glands present or vestigial, if present, paired in 18, large, racemose, extending anteriorly to 16 and posteriorly to 21, asymmetric in position and size between left and right, prostatic duct hook-shaped, if vestigial, only ducts present. associated with a round, stalked Accessory glands present in 17-21, round, stalked, corresponding to external papillae.

Remarks

This species may be parthenogenetic.

Reference

Amynthas chilanensis Tsai & Tsai, 2007

Amynthas chilanensis Tsai et al., 2007: 362; - Tsai et al., 2009: 39.

Type locality
Along the No. 100 Forest Road (elevation 1,325m), Chilan, Ilan County, Taiwan.

Deposition of types
Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 2002-25-Shen. Paratypes: same collection data as holotype.

Distribution
Endemic to Taiwan, recorded in Chilan, Ilan County, Taiwan.

Etymology
The name *chilanensis* was given to this species with reference to its type locality at Chilan, Ilan County in northeastern Taiwan.

Fig. 14. *Amynthas chilanensis*. (A) male pore; (B) spermatheca; (C) prostatic duct; (D) caecum.
Morphology

External characters
Length 133-168 mm, clitellum width 4.7-4.8 mm, segment number 88-116. Prostomium epilobous. Setae 32-35 in 7, 47-50 in 20, 11-12 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, 3.4-4.2 mm in length, dorsal pore absent, setae absent. Spermathecal pores absent. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pore paired in 18, ventro-lateral, 0.26-0.32 circumferences apart ventrally, on a small, oval, disc-like porophore, with a small round or slightly oval genital papilla with a depressed center equal in size to or slightly smaller than that of the male porophore, on setal line immediately medial to porophore, and surrounded by three to four oval skin folds. Preserved specimens purplish brown on dorsum and light brown on ventrum, clitellum dark chocolate in colour.

Internal characters
Septa 5/6-7/8, 10/11-13/14 thickened, 8/9/10 missing. Gizzard large in 9-10. Intestine from 15. Intestinal caeca paired in 27, simple with a wide base, extending anteriorly to 23 or 24. Oesophageal hearts in 10-13. Spermathecae absent or vestigial, if vestigial, small, with an oval ampulla, a long, straight stalk, a small diverticulum, a small oval seminal chamber and a short, straight diverticulum stalk attached to the middle of the spermathecal stalk. Nephridia tufted, thick on anterior faces of 5/6/7 septa. Ovaries paired in 13, large with follicular surface. Testis sacs two pairs in 10 and 11. Seminal vesicles paired in 11 and 12, small, surface follicular, with a large dorsal lobe. Prostate glands absent, prostatic ducts U-shaped, distal end enlarged. Accessory glands absent.

Reference  Tsai et al., 2007, 2009.
Amynthas corticis (Kinberg, 1867)

**Fig. 15, PLATE 2 (B)**


**Type locality** Oahu, Hawaii.

**Deposition of types** Stockholm Museum, Sweden.

**Distribution** Cosmopolitan. This species is the most widely distributed species of the pheretimoid earthworms. It has been recorded in many countries in east and southeast Asia, Australia, New Zealand, Europe, UK, USA, South America, and South Africa. In Taiwan, it is a common species widely distributed in agricultural lands, parks and schools and in mountain regions around and below the elevation of 2,100 m and in the Kinmen Island.

**Morphology**

*External characters*

Length 96-184 mm, clitellum width 3.0-5.0 mm, segment number 93-118. Prostomium epilobous. Setae 36-40 in 7, 40-46 in 25, 10-14 between male pores. First dorsal pore 11/12 or 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, 0.28 circumference apart ventrally. Genital papillae paired pre-setal and/or post-setal in some or all of 6-9, always near spermathecal pores, in line with spermathecal pores or just median to line of pores. Female pore single in 14. Male pores paired in 18, on depressed corny pads, 0.24-0.3 circumference apart ventrally. Genital papillae present or absent, if present, one or two, small, circular, medial to male pore. Live specimens greenish brown.

*Internal characters*

Septa 5/6-7/8, 10/11-13/14 thickened, 8/9/10 absent. Gizzard in 8-10. Intestine from 15 or 16. Intestinal caeca paired in 27, simple, long slender, extending anteriorly to 23 or 24. Lymph glands present from 26. Oesophageal hearts paired in 11-13. Spermathecae four pairs in 6-9, ampulla ovoid, diverticulum blunt ovoid, with straight stalk. Ovaries in 13. Testis sacs two pairs in 10 and 11, ventrally joined. Seminal vesicles paired in 11 and 12, large, with dorsal lobe. Prostate glands well-developed, rudimentary or absent; if well-developed, paired in 18, extending anteriorly to 16 and posteriorly to 20, subdivided into three to four lobes; if
Fig. 15. *Amynthas corticis*. (A-B) male pores; (C) preclitellar papillae; (D) spermatheca; (E) prostatic duct; (F) caecum.

rudimentary, small or duct only.

**Reference**  
**Amynthas cruxus** Tsai & Shen, 2007

**Fig. 16**


**Type locality** Tengchih (elevation 1,500 m), Taoyuan, Kaohsiung County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 2000-71-Shen. Paratype: same collection data as holotype.

**Distribution** Endemic to Taiwan, recorded in the southwestern part of the Central Mountain Range, at elevations between 900 and 1,700 m in Kaohsiung County.

**Etymology** The name *cruxus* (cross) was given to this species with reference to the cross formation of the genital papillae around the male pore.

*Fig. 16. Amynthas cruxus.* (A) male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

**External characters**

Length 100-170 mm, clitellum width 3.3-4.8 mm, segment number 91-120. Number of incomplete annuli (secondary segmentation) per segment two to three in 7-13. Prostomium epilobous. Setae 27-37 in 7, 39-52 in 20, 11-13 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent, dorsal pores absent, 2.1-3.4 mm long. Spermathecal pores four pairs in 5/6-8/9, lip-like, about 0.31 circumferences apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, 0.24-0.26 circumferences apart ventrally, on a teat-like porophore on a flat, diamond-shaped disc (male disc) with four genital papillae arranged in the form of a cross around the porophore: one anterior, one posterior, one lateral, and one medial, surrounded by three to four diamond-shaped skin folds. Each papilla about 0.2 mm in diameter, white in colour, with a slightly depressed center. Preserved specimens light greyish brown on dorsum, light grey on ventrum, brown around clitellum.

**Internal characters**

Septa 5/6/7/8, 10/11-13/14 thickened, 8/9/10 absent. Gizzard in 9-10, bell-shaped. Intestine from 15 or 16. Intestinal caeca paired in 27, simple, stocky, extending anteriorly to 24 or 25. Oesophageal hearts in 11-13. Spermathecae four pairs in 6-9, large, ampulla oval to pear-shaped, 1.9-2.6 mm long, 1.4-1.8 mm wide, with a slender to stout spermathecal stalk of 0.6-1.0 mm in length, diverticulum with a round or oval, iridescent seminal chamber, 0.5-0.8 mm in length, and a slender stalk of 0.9-1.2 mm in length, diverticulum stalk slightly longer than spermathecal stalk. No accessory glands in the preclitellar region. Testis sacs two pairs in 10 and 11, round, shiny. Seminal vesicles paired in 11 and 12, large, finely folliculated, each with a round or cone-shaped dorsal lobe. Prostate glands paired in 18, lobed, wrinkled, extending anteriorly to 17 and posteriorly to 20, prostatic duct unusually large, U-shaped, occupying three segments in 16-18, proximal half slender and distal half enlarged. No accessory glands in the postclitellar region.

**Reference**

Amynthas exiguus aquilonius
Tsai, Shen & Tsai, 2001

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Amynthas exiguus aquilonius Tsai et al., 2001: 277; - Tsai et al., 2004a: 6; - Blakemore et al., 2006: 228; - Tsai et al., 2009: 39.

Type locality  Mt. Hohuan (elevation 3,000 m), Hualien County, along Rd. 14A near the border with Nantou County, Taiwan.

Deposition of types  Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-8-Shen. Paratypes: coll. no. 1999-24-Shen.

Distribution  Endemic to Taiwan, recorded at medium and high elevations in central and southern Taiwan.

Etymology  The name “aquilonius” was given to this subspecies to indicate that it has a distribution north of A. exiguus exiguus (Gates).

Fig. 17. Amynthas exiguus aquilonius. (A-B) Male pores and the associate papillae; (C) preclitellar papillae; (D) spermatheca; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 39-63 mm, clitellum width 1.9-2.6 mm, segment number 70-84. No secondary segmentation, setal line clearly elevated in preclitellar region. Prostomium prolobous or epilobous. Setae 26-35 in 7, 28-38 in 20, 5-9 between male pores. First dorsal pore 6/7. Clitellum 14-16, annular, dorsal pore absent, setae absent, length 2.0-3.2 mm. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, each in depressed furrow, about 0.45 circumferences apart ventrally. Genital papillae present in 7-9, in longitudinal rows slightly medial to spermathecal pores, number on each side pre-setal 0-4 and post-setal 0-2 in 7, pre-setal 1-5 and post-setal 0-2 in 8, pre-setal 0-6 and post-setal 0-2 in 9. An additional pre-setal papilla present medio-ventral in 8 and 9 or one papilla immediately behind each spermathecal pore in 5/6-7/8 for some specimens. Each papilla small, round, tubercle-like, surrounded by a circular fold, its size about 1/3 to 1/4 distance between setal line and segmental furrow. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, 0.23-0.30 circumferences apart ventrally, porophore large, round, smooth, slightly elevated, with a male aperture inconspicuous on lateral concave area. Genital papillae present in, 17-20, in two longitudinal rows fairly similar to arrangement in the preclitellar region, number on each side pre-setal 0-1 and post-setal 0-5 in 17, pre-setal 1-6 and post-setal 1-4 in 18, pre-setal 1-6 and post-setal 0-2 in 19. Sometimes, an additional post-setal papilla present medio-ventral in 18 or an additional pair of pre-setal papillae present in 20. Each papilla small, round, center flat or slightly concave, 0.2-0.3 mm in diameter, about 1/2 distance between setal line and segmental furrow, surrounded by a circular fold. Preserved specimens dark reddish brown on dorsum, light gray on ventrum, light grayish brown around clitellum.

Internal characters
Septa 8/9/10 absent, 10/11-12/13 thickened. Gizzard round in 9 and 10. Intestine from 15. Intestinal caeca paired in 27, simple, surface slightly wrinkled, extending anteriorly to 24-22. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, ampulla peach-shaped, stalk straight, much shorter than ampulla, diverticulum vestigial, short, seminal chamber rudimentary or absent, length shorter to slightly longer than spermathecal stalk, straight or slightly bent, originating 1/3 distance from spermathecal pore to ampulla. Accessory glands present, each round, stalked, corresponding to each external genital papilla. An accessory gland present at proximal end of spermathecal stalk near spermathecal pore, indicating presence of a genital papilla submerged within each spermathecal pore, but undetectable outside. Testis sacs two pairs in 10 and 11, small, round. Seminal vesicles paired in 11 and 12, large, surface wrinkled, follicular, with dorsal lobes. Prostate glands paired in 18, large, wrinkled, extending anteriorly to 16 and posteriorly to 20, prostatic duct C-shaped, distal end enlarged. Accessory glands present, similar in structure to those in the spermathecal region.

Reference
**Amynthas fenestrus** Shen, Tsai & Tsai, 2003

**Type locality** Rueyen Creek Nature Reserve (elevation 2,300 m), Nantou County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-24-Shen. Paratypes: same collection data as for holotype.

**Distribution** Endemic to Taiwan, recorded at elevations between 1,800 and 2,300 m in central Taiwan.

**Etymology** The name *fenestrus* was given to this species to indicate the window-like, paired genital papillae in the preclitellar region.

Fig. 18. *Amynthas fenestrus*. (A) male pores and the associate papillae; (B) preclitellar papillae; (C) spermathecae; (D) prostate gland; (E) caecum.
Morphology

External characters

Length 60-73 mm, clitellum width 2.6-2.9 mm, segment number 83-103. Number of incomplete annuli (secondary segmentation) per segment 2-3 in 9-13, 17 and 18. Prostomium epilobous. Setae 30-36 in 7, 33-43 in 20, 8-10 between male pores. First dorsal pore 5/6 or 6/7. Clitellum 14-16, annular, 2.2-3.4 mm long, setae absent, dorsal pore absent. Spermathecal pores three pairs in 6/7-8/9, ventro-lateral in depressed furrow, 0.31-0.34 circumference apart ventrally. Genital papillae pre-setal, widely paired in 9, close to intersegmental furrow, 5 or 6 intersetal distances apart. Each papilla large, round, concave, about 0.3 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, 0.26-0.3 circumferences apart. One or two round papillae adjacent laterally to each male pore. Additional papillae absent or present, if present, large, widely paired, pre-setal, immediately posterior to 17/18, and/or post-setal on medio-ventrum, closely paired or missing one of them. Each papilla round, center concave, about 0.3 mm in diameter. Preserved specimens brownish gray on dorsum, light gray on ventrum, light brownish gray around clitellum.

Internal characters

Septa 5/6-7/8, 10/11-12/13 thickened, 8/9/10 absent. Gizzard round in 9-10. Intestine from 15. Intestinal caeca paired in 27, simple, short, stocky, surface slightly wrinkled, extending anteriorly to 25 or 24. Esophageal hearts in 11-13. Spermathecae three pairs in 7-9, ampulla peach-shaped, about 1.0 mm long and 0.9 mm wide, stalk stout, 0.4-0.5 mm long, diverticulum stalk slightly bent or curved, 0.5-0.7 mm long, seminal chamber oval-shaped, 0.4 mm long. Accessory glands large, oval-shaped or divided into 3 or 4 round lobes, each lobe 0.3-0.5 mm long, stalk short, corresponding to external genital papillae. Testis sacs two pairs in 11, round. Seminal vesicles large, extending between segments 11 and 13, surface wrinkled, follicular, each with a large dorsal lobe with folliculated surface. Prostate glands paired in 18, wrinkled, extending anteriorly to 16 and posteriorly to 20, prostatic duct C-shaped. Accessory glands round, sessile or with stalk.

Reference

Shen et al., 2003b; Tsai et al., 2009.
Amynthas gracilis (Kinberg, 1867)

Type locality  
Rio de Janeiro, Brazil.

Deposition of types  
Leiden Museum, Netherlands.

Distribution  
Cosmopolitan. In Taiwan, it is a common species distributed in the regions below the elevation of 2,100 m and in the Kinmen Island.

Etymology  
The specific name “gracilis” literally means gracile in Latin.

Fig. 19. Amynthas gracilis. (A-C) Male pores; (D) spermatheca; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 60-158 mm, clitellum width 3.8-5 mm, segment number 71-98. Prostomium epilobous. Setae 37-46 in 8, 56-59 in 20, 14-19 between male pores. First dorsal pore 10/11 or 11/12. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores three pairs in 5/6-7/8, 0.25-0.3 circumference apart ventrally. Female pore single, medio-ventral in 14. Male pores paired in 18, on small circular porophores, lateral to one or more pairs of small post-setal genital markings (small discs). Live specimens dark red with white clitellum.

Internal characters

Reference
Blakemore, 2002; James et al., 2005; Tsai, 1964; Tsai et al., 2004a, 2009.
**Amynthas hohuanmontis**
Tsai, Shen & Tsai, 2002

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**Type locality**  Mt. Hohuan (elevation 3,000 m), along Rd. 14A in Hualien County, near the border with Nantou County, Taiwan.

**Deposition of types**  Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-17-Shen. Paratypes: same collection as holotype.

**Distribution**  Endemic to Taiwan, recorded in Mt. Hohuan, at elevations around 3,000 m, Nantou and Hualien counties, Taiwan.

**Etymology**  The name *hohuanmontis* was given to this species with reference to its type locality at Mt. Hohuan in central Taiwan.

Fig. 20. *Amynthas hohuanmontis*. (A) Male pore and associate papillae; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 73-113 mm, clitellum width 3.4-4.4 mm, segment number 85-103. Number of annuli (secondary segmentation) per segment three in 6-13. Prostomium tanylobous. Setae 32-41 in 7, 42-46 in 20, 9-11 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, 2.5-5.3 mm long, 0.72-1.21 times longer than width, dorsal pores absent, setae absent. Spermathecal pores variable from three pairs in 5/6/7/8 to absent. Genital papillae absent in preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, 0.26-0.29 circumference apart ventrally. Porophores small, papilla-like or indistinct, male apertures invisible, but each with two genital papillae, one anterior and one posterior, or with three papillae, one anterior, one posterior and one lateral, and then surrounded by four to six circular folds, each papilla round, center flat or slightly convex, 0.2-0.3 mm in diameter, surrounded by a circular fold. A horizontal row of genital papillae, one to three (usually two) in number, just medial to each of the male pore regions, immediately posterior to setal line, each papilla similar in size and structure to those associated with the male pores. Preserved specimens light greyish brown on dorsum, light grey on ventrum, dark brown around clitellum.

Internal characters
Septa 5/6-7/8, 10/11-12/13 thickened, 8/9/10 absent. Gizzard round in 9 and 10. Intestine from 15. Intestinal caeca paired in 27, simple, surface slightly wrinkled, extending anteriorly to 24-22. Esophageal hearts in 11-13. Spermathecae variable from three pairs in 6-8 to absent. Accessory glands absent in preclitellar region. Testis sacs two pairs in 11, or anterior pair in 10/11 (partly in 10 and 11) and posterior in 11, each small, round or oval. Seminal vesicles paired in 11 and 12, surface smooth or folliculate, with a granulate dorsal lobe. Prostate glands variable from normal to absent, prostatic ducts normal, large, C- or S-shaped. Accessory glands round with stalk, corresponding to genital papillae in 18.

Remarks
This species may be parthenogenetic.

Reference
Tsai et al., 2002, 2009.
Amynthas hupeiensis (Michaelsen, 1895)


Amynthas hupeiensis - Shih et al., 1999: 436; - Tsai et al., 2000a: 287; - Chang et al., 2001: 76; - Chen et al., 2002: 77; - Chuang et al., 2002: 68; - Tsai et al., 2004a: 6; - Blakemore et al., 2006: 228; - Tsai et al., 2009: 39.

Type locality Hupei, China.

Deposition of types The type is missing.

Distribution China, Japan, Korea, Taiwan, North America, and New Zealand. In Taiwan, it is distributed in northern and central Taiwan and the Kinmen Island.

Etymology This species was named after Hupei Province of China.

Fig. 21. Amynthas hupeiensis. (A) Male pore and associate papillae; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

**External characters**

Length 40-170 mm, clitellum width 3-5 mm, segment number 119-132. Prostomium epilobous. Setae 100-121 in 8, 79-88 in 20, 14 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores three pairs in 6/7-8/9, ventral, near the line of male pores. Female pore single in 14. Male pores paired in 18, ventral, on the center of a round papilla. Large discs paired postsetal in 17 and presetal in 19, just medial to male pores, oval, center concave. Live specimens greenish brown or greenish gray. Preserved specimens dark green on dorsum, light green on ventrum.

**Internal characters**


**Reference**

Blakemore, 2002; Tsai, 1964; Tsai et al., 2009.
Amynthas incongruus (Chen, 1933)

Fig. 22, PLATE 3 (A)

Amynthas incongruus - Shih et al., 1999: 436; - Tsai et al., 2000a: 287; - Tsai et al., 2004a: 6; - James et al., 2005: 1025; - Blakemore et al., 2006: 228; - Tsai et al., 2009: 40.
Amynthas incongrua - Chuang et al., 2002: 69; - Chen et al., 2003: 58.

Type locality Yun-Feng, Lin-hai-Hsien, Chekiang Province, China.
Deposition of types United States National Museum, USA.
Distribution China and Taiwan. In Taiwan, it is recorded from northern, northeastern, central, and southern Taiwan, and the Kinmen Island.
Etymology The specific name “incongruus” literally means incongruous in Latin.

Fig. 22. Amynthas incongruus. (A) Male pore; (B) male pores and associate papillae; (C) spermatheca; (D) prostate gland; (E) caecum.
Morphology

External characters

Length 82-207 mm, clitellum width 4.2-5.5 mm, segment number 157-167. Number of annuli (secondary segmentation) per segment three after 5. Setae 51-56 in 8, 44-58 in 20, 9-10 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores two pairs in 5/6/7, genital papillae present or absent, if present, paired in 6 and/or 7, pre- and/or post-setal, slightly medial to spermathecal pores, each papilla round, additional smaller papillae present near spermathecal pores. Female pore single in 14, medio-ventral. Male pores paired in 18, on a round papilla, with 3-7 similar papillae around it, surrounded by several circular folds. In some specimens, several pre-setal papillae present medio-ventral in 18, just between the paired male pores. Live specimens semitranslucent, light red on dorsum with numerous irregular white spots. Preserved specimens light brown on dorsum, light gray on ventrum, purplish gray on clitellum.

Internal characters

Septa 6/7/8 and 10/11-12/13 thickened, 8/9/10 absent. Gizzard in 9 and 10. Intestine from 14 or 15. Intestinal caeca paired in 26, simple, extending anteriorly to 23. Last hearts in 13. Spermathecae two pairs in 6 and 7, ampulla elongated, oval, stalk slender, approximately equal to the length of ampulla, diverticulum absent or small with a round seminal chamber. Accessory glands present, corresponding to external papillae in the spermathecal pore region. Ovaries paired in 13. Testis sacs two pairs in 10 and 11, large. Seminal vesicles paired in 11 and 12, small, with elongated oval dorsal lobe, anterior one included in testis sacs. Prostate glands paired in 18, extending anteriorly to 16 and posteriorly to 20 or 21, divided into several lobes. Accessory glands present, corresponding to external papillae in the male pore region.

Reference

Tsai, 1964; Tsai et al., 2009.
**Amynthas lini**
Chang, Lin, Chen, Chung & Chen, 2007

林氏遠環蚓


**Type locality**  Wulai, Taipei County, Taiwan.

**Deposition of types**  Institute of Zoology, National Taiwan University, Taipei. Holotype: cat. no. 14-02815. Paratypes: cat. no. 14-02801, 14-02814, 14-7292, 14-7291, 14-03864, 14-05451.

**Distribution**  Endemic to Taiwan, recorded in mountainous areas of northern and central Taiwan, at elevations from 400 to 3,000 m.

**Etymology**  The species epithet was given in honor of the Taiwanese zoologist Dr. Yao-Sung Lin, who promoted earthworm studies in Taiwan in the 1990s and 2000s.

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Fig. 23. *Amynthas lini*. (A-B) Male pores and associate papillae; (C) preclitellar papillae; (D) spermathecae; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 212-254 mm, clitellum width 7.0-9.0 mm, segment number 117-129. Number of annuli (secondary segmentation) per segment 3 in 6 and beyond. Prostomium epilobous. Setae 20-26 in 5, 33-45 in 7, 49-57 in 10, 8-17 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, 0.40 circumference apart ventrally. Genital papillae present or absent, if present, papillae pre-setal, post-setal, or both, pre-setal papillae 1-4 pairs in 7-10, each papilla large, round, disc-like, distance between paired genital papillae about 0.10-0.30 circumference apart ventrally, sometimes only one papilla present on some segments, post-setal papillae two pairs in 7 and 8, similar to pre-setal ones but smaller, about 0.40 circumference apart ventrally, sometimes only one papilla present on some segments. Female pore single, medio-ventrally in 14. Male pores paired in 18, latero-ventral, about 0.33 circumference apart ventrally, porophores round or oval on setal line, with a concave center surrounded by 2 or 3 circular folds. Genital papillae post-setal, paired in 19, an additional pair in 17, an additional pair in 20, or two additional pairs in 17 and 20 present in some specimens, each papilla oval, with a concave center surrounded by a few circular folds. Preserved specimens dark brown on dorsum and around clitellum, light yellow on ventrum and setal lines, forming a striped or banded appearance composed of a dark brown circular band and a light yellow one in sequence.

Internal characters
Septa 5/6-7/8 thickened, 8/9/10 absent, 10/11-13/14 greatly thickened. Gizzard round in 10. Intestine from 15. Intestinal caeca paired in 27, simple, surface slightly folded with the septa, extending anteriorly to 23 or 22. Lateral hearts in 11-14. Spermathecae four pairs in 6-9, with a short thick stalk about 0.45mm long, ampulla round, about 3.0 mm in diameter, diverticulum with a small oval seminal chamber of 2.1 mm and a slender, straight stalk of 1.7 mm. Nephridia tufted, attached to post-segmental septa, surrounding segmental chambers anterior to septum 6/7. No nephridia on spermathecal ducts. Ovaries paired in 13, medio-ventral, close to septum 12/13. Testis sacs two pairs in 10 and 11, small, irregular. Seminal vesicles paired in 11 and 12, large. Prostate glands paired in 18, large, extending anteriorly to 16, with a thick straight duct. Accessory glands paired in 19, with positions corresponding to external papillae.

Remarks
This species is one of the three members of the *Amynthas wulinensis* species complex.

Reference
Chang et al., 2007b; Tsai et al., 2009.
**Amynthas meishanensis**  
Chang, Lin, Chen, Chung & Chen, 2007

**Type locality** Meishan, Chiayi County, south-central Taiwan.

**Deposition of types** Institute of Zoology, National Taiwan University, Taipei.  

**Distribution** Endemic to Taiwan, recorded at elevations around 600 m in central Taiwan.

**Etymology** The species epithet was given with reference to the type locality, Meishan in Chiayi County in Taiwan.

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Fig. 24. *Amynthas meishanensis*. (A-B) Male pores and associate papillae; (C) preclitellar papillae; (D) spermathecae; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 38-65 mm, clitellum width 2.7-3.5 mm, segment number 51-113. One annulus (secondary segmentation) per segment on all segments. Prostomium epilobous. Setae 27-31 in 5, 35-42 in 7, 41-48 in 10, 5-8 between male pores. First dorsal pore 10/11. Clitellum 14-16, annular, seta absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, lateral, about 0.5 circumference apart ventrally, two pairs of papillae present in each of 7 and 8, one pre-setal and one post-setal, some specimens lacking papillae to varying extent, some specimens having no spermathecal papillae, some specimens have an additional post-setal papilla in 6, each papilla small, round, distance between paired genital papillae about 0.20 circumference apart ventrally. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, about 0.35 circumference apart ventrally, porophores round or oval on setal line, surrounded by 5-7 circular folds. Genital papillae post-setal, paired in 17 and 19, some specimens having only the left papilla in 19, some specimens having an additional papilla or an additional pair of papillae in 20, each papilla small, oval, with concave center. Preserved specimens reddish brown on dorsum, light yellowish brown on ventrum.

Internal characters
Septa 8/9/10 absent, 10/11-13/14 thickened. Gizzard round in 7-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 24. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, with a short stalk about 0.2 mm long and a peach-shaped or oval ampulla about 0.6-1.0 mm long, diverticulum with a peach-shaped seminal chamber and a straight stalk about as long as seminal chamber. No nephridia on spermathecal ducts. Ovaries paired in 13, medio-ventral, close to septum 12/13. Testis sacs two pairs in 10 and 11, small, irregular. Seminal vesicles paired in 11 and 12, large. Prostate glands paired in 18, large, extending anteriorly to 17 and posteriorly to 20, with a thick duct.

Remarks
This species is one of the three members of the *Amythas wulinensis* species complex.

Reference
Chang *et al.*, 2007b; Tsai *et al.*, 2009.
**Amynthas minimus** (Horst, 1893)

**Microscoleididae**


**Type locality** Tjibodas, Java.

**Deposition of types** Leiden Museum, Netherlands.

**Distribution** Cosmopolitan, recorded in East and Southeast Asia, USA, Hawaii, South Africa, Madagascar, Samoa and Australia. In Taiwan, it is recorded in northern and central Taiwan and the Kinmen Island.

**Etymology** This species was named with reference to its small body size.

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Fig. 25. *Amynthas minimus*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
**Morphology**

**External characters**
Length 22-60 mm, clitellum width 1.5-2.5 mm, segment number 74-100. Prostomium epilobous. First dorsal pore 11/12 or 12/13. Clitellum 14-16, annular. Spermathecal pores one pair in 5/6 or absent. Female pore single in 14, medio-ventral. Male pores paired in 18, on simple circular poropores. Live specimens light red to reddish white.

**Internal characters**

**Reference**
Blakemore, 2002; Tsai et al., 2009.
**Amythas morrisi** (Beddard, 1892)


**Amythas morrisi** - Shih et al., 1999: 436; - Tsai et al., 2000a: 287; - Chuang et al., 2002: 69; - Tsai et al., 2004a: 6; - Blakemore et al., 2006: 228; - Tsai et al., 2009: 40.

**Type locality**  Kew Gardens from Penang/Hong Kong.

**Deposition of types**  British Museum, England.

**Distribution**  Cosmopolitan, In Taiwan, it is distributed from the coastal plain to the Central Mountain Range to the elevation of 1,100 m and the Kinmen Island.

**Etymology**  This species was named after Mr. Morris.

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Fig. 26. *Amythas morrisi*. (A) Male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 75-126 mm, clitellum width 3-4.3 mm, segment number 80-156. Prostomium epilobous. Setae 56 in 8, 58 in 20, 13-15 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores two pairs in 5/6/7, ventro-lateral, 0.4 circumference apart ventrally. Genital papillae present or absent, if present, small, number and position variable, in 5-7, 6 and 7, or 7 only, mid-ventral or just medial to spermathecal pores. Female pore single in 14, medio-ventral. Male pores paired in 18, slightly medial to a pair of adjacent pre- and post-setal papillae, surrounded by several circular folds, 0.3 circumference apart ventrally, additional pre-setal papillae present in 18 and/or 19 in some specimens. Preserved specimens bright brownish gray or dark brown on dorsum, light gray on ventrum, reddish brown on clitellum.

Internal characters
Septa 5/6-7/8 greatly theakened, 8/9/10 absent, 10/11-14/15 thickened. Gizzard in 9 or 8-9. Intestine from 15. Intestinal caeca simple, paired in 27, extending anteriorly to 24. Lateral hearts paired in 10-13. Spermathecae two pairs in 6 and 7, ampulla oval or pear-shaped, stalk slender, straight, diverticulum slender with a thin stalk and a dilated, elongated bulb. Nephridia meroic, in 4-7 numerous tubules or tufted, micro-nephridia present from 8 posteriorly. Ovaries paired in 13. Testis sacs two pairs in 10 and 11, large. Seminal vesicles paired in 11 and 12. Prostate glands paired in 18, racemose, extending anteriorly to 17/18 and posteriorly to 20 or 21, duct straight or in single loops.

Reference
Blakemore, 2002; Tsai, 1964; Tsai et al., 2009.
**Amynthas nanrenensis**
James, Shih & Chang, 2005

南仁遠環蚓


**Type locality** Nanrenshan, Kending, Pingtung County, Taiwan.


**Distribution** Endemic to Taiwan, recorded in Nanrenshan, Kending, Pingtung County.

**Etymology** This species was named after its type locality, Nanrenshan or Mt. Nanren.

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**Fig. 27.** *Amynthas nanrenensis*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 97 mm, clitellum width 4.2 mm, segment number 98. No secondary segmentation. Prostomium epilobous. Setae 60-64 in 7, 62-72 in 20, 10-12 between male pores. First dorsal pore 11/12 or 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, ventral, 0.22 circumference apart ventrally. Female pore single in 14. Male pores paired in 18, distance between the paired pores 0.21 circumference apart ventrally, each flanked by two circular 0.2 mm genital markings closely median, lateral to male pores. Unpigmented.

Internal characters
Septa 5/6-7/8 greatly thickened, 8/9/10 absent, 10/11-13/14 thickened. Gizzard in 8-10. Intestine from 16. Lymph glands present from 27. Intestinal caeca simple in 27, extending anteriorly to 23. Oesophageal hearts paired in 12 and 13. Spermathecae four pairs in 6-9, ampulla ovoid, diverticulum short, reaching the middle of ampulla, with elongated ovoid to almond shaped seminal chamber and slender straight stalk. Ovaries in 13. Testis sacs two pairs in 10 and 11, ventrally jointed. Seminal vesicles paired in 11 and 12, large, with dorsal lobe. Prostate glands paired in 18, two or three main lobes, ducts thick.

Reference
James et al., 2005; Tsai et al., 2009.
**Amynthas nanshanensis**
Shen, Tsai & Tsai, 2003

**Type locality**  A mountain slope along Nanshan Creek (elevation 800-900 m), Jenai Township, Nantou County, Taiwan.

**Deposition of types**  Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-20-Shen. Paratypes: same collection data as for holotype.

**Distribution**  Endemic to Taiwan, recorded at Nanshan Creek and Mt. Beidongyan (elevation 800-1,800 m) in central Taiwan.

**Etymology**  The name "nanshanensis" was given with reference to the type locality, Nanshan Creek.

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**Fig. 28. Amynthas nanshanensis.** (A) Male pore and associate papillae; (B-C) preclitellar papillae; (D) spermatheca; (E) prostate gland; (F) caecum.
**Morphology**

**External characters**

Length 41-89 mm, clitellum width 2.2-3.0 mm, segment number 50-104. Number of incomplete annuli (secondary segmentation) per segment 2-3 in 9-13. Prostomium epilobous. Setae 28-36 in 7, 34-44 in 20, 8-12 between male pores. First dorsal pore 5/6. Clitellum 14-16, annular, 1.9-3.2 mm long, setae absent, dorsal pores absent. Spermathecal pores four pairs in 5/6-8/9, 0.33-0.34 circumference apart ventrally. Genital papillae present or absent in 7-9, if present, in 7, pre-setal papillae single, medial ventral; in 8, pre-setal papillae single median, paired, single median with one on right or left, single median with one on both sides, two median with one on either side, or six papillae, post-setal papillae single on right or left or two; in 9, pre-setal papillae one on left or two; each papilla round, center concave, 0.2-0.4 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, 0.24-0.29 circumference apart ventrally, each with a lateral papilla closely adjacent, both male pore and papilla surrounded by 2 or 3 slight circular folds. Genital papillae present or absent, if present, widely paired, pre-setal in 18 and 19, slightly medial to male pores, paired, single on right, or single on left, each papilla round, center concave, about 0.2 mm in diameter, similar in structure to those in the preclitellar region. Preserved specimens purplish brown on dorsum, light gray on ventrum, yellowish gray around clitellum.

**Internal characters**

Septa 5/6-7/8, 10/11-13/14 thickened, 8/9/10 absent. Gizzard round in 9 and 10. Intestine from 14 or 15. Intestinal caeca paired in 27, simple, surface slightly wrinkled, short, extending anteriorly to 25. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, ampulla peach-shaped, 1.0-1.5 mm long, 0.6-1.5 mm wide, duct stout, 0.5 mm long, diverticulum stalk slender, about 0.5 mm long, seminal chamber oval, about 0.5 mm long. Accessory glands large, round, about 0.5 mm in diameter, stalk short, about 0.2 mm long, corresponding to external genital papillae. Testis sacs two pairs in 11, round. Seminal vesicles paired in 11 and 12, large, each occupying about 1.5 segments, follicular. Prostate glands paired in 18, extending anteriorly to 17 and posteriorly to 20, prostatic duct C-shaped. Accessory glands smaller than those in preclitellar region, slightly lobed, stalk 0.1-0.3 mm long, head 0.1-0.3 mm long. No gland associated with papilla lateral to male pore.

**Reference** Shen *et al.*, 2003b; Tsai *et al.*, 2009.
Amynthas papilio (Gates, 1930)

Type locality  San Hlan, Burma.
Deposition of types  Zoological Survey of India, India.
Distribution  Burma, the Iriomote Island of the Ryukyus, Japan and Taiwan. In Taiwan, it is recorded in the main campus of National Taiwan University and in the campus of Hsin-Chu Girl’s High School.
Etymology  This species was named with reference to its papilionaceous male pore region.

Fig. 29. Amynthas papilio. (A) Male pores; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology
External characters
Length 40-70 mm, clitellum width 2 mm, segment number 117-119. Prostomium epilobous. Setae 37-41 in 7, 11 in 17, 80 in 20, 6-8 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, 2 mm long, setae absent, dorsal pore absent. Spermathecal pores one pair in 5/6, ventral, not easily visible, 0.21 circumference apart ventrally. Genital papillae one pair in 5, post-setal, anterior to the spermathecal pores, each circular in shape with a slightly convex center. Female pore single, medio-ventral in 14. Male pores closely paired, ventral in 18, distance between the pores 0.18 circumference apart ventrally, the pore regions with elliptical skin pads like butterfly wings extending from anterior border of 17 to the setal line of 19, porophores located at the posterior end of longitudinal slits of the pads. Preserved specimens white in color, clitellum yellow.

Internal characters
Septa 5/6/7 thickened, 8/9/10 absent. Gizzard in 9-10, peach-shaped. Intestine from 15. Intestinal caeca paired in 26, simple, surface wrinkled, extending anteriorly to 24. Spermathecae one pair in 6, ampulla oval, about 1.5 mm long, 0.7 mm wide, stalk slender, 1.5 mm in length, equivalent to that of ampulla, diverticulum with a long striped seminal chamber of 0.7 mm long and a stalk of about 1.2 mm long. Testis sacs one pair in 10, ventral, small, not easily visible. Seminal vesicles paired in 11 and 12, large, with dorsal lobe. Prostate glands paired in 18, large, extending anteriorly to 15 and posteriorly to 21, ducts 2 mm long, L-shaped.

Reference Chen & Chuang, 2003; Tsai et al., 2009.
Fig. 30. *Amynthas papulosus*. (A) Male pore; (B) male pores and genital papillae; (C) spermatheca; (D) prostate gland; (E) caecum.
Morphology

External characters

Internal characters

Reference
Blakemore, 2002; Michaelsen, 1922; Tsai et al., 2009.
Amynthas penpuensis Shen, Tsai & Tsai, 2003

Type locality A mountain slope along Penpu Creek, Jenai Township, Nantou County, Taiwan.

Deposition of types Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-21-Shen. Paratypes: same collection data as for holotype.

Distribution Endemic to Taiwan, recorded from Nanshan and Penpu Creeks at elevations between 700 and 900 m in central Taiwan.

Etymology The name “penpuensis” was given with reference to the type locality, Penpu Creek.

Fig. 31. Amynthas penpuensis. (A) Male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 55-104 mm, clitellum width 2.2-3.2 mm, segment number 62-104. Number of incomplete annuli (secondary segmentation) per segment 2-3 in 8-13. Prostomium epilobous. Setae 27-37 in 7, 36-46 in 20, 8-11 between male pores. First dorsal pore 5/6 or 6/7. Clitellum 14-16, annular, 2.1-2.8 mm long, setae absent, dorsal pores absent or marked with shallow depression. Spermathecal pores four pairs in 5/6-8/9, not visible externally. Female pore single, medio-ventral in 14. Male pores paired in 18, 0.25-0.28 circumference apart ventrally, porophore round, around 0.3 mm in diameter, surrounded by 2 to 4 slight circular or diamond-shaped folds. Preserved specimens gray on dorsum, whitish gray on ventrum, light brown around clitellum.

Internal characters
Septa 6/7/8, 11/12-13/14 thickened, 8/9/10 absent. Gizzard round in 9 and 10. Intestine from 16. Intestinal caeca paired in 27, simple, surface slightly wrinkled, extending anteriorly to 25-24. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, ampulla peach-shaped, 1.0-1.3 mm long, 0.7-0.9 mm wide, duct stout, about 0.4 mm long, diverticulum stalk slender, straight or curved, 0.4-0.6 mm long, seminal chamber oval, 0.4-0.5 mm long. Testis saes two pairs in 11, round. Seminal vesicles paired in 11 and 12, the posterior pair larger than the anterior one, occupying 1.5 to nearly 2 segments, fairly smooth. Prostate glands paired in 18, extending anteriorly to 17 and posteriorly to 20, prostatic duct slender, U-shaped.

Reference
Shen et al., 2003b; Tsai et al., 2009.
**Amyntas polyglandularis** (Tsai, 1964)

多腺遠環蚓

*Pheretima polyglandularis* Tsai, 1964: 30.

*Pheretima polyglandularis* - Chen & Shih, 1996: 54.

*Amyntas omeimontis polyglandularis* - Shih *et al*., 1999: 436.


*Amyntas omeimontis polyglandular* - Chen *et al*., 2002: 77; - Chuang *et al*., 2002: 68.

**Type locality**
A small hill near the main campus of National Taiwan University, Taipei City, Taiwan.

**Deposition of types**
Types are missing.

**Distribution**
Endemic to Taiwan, recorded in low elevation regions in northern Taiwan.

**Etymology**
The specific name indicates its numerous accessory glands in the pre- and post-clitellar regions.

**Morphology**

**External characters**
Length 134 mm, clitellum width 5.5 mm, segment number 88. Setae 64-65 in 8, 67-70 in 25, 20-21 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores two pairs in 7/8/9, lateral, with one to five small, round genital papillae in a transverse row on both the anterior and posterior edges of the pores, a group of small, round genital papillae present in 8 and 9, medio-ventral, numbering 10-23. Female pore single in 14, medio-ventral. Male pores paired in 18, ventro-lateral, round or transverse slit-like, situated on a flat-topped, heart-shaped tubercle surrounded by 2-9 small, round genital papillae with irregular arrangement, two oval, large, flat-topped genital pads situated medial to the pores and the round genital papillae, the above structures surrounded by 1-3 circular folds, a large number of small, round papillae present between the paired male pores, numbering 19-31 and 15-22 pre-setal and post-setal, respectively, forming a rectangular or irregular plate ventrally in 18. Preserved specimens purplish brown on dorsum and light gray on ventrum and clitellum.

**Internal characters**
Septa 6/7/8 thickened, 8/9/10 absent, 10/11 thin. Gizzard in 9 and 10. Intestine from 15. Intestinal caeca simple in 27, extending anteriorly to 23. Lateral hearts in 10-13. Spermathecae two pairs in 8 and 9, ampulla heart-shaped or peach-shaped, with short and stout stalk, diverticulum long and large, with horn-shaped seminal chamber and coiled slender stalk. Accessory glands present, 2-5 and numerous near the base of spermathecae and between the paired spermathecae, respectively, each corresponding to external papillae in preclitellar regions, each accessory
gland round or heart-shaped, with a short, slender stalk. Ovaries paired in 13. Testis sacs two pairs combined together within a single sac in 11. Seminal vesicles paired in 11 and 12. Prostate glands paired in 18, large, extending anteriorly to 16 and posteriorly to 21, subdivided into several lobes, prostatic ducts looped, with several accessory glands around its base, each corresponding to an external papilla in the male pore region. A group of accessory glands present ventrally between the paired prostate glands, with size and shape similar to those around spermathecae.

Reference Tsai, 1964; Tsai et al., 2009.
Amynthas proasacceus Tsai, Shen & Tsai, 2001

Type locality Mt. Hohuan (elevation 3,000 m), near the border between Hualien and Nantou counties in central Taiwan.

Deposition of types Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-17-Shen. Paratypes: same collection data as for holotype.

Distribution Endemic to Taiwan, recorded in central Taiwan, at elevations between 2,300 and 3,000 m.

Etymology The name “proasacceus” was given to the species to indicate that it is a species closely related to the ancestral form of A. asacceus.

Fig. 33. Amynthas proasacceus. (A) Male pore; (B-C) spermathecae; (D-E) prostate glands; (F) caecum.
Morphology

External characters
Length 39-76 mm, clitellum width 2.9-4.0 mm, segment number 57-106. Number of annuli (secondary segmentation) per segment three after 3 in preclitellar region. Prostomium with a large mouth opening surrounded by a small, soft, thick semicircular dorsal lip and a large, thick, white ventral lip. Setae 33-40 in 7, 43-51 in 20, 6-9 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, length 1.4-2.5 mm. Spermathecal pores not visible. No genital papillae in preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, 0.22-0.28 circumferences apart ventrally, each round or oval, surface smooth, slightly convex, with or without a shallow horizontal slit (depression) in middle, surrounded by 2 or 3 circular folds, male aperture not visible. No genital papillae in postclitellar region. Preserved specimens whitish pink on dorsum, whitish gray on ventrum, light grayish tan on clitellum.

Internal characters
Septa 5/6-7/8, 10/11-13/14 thickened, 8/9 and 9/10 absent. Gizzard in 8-10, cylindrical. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 20, 21 or 23. Esophageal hearts in 11-13. Spermathecae 6 (three pairs), 5, 4 or 2 in 6-8, structure highly variable: for normal spermathecae, ampulla oval-shaped, 0.8-1.4 mm long, with slender spermathecal stalk 0.9-1.3 mm long, diverticulum small with oval seminal chamber, about 0.3 mm long with a slender stalk about 0.6 mm long; for vestigial spermathecae, diverticula often lacking seminal chambers, stalk vestigial or absent, some spermathecae lacking diverticula, and some diverticula lacking seminal chambers. Ovaries paired in 13, each large with follicular surface. Testis sacs two pairs in 11 and partly in 10 or/and 12, each round or triangular. Seminal vesicles paired in 11 and 12, each small, irregularly-shaped with a small, oval dorsal lobe. Prostate glands paired in 18, racemose, occupying 3 to 6 segments in 16-21, prostatic duct hook-shaped, some specimens lacking prostate glands but with prostatic ducts.

Reference
**Amythas robustus** (Perrier, 1872)

![Fig. 34, PLATE 4 (B)](image)

Pheretima lauta - Ude, 1905 - Tsai, 1964: 25.
Amythas robustus - Shih et al., 1999: 436; - Tsai et al., 2000a: 286; - Chang et al., 2001: 76; - Chen et al., 2002: 77; - Chuang et al., 2002: 68; - Chen et al., 2003: 58; - Tsai et al., 2004a: 7; - James et al., 2005: 1025; - Blakemore et al., 2006: 229; - Tsai et al., 2009: 41.
Amythas lautus - Tsai et al., 2000a: 286; - Tsai & Tsai, 2001: 21; - Shen & Tsai, 2002b: 3.
Amythas masatakei (Beddard, 1892) - Chuang & Chen, 2002: 74.

**Type locality** Ile de France near Mauritius or Manila.

**Deposition of types** Paris, France.

**Distribution** Cosmopolitan, recorded in China, Korea, Japan, Taiwan, Philippines, Myanmar, India, Mauritius. In Taiwan, it is recorded in northeastern, northern, central, and southern Taiwan and Lanyu Island.

**Etymology** The specific name indicates its robust body size and shape.

**Morphology**

*External characters*
- Length 113-244 mm, clitellum width 5.6-7.5 mm, segment number 71-138.
- Prostomium epilobous. Setae 46-55 in 8, 15-21 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores two pairs in 7/8/9, ventro-lateral, 0.5 circumference apart ventrally. Genital papillae paired in spermathecal pores and/or pre-setal in 8 and 9, slightly medial to spermathecal pores, additional pre-setal papillae present in 7 and 10 in some specimens. Female pore single in 14, medio-ventral. Male pores paired in 18, on a raised papillae with one or two similar papillae around it, surrounded by several circular folds, one or two additional pre-setal papillae present medio-ventral in 18, if two, slightly connected. Live specimens light red or reddish brown on dorsum, redish white on ventrum, redish white or dark red on clitellum.

*Internal characters*
- Septa 6/7/8, 10/11-13/14 greatly thickened, 8/9/10 absent. Gizzard in 8 and 9. Intestine from 14 or 15. Intestinal caeca paired in 26 or 27, simple, extending anteriorly to 23 or 24. Lateral hearts in 10-13. Spermathecae two pairs in 8 an 9, ampulla large, round or oval, stalk stout, straight, shorter than ampulla, diverticulum long, stalk slender, looped, seminal chamber rod-shaped. Ovaries paired in 13. Testis sacs two pairs in 10 and 11. Seminal vesicles paired in 11 and 12, with dorsal lobes. Prostate glands paired in 18, racemose, extending anteriorly to 16 and posteriorly to 20 or 21.
Fig. 34. *Amynthas robustus*. (A-B) Male pores and associate papillae; (C) spermathecal pores and papillae; (D) spermathecae; (E) prostate gland; (F) caecum.

**Remarks**

*Amynthas robustus* is a common species in the cities in Taiwan. It sometimes emerges from the soil and crawls on the ground in large numbers in parks, such as the Ta-An Forest Park in the Taipei City, after heavy rains. It is the second largest earthworm species that can be found in big cities in Taiwan.

**Reference**

Blakemore, 2002; Tsai, 1964; Tsai & Tsai, 2001; Tsai *et al.*, 2009.
**Amythas rockefelleri** (Chen, 1933)

**Fig. 35, PLATE 4 (C)**


*Pheretima rockefelleri* - Tsai, 1964: 8.


*Pheretima rockefelleri* - Chen & Shih, 1996: 54.

*Amynthas papulosus* - Shih *et al*., 1999: 436 and 437; - Chang *et al*., 2001: 76.


**Type locality**  Lin-hai, Tien-tai, Sheng-hsien in Chekiang Province, China.

**Deposition of types**  National Museum of Natural History, USA.

**Distribution**  China and Taiwan. It is recorded in northern, central and southern Taiwan and the Kinmen Island.

**Etymology**  This species was named after Rockefeller, after whom the Rockefeller Foundation was named.

**Morphology**

**External characters**

Length 82-130 mm, clitellum width 3.2-4.2 mm, segment number 108-142. Number of annuli (secondary segmentation) per segment 3 after 5. Setae 58-75 in 8, 49-59 in 20, 10-16 between male pores. Prostomium epilobous. First dorsal pore 11/12. Clitellum 14-16, smooth, setae present ventrally, dorsal pore absent. Spermathecal pores paired in 5/6/7/8, ventro-lateral. Papillae present or absent. If present, one pair presetatal and one postsetatal in 8, presetatal pair slightly medial to spermathecal pores, postsetatal pair more medial than the presetatal one. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, on top of a small, round papilla surrounded by several circular folds. One pair of genital papillae in 17, postsetatal, large, round, flat-topped, in line with male pores; in some specimens, an additional pair just medial to the first one, the two pairs sometimes fused partially. Live specimens light red on the anterior one-third part of body, white on tail, reddish white on clitellum. Preserved specimens white with light brownish yellow clitellum.

**Internal characters**

Septa 5/6-7/8 and 10/11-12/13 thickened, 8/9 and 9/10 absent. Gizzard in 9 and 10, round. Intestine enlarged from 15, 16 or 17. Intestinal caeca simple in 26 or 27, extending anteriorly to 23 or 24. Lateral hearts in 10-13. Spermathecae paired in 6-8, ampulla round to rod-shaped, stalk slender. Diverticulum slender, rod-shaped, seminal chambers indistinguishable. Ovaries paired in 13. Testis sacs paired in 10 and 11, large, occupying full segments. Seminal vesicles paired in 11 and 12, small,
Fig. 35. *Amynthas rockefelleri*. (A) Male pore and associate papillae; (B) spermathecae; (C) prostate gland; (D) caecum.

anterior pair included in posterior testis sacs. Prostate glands absent with only prostatic ducts. Accessory glands present, large, corresponding to external genital papillae.

**Remarks**

*Amynthas rockefelleri* has long been considered as a parthenogenetic morph of *A. papulosus* and thus a junior synonym by many authors. However, after examining the type specimens of *A. rockefelleri* and comparing the morphology and distribution of the two species, H.-P. Shen concluded that they are two distinct species (Tsai *et al.*, 2009). A recent molecular study based on DNA sequences from specimens of the two species collected from Taiwan also supports Shen’s hypothesis (Chang *et al.*, 2007a, 2009a). In our experience, the two species are very different in coloration and body shape when they are still alive (PLATE 4A & 4C).

**Reference**

Shen *et al.*, 2003a; Tsai, 1964; Tsai *et al.*, 2009.
**Amynthas sexpectatus** Tsai, Shen & Tsai, 1999

*Fig. 36, PLATE 5 (A)*


**Type locality** Guoshing, Nantou County, Taiwan.

**Deposition of types** Taiwan Endemic Species research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1998-44. Paratypes: same collection as for holotype.

**Distribution** Endemic to Taiwan, recorded in Taichung, Nantou and Yunlin counties in central Taiwan.

**Etymology** The name was given with reference to the three pairs of large oval, disk-like pads in the spermathecal pore region of this species.

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Fig. 36. *Amynthas sexpectatus*. (A) Male pores; (B) spermathecal pores and pads; (C) spermathecae; (D) prostate glands; (E) caecum.
Morphology

External characters
Length 193-258, segment number 102-140. Number of annuli (secondary segmentation) per segment three in 9-13. Prostomium epilobous. Setae 56-62 in 7, 66-94 in 20, 17-24 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, 6.2-8.6 mm long, setae absent, dorsal pore absent. Spermathecal pores three pairs in 6/7-8/9, lateral, 0.4-0.5 circumference apart ventrally. Three pairs of large, oval, disk-like genital pads present in 6-8 in some specimens, each immediately medio-anterior to spermathecal pores, 1.2 mm in diameter. Female pore single in 14. Male pores paired in 18, latero-ventral, 0.25-0.30 circumference apart ventrally, number and structure of genital papillae variable: if contracted, male pores with two papillae, anterior one sandal-shaped, posterior one round, surrounded by several circular folds; if protruded, male pores located at the top of a corn-shaped porophore, associated closely with the genital papillae and surrounded by several circular folds; each papilla flat with slightly concave center. Live specimen yellow or greenish brown. Preserved specimens brown on dorsum, light gray on ventrum, dark brown on clitellum.

Internal characters
Septa 9/10 absent, 7/8/9 and 10/11-13/14 thickened. Gizzard in 9 and 10, round, with a small pharyngeal crop in 8. Intestine from 15. Intestinal caeca paired in 27, smooth, extending anteriorly to 24. Lateral hearts in 10-13. Spermathecae three pairs in 7-9, each with a large, peach-shaped ampulla and a short, slightly curved stalk, diverticulum with a slender, slightly curved stalk and a granulated seminal chamber. A pair of small, round nephridia on the dorsal side of intestine in each segment, nephridia tilted in 5 and 6. Ovaries paired in 13, medio-ventral. Testis sacs two pairs in 11 and 12, medio-ventral, small, smooth. Seminal vesicles paired in 11 and 12, smooth, with a large dorsal lobe. Prostate glands paired in 18, large, lobulated, extending anteriorly to 17 and posteriorly to 19, prostatic duct n-shaped, diameter gradually increased from the distal end to the proximal end. No accessory glands associated with external genital papillae in the spermathecal pore and male pore regions.

Reference
Tsai et al., 1999.
**Amynthas shinanmontis** Tsai & Shen, 2007

**溪南山遠環蚓**

*Amynthas shinanmontis* Tsai *et al.*, 2007: 358; - Tsai *et al.*, 2009: 42.

**Type locality** Mt. Shinan (elevation 2,000 m) along the Shihshan Forest Road near the Middle Altitude Experimental Station of the Taiwan Endemic Species Research Institute, Kaohsiung County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-2-Shen. Paratypes: coll. no. 2000-75-Shen.

**Distribution** Endemic to Taiwan, recorded from the Central Mountain Range in southern Taiwan, at elevations between 1,700 and 2,700 m in Kaohsiung and Taitung counties.

**Etymology** The name *shinanmontis* was given with reference to its type locality, Mt. Shinan, in southern Taiwan.

Fig. 37. *Amynthas shinanmontis*. (A) Male pore; (B-C) spermathecae; (D-E) prostate glands; (F) caecum.
Morphology

External characters
Length 86-187 mm, clitellum width 5.0-5.2 mm, segment number 75-114. Prostomium epilobous. Setae 31-43 in 7, 38-55 in 20, 6-11 between male pores. First dorsal pore 11/12-13/14. Clitellum 14-16, annular, 1.7-5.3 mm long. Spermathecal pores invisible externally. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, 0.20-0.28 circumferences apart ventrally, each on an oval or round papilla-like or disc-like porophore, surrounded by three to five oval skin folds, often with a horizontal groove anteriorly, looking like an eye. Genital papillae absent in both preclitellar and postclitellar regions. Preserved specimens greyish brown on head and dorsum, dark grey on mid-dorsum, light brown on ventrum, light to dark grey on clitellum.

Internal characters
Septa 5/6-7/8, 10/11-13/14 thickened, 8/9/10 absent. Gizzard large in 9-10. Intestine from 15 or 16. Intestinal caeca paired in 27, simple, slender, extending anteriorly to 22-25. Oesophageal hearts in 11-13. Spermathecae varied in number from three pairs (sextethec) to absent (athete): three pairs in 6-8, three spermathecae on one side in 6-8 and a single one on the other side in 6 or 7, two spermathecae in each of 6, 7 and 7, 8, one pair in 6, one spermatheca in 7, or completely absent; sizes and structure of spermathecae variable from large (normal), vestigial, nodule to absent: large spermatheca with a peach-shaped ampulla, a very short, stout stalk or almost no stalk, and a diverticulum with a small, oval seminal chamber and a slender stalk, vestigial spermatheca with a small degenerated ampulla and stalk, and no diverticulum, nodule-like spermatheca with a small, degenerated ampulla without stalk and no diverticulum. Nephridia tufted in 5 and 6. Testis sacs two pairs in 10 and 11 or both in 11, small. Seminal vesicles paired in 11 and 12, normal or vestigial. Prostate glands paired in 18 or absent, if present, normal (extending anteriorly to 16), vestigial (in only 18 or extending anteriorly to 17), or nodule-like (in 18), prostatic duct thick, swollen, U-shaped or coiled, in some a prostatic specimens, only one prostatic duct and the corresponding male porophore present. Accessory glands absent in both preclitellar and postclitellar regions.

Remarks
This species may be parthenogenetic.

Reference
Tsai et al., 2007, 2009.
**Amynthas swanus** (Tsai, 1964)


**Type locality** Main Campus of National Taiwan University, Taipei City, Taiwan.

**Deposition of types** Types are missing.

**Distribution** Endemic to Taiwan, recorded in plain regions in northern and central Taiwan.

**Etymology** The specific name “swanus” was derived from “swan”, indicating the white coloration of this species.

**Morphology**

**External characters**

Length 141-182 mm, clitellum width 5.0-5.5 mm, segment number 154-175. Number of annuli (secondary segmentation) per segment 3 in 7, 5 after middle body. Setae 98 in 5, 103-104 in 8, 76-82 in 20, 16-18 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores invisible externally. Preclitellar papillae absent. Female pore single in 14, medio-ventral. Male pores paired in 18, situated within a chamber with tuberculated surface covered by lateral skin wall and exteriorly surrounded by several circular folds. Preserved specimens grayish brown on clitellum, white in other parts of the body.

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Fig. 38. *Amynthas swanus*. (A) Spermatheca; (B) prostate gland; (C) caecum.
**Internal characters**

Septa 5/6–7/8 greatly thickened, 10/11–12/13 theakened, 8/9/10 absent. Gizzard in 10, round. Intestine from 16. Intestinal caeca paired in 27, simple, small, wrinkled with smooth border, extending anteriorly to 25 or 26. Last hearts in 13. Spermathecae two pairs in 5 and 6 or two pairs plus a left rudimentary spermatheca in 7, ampulla peach-shaped with a slender, straight stalk, diverticulum small, with a heart-shaped seminal chamber and a coiled stalk. Ovaries paired in 13. Testis sacs two pairs in 10 and 11. Seminal vesicles paired in 11 and 12, the anterior pair enveloped within testis sacs. Prostate glands paired in 18, small, extending anteriorly to 17 and posteriorly to 19, with two separate lobes connected by two narrow, short branches of prostatic ducts, prostatic ducts C-shaped.

**Remarks**

This species is so far one of the few endemic earthworm species recorded in the plain regions, and maybe only in the plain regions, in Taiwan. It is rare and endangered due to urbanization. It has been extinct from its type locality, the main campus of National Taiwan University, and has only a few records in the past decade.

**Reference**

Tsai, 1964; Tsai *et al.*, 2009.
**Amynthas taipeiensis** (Tsai, 1964)

*Pheretima taipeiensis* Tsai, 1964: 12; - Chen & Shih, 1996: 54.  
*Amynthas taipeiensis* - Shih et al., 1999: 436; - Tsai et al., 2000a: 287; - Chang et al., 2001: 76; - Chuang et al., 2002: 68; - Blakemore et al., 2006: 229; - Tsai et al., 2009: 42.

**Type locality**  Chon-ho Village, Taipei, Taiwan.  
**Deposition of types**  Types are missing.  
**Distribution**  Taiwan and China. It is recorded in Taipei and Ilan in northern Taiwan.  
**Etymology**  This species was named with reference to its type locality, Taipei.

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**Fig. 39**  
*Amynthas taipeiensis*. (A-B) Male pores; (C) spermathecal pore papillae; (D) spermatheca; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 132-136 mm, clitellum width 4.0-4.5 mm, segment number 107-116. Setae 25 in 5, 46-52 in 8, 61-63 in 20, 9-10 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores three pairs in 6/7-8/9, latero-ventral. Genital papillae present or absent, if present, one or two, small, round, on the posterior margin of the posterior one or two spermathecal pores. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, situated on the center of a flat-topped porophore, a large, round genital papilla situated medial to the male pore, the porophores and papillae surrounded by several oval fields. Preserved specimens purplish green on dorsum, light green or gray on ventrum and setal lines, brown on clitellum.

Internal characters

Reference
Tsai, 1964; Tsai et al., 2009.
Amynthas tantulus Shen, Tsai & Tsai, 2003

Type locality Rueyen Creek Nature Reserve, Nantou County, Taiwan
Deposition of types Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-24-Shen. Paratypes: same collection data as for holotype.
Distribution Endemic to Taiwan, recorded at Rueyen Creek Nature Reserve at an elevation of 2,300 m in central Taiwan.
Etymology The name "tantulus" was given with reference to the small size of this species.

Fig. 40. Amynthas tantulus. (A) Male pore; (B) male pore and associate papillae; (C) preclitellar papillae; (D) spermatheca; (E) prostate gland; (F) caecum.
Morphology

External characters

Length 32-58 mm, clitellum width 1.7-2.2 mm, segment number 65-90. Number of incomplete annuli (secondary segmentation) per segment 2-3 in 8-11. Prostomium epilobous. Setae 26-35 in 7, 28-35 in 20, 8-10 between male pores. First dorsal pore 5/6. Clitellum 14-16, annular, 1.6-2.5 mm long, setae absent, dorsal pores present or absent. Spermathecal pores three pairs in 6/7-8/9, ventro-lateral in depressed furrow, 0.3-0.36 circumferences apart ventrally. Genital papillae pre-setal, closely paired in mid-ventral regions in 9-12, number variable among specimens and segments: in 9 and 10, absent, one on left or one pair, in 11, absent, one on right, one on left or one pair, in 12, absent or one on left, each papilla small, round, flat-topped or slightly concave, about 0.2 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, 0.26-0.31 circumference apart ventrally, male aperture minute in a round porophore of about 0.3 mm in diameter, surrounded by 3 or 4 slight circular or diamond-shaped folds, some male pores with a small, less distinctly marked genital papilla pad adjacent laterally, genital papillae pre-setal, closely paired in mid-ventral portion in 18-20, in 18, one pair or one on left, in 19, one pair one on right or absent, in 20, one pair, each papilla small, round, center concave, size and arrangement similar to those in the preclitellar region. Preserved specimens dark reddish brown on dorsum, light gray on ventrum, light orange brown around clitellum.

Internal characters

Septa 5/6-7/8, 10/11-12/13 thickened, 8/9/10 absent. Gizzard round in 9 and 10. Intestine from 15. Intestinal caeca paired in 27, simple, short, stocky, surface slightly wrinkled, extending anteriorly to 25. Esophageal hearts in 11-13. Spermathecae three pairs in 7-9, ampulla peach-shaped, the posterior two pairs larger than the anterior one, 0.7-1.1 mm long, 0.5-0.8 mm wide, stalk 0.4-0.5 mm long, diverticulum stalk straight or slightly bent, 0.4-0.7 mm long, seminal chamber oval, 0.3-0.4 mm long. Accessory glands round, flat, with extremely short stalk, corresponding to external genital papillae. Testis sacs two pairs, first pair large in 10, connected with posterior pair of lesser enlargement in 12. Seminal vesicles large, extending between segments 11 and 13 or 14, surface wrinkled, follicular. Prostate glands paired in 18, wrinkled, extending anteriorly to 16 and posteriorly to 20, prostatic duct C-shaped. Accessory glands similar in size and structure to those in the spermathecal region.

Reference

Shen et al., 2003b; Tsai et al., 2009.
Amynthas tayalis Tsai, Shen & Tsai, 1999

Type locality  Hsiju, Taipei County, Taiwan
Deposition of types  Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1998-60. Paratypes: same collection data as for holotype.
Distribution  Endemic to Taiwan, recorded in low elevation mountain regions in northern Taiwan.
Etymology  The species was named after the Tayal tribe, a minority aboriginal tribe in northern Taiwan.

Fig. 41. Amynthas tayalis. (A) Male pore; (B) male pore and associate papillae; (C) spermathecal pores and papillae; (D) spermathecae; (E) prostate gland; (F) caecum.
**Morphology**

*External characters*

Length 120-125 mm, clitellum width 3.4-3.7 mm, segment number 85-98. No secondary segmentation. Prostomium epilobous. Setae 40-41 in 7, 56 in 20, 11-13 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, 3.7-3.8 long, setae absent, dorsal pore absent. Spermathecal pores three pairs in 6/7-8/9, ventro-lateral, 0.3 body circumference apart ventrally. Genital papillae paired in 6-8, medio-anteriorly adjacent to the spermathecal pore, some of the papillae embedded partially in the pores, for some specimens, two additional pairs of pre- and post-setal papillae in 8, slightly medial to the spermathecal pores, each papilla circular, flat with a slightly concave center, surrounded by one or two circular folds, around 0.3 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, 0.34 circumference apart ventrally, each male opening surrounded by three circular papillae, one medial, one latero-anterior, one latero-posterior, the three papillae surrounded by two or three circular folds, additional post-setal papillae paired in 17, paired or single in 19 and 20, similar in size and structure to those in the preclitellar regions. Preserved specimens dark brown on dorsum and around clitellum, light gray on ventrum and lateral part of head, yellowish white on setal lines; the dark brown dorsal and white setal line colorations giving the worm striped appearance.

*Internal characters*

Septa 6/7 thickened, 7/8 thin, 8/9/10 absent, 10/11-13/14 slightly thickened. Gizzard in 9 and 10, peach-shaped. Intestine from 15. Intestinal caeca paired in 27, simply, with smooth border, extending anteriorly to 25. Lateral hearts paired in 11-13. Spermathecae three pairs in 7-9, each with a smooth, peach-shaped ampulla of about 1.8 mm long and a short, stout stalk about 1.1 mm, diverticulum with a long, slightly pointed seminal chamber and a slender, slightly curved stalk. Ovaries closely paired in 13, medio-ventral. Testis sacs two pairs in 10 and 11, medio-ventral, small, oval. Seminal vesicles paired in 11 and 12, large, surface wrinkled, each with a small smooth, oval dorsal lobe. Prostate glands paired in 18, large, folliculated, extending anteriorly to 14 and posteriorly to 21, with a thick, slightly curved prostatic duct. Accessory glands present for genital papillae in both pre-and post-clitellar regions, each gland round, mushroom-like, with a very short stalk.

**Reference**

Amynthas tessellatus tessellatus
Shen, Tsai & Tsai, 2002

Type locality Rueyen, Nantou County, Taiwan
Deposition of types Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-24-Shen. Paratypes: same collection data as for holotype.
Distribution Endemic to Taiwan, recorded at elevations between 1,000 and 3,200 m in central Taiwan.
Etymology The name “tessellatus” was given to this species to express the character of the “mosaic formation” of its genital papillae in both pre- and post-clitellar regions.

Fig. 42. Amynthas tessellatus tessellatus. (A) Male pore; (B) male pores and associate papillae; (C) preclitellar papillae; (D) spermatheca; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 52-103 mm, clitellum width 2.5-3.4 mm, segment number 66-114. Prostomium epilobous. Setae 30-40 in 7, 35-48 in 20, 5-11 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, 1.7-2.9 mm long, setae absent. Spermathecal pores invisible. Patches of small, round genital papillae present ventro-medially, pre-setal papillae 0-3 in 6, 0-13 in 7, 16-24 in 8, 2-19 in 9, post-setal papillae absent or present, if present, 1-3 in 8, one in 9. Female pore single, medio-ventral in 14. Male pores paired in 18, porophore simple, round, papilla-like, surrounded by two or three incomplete circular folds, about 0.28 circumference apart ventrally. Genital papillae present, patched, medio-ventral, pre-setal papillae 11-21 in 17, 14-25 in 18, 10-25 in 19, 0-16 in 20, 0-3 in 21, post-setal papillae 1-2 in 19, one in 20, with shape and arrangement similar to those in the precitellar region. Preserved specimens whitish olive on dorsum, olive-gray on ventrum, dark brown on clitellum.

Internal characters
Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 9-10, round. Intestine from 16. Dorsal typhlosole from 27, with height about one third of that of intestine. Intestinal caeca paired in 27, simple, extending anteriorly to 23. Esophageal hearts in 11-13. Spermathecae three pairs in 6-8, ampulla oval, about 1.3 mm long, 0.9 mm wide, with a stout stalk of about 0.9 mm long, diverticulum with an oval seminal chamber about 0.6 mm long and a slender stalk of about 1.1 mm long. Nephridia tufted in intersegmental spaces, anteriorly to 6/7. Testis sacs two pairs in 11. Seminal vesicles paired in 11 and 12, with a round dorsal lobe. Prostate glands paired in 18, large, follicular, extending anteriorly to 16 and posteriorly to 20, prostatic duct U-shaped with the slender proximal end connecting to prostate gland and the enlarged distal end connecting to male pore. Accessory glands present in pre-setal and post-setal areas in the spermathecal and male pore regions, round, mostly sessile on body wall, few with very short stalks of about 0.2 mm long, number much less than that of external genital papillae in the corresponding segments.

Reference
Shen et al., 2002; Tsai et al., 2009.
**Amynthas tessellatus paucus**  
Shen, Tsai & Tsai, 2002


**Type locality**  
Mountain slope along Nanshan Creek (elevation 800-900 m), Jenay, Nantou County, Taiwan.

**Deposition of types**  
Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-20-Shen. Paratypes: same collection data as for holotype.

**Distribution**  
Endemic to Taiwan, reported from Wanda, Nanshan and Penpu at elevations of 700 to 1,100 m in Nantou

**Etymology**  
The name "paucus" was given to this subspecies with reference to its “less degree” of the mosaic formation for the patch of the genital papillae, as compared to that of *A. tessellatus tessellatus*.

![Fig. 43. *Amynthas tessellatus paucus*. (A) Male pore; (B) male pore and associate papillae; (C) preclitellar papillae; (D) spermathecae; (E) prostate gland; (F) caecum.](image-url)
Morphology

**External characters**

Length 42-109 mm, clitellum width about 3 mm, segment number 68-107. Prostomium epilobous. Setae 31-40 in 7, 36-46 in 20, 9-11 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, setae absent. Spermathecal pores invisible. Patches of small, round pre-setal genital papillae present ventro-medially 0 or 2 in 6, 0, 5 or 11 in 7, 0-12 or 15 in 8. Female pore single, medio-ventral in 14. Male pores paired in 18, porophore simple, round, papilla-like, surrounded by two or three incomplete circular folds, about 0.28 circumference apart ventrally, genital papillae pre-setal 5-11 or 18 and post-setal 1-4 or 8 in 18. Preserved specimens whitish olive on dorsum, olive-gray on ventrum, dark brown on clitellum.

**Internal characters**

Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 9-10, round. Intestine from 16. Dorsal typhlosole from 27, with height about one third of that of intestine. Intestinal caeca paired in 27, simple, extending anterorly to 23. Esophageal hearts in 11-13. Spermathecae three pairs in 6-8, ampulla oval, diverticulum with an oval seminal chamber and a slender stalk. Nephridia tufted in intersegmental spaces, anteriorly to 6/7. Testis sacs two pairs in 11. Seminal vesicles paired in 11 and 12, each with a round dorsal lobe. Prostate glands paired in 18, large, follicular, extending anteriorly to 16 and posteriorly to 20, prostatic duct U-shaped with the slender proximal end connecting to prostate gland and the enlarged distal end connecting to male pore. Accessory glands present in the spermathecal and male pore regions, each gland round, with a slender stalk 0.7-1.4 mm long, corresponding to each external genital papilla.

**Remarks**

*Amynthas tessellatus paucus* differs from *A. tessellatus tessellatus* by having patches of both pre-setal and post-setal genital papillae only in 18 in the postclitellar region, and by having accessory glands with long, slender stalks.

**Reference**

Shen et al., 2002; Tsai et al., 2009.
Amynthas tungpuensis Tsai, Shen & Tsai, 1999

Type locality  Tungpu, Nantou County, Taiwan
Deposition of types  Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1998-61. Paratypes: Same collection data as for holotype.
Distribution  Endemic to Taiwan, recorded in the mountain regions in the western part of the Central Mountain Range.
Etymology  The species was named after its type locality, Tungpu, a small village with hot spring in the Central Mountain Range.

Fig. 44. Amynthas tungpuensis. (A-B) Male pores; (C) preclitellar papillae; (D) spermathecae; (E) prostate gland; (F) caecum.
Morphology  

External characters  
Length 142-160 mm, clitellum width 4.5-5.3 mm, segment number 119-128. No secondary segmentation. Prostomium epilobous. Setae 40-47 in 7, 54-59 in 20, 12-16 between male pores. First dorsal pore 11/12, 12/13 or 13/14. Clitellum 14-16, annular, 4.3-5.3 mm long, seta absent, dorsal pore present or absent. Spermathecal pores three pairs in 6/7-8/9, ventro-lateral, 0.26-0.29 circumference apart ventrally, each in a depressed furrow with a tiny projection. Genital papillae two transverse rows pre-setal in 8 and 9, numbering 4-11 for each row, an additional pair of post-setal papillae present at the ventro-lateral part of 8 in some specimens. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, 0.26-0.29 circumference apart ventrally, each pore simple, on top of a papilla-like porophore surrounded by 7-8 circular folds, a genital papilla immediately anterior to setal line in the medial position between the male pores in 18, an additional papilla at the same location in 17 for some specimens, each papilla round, with a slightly concave center, 0.4 mm in diameter, about half of the distance between setal line and anterior intersegmental furrow. Preserved specimens violet brown on dorsum with a dark violet longitudinal dorsal line, light gray on ventrum, brown on clitellum, light yellowish white on setal line.

Internal characters  
Septa 6/7/8 thin, 8/9/10 absent, 10/11-14/15 slightly thickened. Gizzard in 9 and 10, round. Intestine enlarged from 15. Intestinal caeca paired in 27, simple, smooth, extending anteriorly to 23, with wide basal and slender distal portions. Lateral hearts in 10-13. Spermathecae three pairs in 7-9, ampulla large, round, peach-shaped, with a short, stout stalk, diverticulum with a small, peach-shaped seminal chamber and a straight, slender stalk. Nephridial batteries large, paired in 5 and 6. Ovaries closely paired in 13, medio-ventral. Testis sacs two pairs in 10 and 11, smooth, medio-ventral. Seminal vesicles paired in 11 and 12, surface folliculate, each with a small, dorsal lobe. Prostate glands paired in 18, racemose, large, extending anteriorly to 14 and posteriorly to 19, prostatic duct n-shaped, proximal half enlarged. No accessory glands associating with pre- and post-clitellar genital papillae.

Remarks  
Number of genital papillae of this species shows great individual variation. That might be the reason for *Amynthas monsoonus* being regarded as a distinct species from *A. tungpuensis* by James et al. (2005), but after examining type specimens, Tsai et al. (2009) argued that the former is a junior synonym of the latter. This dispute is probably a matter of opinion on morphological variations, with solution relying on new data in the future (S. James, personal communication).

Reference  
James et al., 2005; Tsai et al., 1999, 2009.
Amynthas uvaglandularis
Shen, Tsai & Tsai, 2003

Fig. 45

Type locality: Rueyen Creek Nature Reserve, Nantou County, Taiwan.
Deposition of types: Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-24-Shen. Paratypes: same collection data as for holotype.

Distribution: Endemic to Taiwan, recorded in central Taiwan, at elevations between 1,800 and 2,300 m in Nantou County.

Etymology: The name “uvaglandularis” was given with reference to the grape-like accessory glands of this species.

Fig. 45. *Amynthas uvaglandularis*. (A) Male pore; (B-C) spermathecal pores and papillae; (D) spermathecae; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 62-113 mm, clitellum width 3.0-3.3 mm, segment number 75-115. Number of incomplete annuli (secondary segmentation) per segment 2-3 in 8-13. Prostomium epilobous. Setae 33-44 in 7, 38-48 in 20, 11-13 between male pores. First dorsal pore 10/11. Clitellum 14-16, annular, 2.5-3.6 mm long, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, each on a papilla-like porophore in segmental furrow, 0.31-0.35 circumference apart ventrally. Genital papillae present post-setal in 8 and pre-setal in 9, widely paired or with an additional one on medio-ventrum, occasionally, additional pre-setal papillae present in 8, each papilla round, center flat or slightly concave, 0.3-0.4 mm in diameter, surrounded by a white rim. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, minute, on a depressed porophore, with a small papilla adjacent laterally, both surrounded by 2 or 3 circular folds, 0.25-0.30 circumference apart ventrally, two post-setal genital papillae present in 18, each adjacent medially to male pore and close to setal line, about 10 or 11 intersetal distances apart, or two closely arranged in middle between the paired male pores, each papilla round, similar in structure to those in the preclitellar region. Preserved specimens dark brown on dorsum, light brown on ventrum, dark brown around clitellum.

Internal characters
Septa 8/9/10 absent, 11/12-13/14 thickened. Gizzard round in 9 and 10. Intestine from 15. Intestinal caeca paired in 27, simple, surface slightly wrinkled, extending anteriorly to 24 or 23. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, ampulla oval, 1.3-1.5 mm long, 0.7-1.1 mm wide, duct stout, around 0.4 mm long, diverticulum long and slender, 1.2-1.6 mm long, with or without distal oval seminal chamber. Accessory glands sessile, each in the form of a grape-like follicular mass, about 0.7 mm long and 0.5 mm wide, corresponding to each of the external genital papillae, additional accessory glands present at the base of each spermathecal duct, in a mass of smaller follicles. Testis sacs two pairs in 10 and 11, large, round. Seminal vesicles paired in 11 and 12, large, each occupying 1.5 to 2 segments, follicular, with a large granulated dorsal lobe. Prostate glands paired in 18, large, lobed, extending anteriorly to 16 and posteriorly to 20 or 21, prostatic duct C-shaped, distal end enlarged. Accessory glands present, similar in structure to those in the spermathecal region, large glands (about 0.8 mm long) corresponding to genital papilla medial to male pores, small ones (about 0.6 mm in length) at the base of prostatic duct corresponding to papilla lateral to male pore, both about 0.4 mm wide.

Reference
Shen et al., 2003b; Tsai et al., 2009.
**Amynthas wangi** Shen, Tsai & Tsai, 2003

**中文名**王氏遠環蚓


**Type locality** Rueyen Creek Nature Reserve, Nantou County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-24-Shen.

**Distribution** Endemic to Taiwan, only reported from Rueyen Creek Nature Reserve (elevation 2,300 m) in Nantou County, central Taiwan.

**Etymology** The name *wangi* was given to this species in honor of Dr. Yuhsi Wang, late professor and head of the Department of Zoology, National Taiwan University between 1955 and 1973, who made great contributions to the early taxonomy of millipedes and centipedes of Taiwan.

Fig. 46. *Amynthas wangi*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters

Length 62 mm (amputated), clitellum width 3.4 mm, segment number 70 (amputated). Number of incomplete annuli (secondary segmentation) per segment 2-3 in 8-13 and 17. Prostomium epilobous. Setae 34 in 7, 36 in 20, 10 between male pores in 18. First dorsal pore 11/12. Clitellum 14-16, annular, 2.7 mm long, setae absent, dorsal pore absent. Spermathecal pores three pairs in 5/6-7/8, about 0.3 circumference apart ventrally, each surrounded by a genital papilla anteriorly and one or two papillae posteriorly, each papilla round, center concave, about 0.2 mm in diameter. Female pore single, medio-ventral in 14. Male pores paired in 18, about 0.28 circumference apart ventrally, male aperture minute, in a transversely oval porophore of about 0.5 mm in diameter, surrounded by a few slight oval folds; post-setal genital papillae present in a horizontal row in right and left latero-ventral regions of 17, each row with four papillae adjacent to setal line, each papilla round, center concave, 0.2-0.3 mm in diameter, breadth of the four papillae about 0.9 mm. Preserved specimens whitish olive on dorsum, whitish gray on ventrum, light brown around clitellum.

Internal characters

Septa 5/6-7/8 and 10/11-12/13 thickened, 8/9/10 absent. Gizzard round in 9 and 10. Intestine from 15. Intestinal caeca paired in 27, simple, surface slightly wrinkled, short, extending anteriorly to entire segment of 24. Esophageal hearts in 11-13. Spermathecae three pairs in 6-8, ampulla large, elongated oval, 2.2-2.9 mm long, 1.2-1.5 mm wide, duct 0.9-1.4 mm long, diverticulum stalk slender, 0.8-1.1 mm long, seminal chamber oval, 0.8-1.1 mm long. Accessory glands stalked, 0.3-0.7 mm long, corresponding to each of the papillae around spermathecal pores. Testis sacs two pairs in 10 and 11, small, round. Seminal vesicles paired in 11 and 12, large. Prostate glands paired in 18, extending anteriorly to 16 and posteriorly to 21, lobed, prostatic duct C-shaped, distal end enlarged. Accessory glands stalked, a large gland or paired small glands associated with each of the genital papillae, stalk about 0.2 mm and head 0.1-0.2 mm long.

Reference

Shen et al., 2003b; Tsai et al., 2009.
Amynthas wulinensis Tsai, Shen & Tsai, 2001

Type locality Wulin Natural Scenery Observatory at an elevation of 3,200 m, Nantou County, Taiwan.

Deposition of types Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1999-16A-Shen. Paratypes: same collection data as for holotype.

Distribution Endemic to Taiwan, recorded at elevations from 800 m to the mountain ridge of 3,200 m in the western part of the Central Mountain Range in central Taiwan.

Etymology This species was named after its type locality, Wulin.

Fig. 47. Amynthas wulinensis. (A) Male pore and associate papillae; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters

Length 128-174 mm, clitellum width 5.6-6.1 mm, segment number 93-123. Number of annuli (secondary segmentation) per segment three after 6. Prostomium epilobous. Setae 42-45 in 7, 55-69 in 20, 13 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, length 5.5-5.8 mm, slightly shorter than width, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, about 0.29 circumference apart ventrally. No papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, 0.24-0.28 body circumferences apart ventrally, each round or oval, on setal line with depressed center (male aperture not visible), surrounded by two or three circular folds, usually a pair of genital papillae slightly medial to male pore present in each of 17 and 19, each papilla oval with a depressed center, in posterior annuli between setal line and posterior intersegmental furrow, occasionally an additional pair or one papilla present in 20, or missing one in 17 or 19. Preserved specimens light brown on dorsum, light yellow on ventrum, grayish tan around clitellum.

Internal characters

Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard small, round in 10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 22 or 20. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, each with a very short, stout stalk, diverticulum with an oval seminal chamber and a slender, straight stalk originating from spermathecal stalk. Testis sacs two pairs in 10 and 11, small, round. Seminal vesicles paired in 11 and 12, each large, follicular, with a large, follicular dorsal lobe. Prostate glands paired in 18, large, racemose, follicular, extending anteriorly to 15 and posteriorly to 20, prostatic duct coiled, hook-shaped. Accessory glands paired in 17 and 19, each corresponding to external genital papillae, sessile (no stalk), flowery.

Remarks

This species is one of the three members of the Amynthas wulinensis species complex. The other two members are Amynthas lini and Amynthas meishanensis (Chang et al., 2007b). Its body length and setal number show vertical (elevational) variations.

Reference

**Metaphire bununa** Tsai, Tsai & Liaw, 2000

布農腔環蚓


**Type locality** Mt. Jilong between Jiji and Chungliau, Nantou County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Holotype: coll. no. 1998-32.

**Distribution** Endemic to Taiwan, distributed between the Sheishan Mountain Ridge and Launong River in the west of the Central Mountain Range, at elevations between 300 and 3,000 m.

**Etymology** The species name “*bununa*” was given with reference to the Bunun Tribe of the aboriginal people in Nantou, Taiwan.

**Morphology**

**External characters**

Length 255-352 mm, clitellum width around 10.0 mm, segment number 189-221. Number of annuli (secondary segmentation) per segment three in 4-6, 5 to 7 in 8-13, and 5 in body segments after 17. Prostomium prolobous. Setae 103-111 in 5, 114-158 in 7, 119-145 in 20, 19-29 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length around 10.0 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, 0.36 circumference apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, about 0.25 circumference apart ventrally, each pore C-shaped with swollen and folliculated edge surrounded with circular folds, extending to the inter-segmental furrows of 17/18 and 18/19, an oval pad situated behind the setal line of 17, close to the anterior end of the male pore area, linked to the male aperture through a seminal groove. Genital papillae absent in the male pore area. Preserved specimen dark purplish blue on dorsum, light grey on ventrum, grayish brown on clitellum.

**Internal characters**

Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-12/13 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 26. Lateral hearts in 9, 12 and 13. Spermathecae four pairs in 6-9, ampulla elongated, peach-shaped, with a slender stalk, diverticulum with a long stalk, with straight proximal portion and coiled or twisted distal portion and a small seminal chamber. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers in 5 and 6. Ovaries paired in 13,
Fig. 48. *Metaphire bununa*. (A-C) Male pores; (D) spermatheca; (E) prostate gland; (F) caecum.

 medio-ventral, close to the 12/13 septum. Testis sacs one pair in 10, oval, smooth, medio-ventral in front of 10/11. Seminal vesicles paired in 11, large, each one with a folliculate dorsal lobe. Prostate glands paired in 18, large, lobular, extending anteriorly to 17 and posteriorly to 20.

**Remarks**

*M. bununa* is a member of the *M. formosae* species group. It can tolerate a wide range of temperature, living in the mountains where the vegetations are evergreen broadleaf forest, deciduous broadleaf forest, mixed coniferous-broadleaf forest or coniferous forest. It can be found in both virgin and secondary forests. *M. bununa* is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day.

**Reference**

Chang & Chen, 2008a; Chang *et al.*, 2008a; Tsai *et al.*, 2000c, 2009.
Metaphire californica (Kinberg, 1867)

加州腔環蚓


Metaphire californica - Shih et al., 1999: 436; - Tsai et al., 2000a: 287; - Chang et al., 2001: 76; - Chuang et al., 2002: 68; - Shen & Tsai, 2002b: 3; - Chen et al., 2003: 58; - Tsai et al., 2004a: 6; - Chang & Chen, 2005a: 593; - James et al., 2005: 1026; - Blakemore et al., 2006: 229; - Tsai et al., 2009: 43.

Metaphire hesperidum (Beddard, 1892) - Tsai et al., 2000a: 286.

Type locality Sausolita Bay, California, USA.

Deposition of types Types from San Francisco in Stockholm Museum, Sweden.

Distribution Cosmopolitan. In Taiwan, it is a common species below the elevation of 2,100 m, and in the Lanyu, Turtle and Kinmen Islands.

Etymology This species was named after its type locality, California.

Fig. 49. Metaphire californica. (A) Male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 50-156 mm, clitellum width 3-5 mm, segment number 55-115. Prostomium epilobous. Setae 38-41 in 7, 55 in 20, 14-20 between male pores. First dorsal pore 11/12. Clitellum 14-16, annular, dorsal pore absent, setae absent. Spermathecal pores two pairs in 7/8-8/9, 0.3-0.5 circumference apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, about 0.4 body circumference apart ventrally, in lateral slits of retracted copulatory pouches. Live specimens dark red-brown on dorsum, white on clitellum.

Internal characters

Reference
Blakemore, 2002; Tsai, 1964; Tsai et al., 2009.
**Metaphire feijani** Chang & Chen, 2004

飛棲腔環蚓


*Amynthas ailiaoensis* James, Shih & Chang, 2005: 1020; - Blakemore et al., 2006: 227.

**Type locality** Majia, Pingtung County, Taiwan.

**Deposition of types** Institute of Zoology, National Taiwan University, Taipei, Taiwan. Cat. Nos. 14-07095 for the holotype, and 14-07099 for the paratype.

**Distribution** Endemic to Taiwan, distributed in the low elevation regions in the southwest of the Central Mountain Range.

**Etymology** The species epithet “feijani” was given in remembrance of the Taiwanese evolutionary biologist Dr. Fei-Jan Lin.

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**Fig. 50.** *Metaphire feijani*. (A) Male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 215-310 mm, clitellum width 8.0-12.0 mm, segment number 95-140. Number of annuli (secondary segmentation) per segment three in 6-9, five in 10-13, three in body segments behind 17. Prostomium prolobous. Setae 76-96 in 7, 101-104 in 20, 20-22 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length 10.2-11.0 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, invisible from outside, ventral, 0.27-0.35 circumference apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores (opening of copulatory pouch) small, paired, situated on setal line close to lateral border of 18, about 0.26 circumference apart ventrally, each copulatory pouch compressed to the outer body wall, surrounded by 2-6 circular folds, laterally bordered by a thick skin lip, the opening of copulatory pouch forming a split parallel to the body axis, facing the medio-ventral line, male aperture inconspicuous, embedded in the copulatory pouch, a small genital pad present in the front of the opening of the copulatory pouch. Live specimens bluish brown with metallic luster on dorsum, light reddish brown on ventral. Preserved specimens purplish brown on dorsum, light brown on ventral.

Internal characters
Septa 5/6-7/8 thickened, 8/9 thin, 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 26. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, ampulla large, about 2.8-4.2 mm in length, with a stalk about 1.4-2.4 mm in length, diverticulum short, around the middle of spermathecae, with a small oval seminal chamber on the tip, stalk long, tightly coiled, forming a short and thick appearance. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers anterior to the 6/7 septum. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs one pair in 10, oval, smooth, medio-ventral in front of 10/11. Seminal vesicles paired in 11, large, each one with a folliculate dorsal lobe. Prostate glands paired in 18, large, lobular, extending anteriorly to 17 and posteriorly to 19.

Remarks
M. feijani is a member of the M. formosae species group. It lives in the mountains where the vegetations are broadleaf forest and can be found in both virgin and secondary forests. M. feijani is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day.

Reference
Chang & Chen, 2004, 2008a; Chang et al., 2008a; James et al., 2005; Tsai et al., 2009.
**Metaphire formosae** (Michaelsen, 1922)

Type locality  Chiahsien, Kaohsiung County, Taiwan.


Distribution  Endemic to Taiwan, distributed between Taoyuan and Kaohsiung counties in the Western Foothills, at elevations below 1,500 m.

Etymology  The specific name “formosae” was given referring to the type locality “Formosa”, which is one of the former names for Taiwan.

Morphology

**External characters**

Length 159-393 mm, clitellum width 8.0-11.0 mm, segment number 103-176. Prostomium probolous or epilobous. Setae 130-150 in 7, 126-138 in 10, 104-120 in 25, 19-32 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, dorsal, intrasegmental, 0.875-0.94 body circumference apart ventrally. No genital papillae in the precitrellar region. Female pore single, medio-ventral in 14. Male pores (opening of copulatory pouch) paired, situated on setal line close to lateral border of 18, on large conical porophores, surrounded by several circular folds, with an oval pad within the copulatory pouch or near the opening, 0.25-0.33 circumference apart ventrally. Preserved specimens purplish brown on dorsum, light brown on ventral.

**Internal characters**

Prostate glands paired in 18, large, lobular, extending anteriorly to 17 and posteriorly to 19.

**Remarks**

*M. formosae* is a member of the *M. formosae* species group. It lives in the mountains where the vegetations are broadleaf forest and can be found in both virgin and secondary forests. This species is anecic with permanent vertical burrows 30 cm or more below the ground. *Amynthas chaishanensis* was regarded as a distinct species from *M. formosae* by James *et al.* (2005), but after examining type specimens, Tsai *et al.* (2009) argued that the former is a junior synonym of the latter. This dispute is probably a matter of opinion on morphological variations, with solution relying on new data in the future (S. James, personal communication).

**Reference**

Chang & Chen, 2005a, 2008a; Chang *et al.*, 2008a; James *et al.*, 2005; Michaelsen, 1922; Tsai *et al.*, 2009.
Metaphire glareosa Tsai, Tsai & Liaw, 2000

Type locality  Jhihben Forest Recreation Park, Jhihben, Taitung, Taiwan.

Deposition of types  Previously deposited in Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan (coll. no. 1998-18 for the holotype and two paratypes), the types were destroyed in a strong earthquake in 1999.

Distribution  Endemic to Taiwan, distributed in eastern Taiwan, including the Coastal Mountain Range and regions southward of the Taitung City in the southeast of the Central Mountain Range, probably at elevations below 1,000 m.

Etymology  The name “glareosa” is Latin adjective of “gravelly”, which was given to indicate the habitat of the type locality.

Morphology  

External characters
Length 204-330 mm, clitellum width around 10.0 mm, segment number 124-155. Prostomium epilobous. Setae 46 in 5, 61-90 in 7, 81-91 in 20, 6-27 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length around 10.0 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, latero-ventral, each pore C-shaped with swollen and folliculated edge surrounded by circular folds, extending to the inter-segmental furrows of 17/18 and 18/19, an oval pad situated behind the setal line of 17, close to the anterior end of the male pore area, linked to the male aperture through a seminal groove. Preserved specimen purplish blue on dorsum, light grey on ventrum.

Internal characters
Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11 and 12/13 greatly thickened. Gizzard in 8-10. Intestine rom 15. Intestinal caeca paired in 27, simple, extending anteriorly to 25. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, ampulla elongated, peach-shaped, with a slender stalk, diverticulum with a long stalk, with straight proximal portion and coiled or twisted distal portion and a small white seminal chamber. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers in 5 and 6. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs one pair in 10, oval, smooth, medio-ventral in
front of 10/11. Seminal vesicles paired in 11, large, each one with a folliculate dorsal lobe. Prostate glands paired in 18, large, lobular, extending anteriorly to 17 and posteriorly to 19.

Remarks

*M. glareosa* is a member of the *M. formosae* species group. It lives in the mountains where the vegetations are broadleaf forest and can be found in both virgin and secondary forests. *M. glareosa* is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day.

Reference

Chang & Chen, 2008a; Chang *et al.*, 2008a; Tsai *et al.*, 2000c, 2009.
Metaphire houlleti (Perrier, 1872)

Fig. 53

Metaphire houlleti - Shen et al., 2005a: 13; - James et al., 2005: 1026; - Blakemore et al., 2006: 230; - Tsai et al., 2009: 43.

Amyntas huangi James et al., 2005: 1014; - Blakemore et al., 2006: 228.

**Type locality**  Calcutta, India.

**Deposition of types**  Museum National d’Histoire Naturelle, Paris, France.

**Distribution**  Cosmopolitan. Indigenous to Southeast Asia. It is recorded in Pingtung and Kaohsiung counties at elevations around 200-400 m in southern Taiwan.

**Etymology**  The species was named after Mr. Houllet.

Fig. 53. Metaphire houlleti. (A) Male pore; (B) spermathecae; (C) prostate gland; (D) caecum.
Earthworm Fauna of Taiwan

Morphology

External characters
Length 70-118 mm, clitellum width 2.4-3.6 mm, segment number 86-102. Number of incomplete annuli (secondary segmentation) per segment three in 6-13. Prostomium epilobous. Setae 30-38 in 7, 50-52 in 20, 9-10 between male pores. First dorsal pore 9/10. Clitellum 14-16, annular, 3.2-4.4 mm long, dorsal pore absent, each segment with about 40 setal pits. Spermathecal pores three pairs in 6/7-8/9, ventro-lateral, slit-like, wrinkled at both anterior and posterior margins, buried deeply in intersegmental furrow, 0.3-0.32 circumference apart ventrally. Female pore single, medio-ventral in 14. Male pores paired in 18, about 0.28 circumference apart ventrally, each in copulatory pouch with C-shaped opening (slit), surrounded by a round swelling area with numerous transverse ridges. Genital papilla absent in both pre- and post-clitellar regions. Preserved specimens black on dorsum, greyish on ventrum, dark brown around clitellum.

Internal characters
Septa 5/6-7/8 and 10/11-12/13 thickened, 8/9/10 absent. Gizzard large in 9-10. Intestine from 15. Intestinal caeca paired in 27, simple, stocky, wrinkled, extending anteriorly to 24. Esophageal hearts in 10-13. Spermathecae three pairs in 7-9, ampulla oval, large, surface wrinkled, 1.7-2.6 mm long, 1.1-1.9 mm wide, duct long, stout, 0.8-1.9 mm long, with a swelling basal portion, diverticulum originating from below the swelling portion of the spermathecal duct, stalk slender at the proximal end, 0.4-0.6 mm long, enlarged and greatly coiled toward distal end. Accessory glands stalked, stalk length 0.4-1.1 mm, with a round or slightly lobed head, connecting to the swelling basal portion of the spermathecal duct. Meronephridia bush-like mass in intersegmental spaces anterior to septa 5/6 and 6/7. Testis sacs two pairs in 10 and 11, round, second pair vestigial. Seminal vesicles paired in 11 and 12, small, folliculate, posterior pair larger, each with a round or oval dorsal lobe. Prostate glands paired in 18, large, lobed, smooth, extending anteriorly to 16 and posteriorly to 22 or 23, 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.

Remarks
Amynthas huangi was regarded as a distinct species from M. houleti by James et al. (2005), but after examining type specimens, Tsai et al. (2009) argued that the former is a junior synonym of the latter. This dispute is probably a matter of opinion on morphological variations, with solution relying on new data in the future (S. James, personal communication).

Reference
James et al., 2005; Shen et al., 2005a; Tsai et al., 2009.
**Metaphire nanaoensis** Chang & Chen, 2005


*Metaphire nanaoensis* - Chen et al., 2003: 58.

**Type locality**  Nanao, Ilan County, Taiwan.

**Deposition of types**  Institute of Zoology, National Taiwan University, Taipei, Taiwan. Cat. Nos.14-04354 for the holotype, and 14-04355 and 14-05024 for the paratypes.

**Distribution**  Endemic to Taiwan, distributed in the regions northward of the Heping River in the northeast of the Central Mountain Range.

**Etymology**  The species name “*nanaoensis*” was given referring to Nanao in Ilan County in Taiwan, where the species was first collected.

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Fig. 54. *Metaphire nanaoensis*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 335-429 mm, clitellum width 10.1-14.9 mm, segment number 132-177. Number of annuli (secondary segmentation) per segment three in 5-9, five in 10-13, three in body segments behind 17. Prostomium prolobous. Setae 103-114 in 7, 120-131 in 20, 19-23 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length 13.8-14.4 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, ventral, about 0.4 body circumference apart ventrally. No genital papillae in the spermathecal region. Female pore single, medio-ventral in 14. Male pores paired, situated on setal line close to lateral border of 18, each male pore area C-shaped, enlarged, with the opening of the C facing the ventral setal line, and length about twice the length of 18, extending to the setal line of 17 and 19, laterally bordered by a thick skin wall, with several folds on lateral side; male apertures situated at the ends of the ventral setal line, partially covered by the skin wall bordering the male pore area; the region covered by the skin wall swollen, forming a smooth appearance; a very small pad present on the posterior end of the male pore area. Live specimens bluish brown or dark purplish gray with metallic luster on dorsum, reddish brown on ventral. Preserved specimens purplish brown on dorsum, light grayish brown on ventral.

Internal characters
Septa 5/6-7/8 thickened, 8/9 thin, 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 23. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, ampulla large, about 3.5-5.5 mm in length, with a stalk about 0.5-1.4 mm in length, diverticulum short, beyond the middle of spermathecae, with a small oval seminal chamber on the tip. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers anterior to the 6/7 septum. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs one pair in 10, oval, smooth, medio-ventral in front of 10/11. Seminal vesicles paired in 11, filling the space between septa, a pair of very small vestiges of seminal vesicles present in 12 in some specimens. Prostate glands paired in 18, large, lobular, extending anteriorly to 17.

Remarks
M. nanaoensis is a member of the M. formosae species group. It lives in the mountains where the vegetations are virgin or secondary broadleaf forest. M. nanaoensis is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day.

Reference
Chang & Chen, 2005b, 2008a; Chang et al., 2008a; Tsai et al., 2009.
Metaphire paiwanna paiwanna
Tsai, Tsai & Liaw, 2000

Type locality  Mudan, Pingtung County, west of the Central Mountain Range near the southern tip of Taiwan.

Deposition of types  Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Coll. no. 1998-40 for the holotype and paratypes.

Distribution  Endemic to Taiwan, distributed in the regions southward of the Launong River in the west and southward of the Taimali River in the east, at elevations below 2,000 m.

Etymology  The species epithet “paiwanna” was given with reference to the Taiwanese aboriginal Paiwan tribe.

Morphology

External characters
Length 170-300 mm, clitellum width 6.8-11.0 mm, segment number 132-177. Number of annuli (secondary segmentation) per segment three in 5-9, five in 10-13, and 17. Prostomium prolobous or epilobous. Setae 108-170 in 7, 126-170 in 10, 100-103 in 20, 104-126 in 25, 22-40 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length 8.5-9.7 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-9, dorsal-lateral, 0.50-0.71 circumference apart ventrally. Female pore single, medio-ventral in 14. Male pores (opening of copulatory pouch) paired, on setal line close to lateral border of 18, 0.25-0.32 circumference apart ventrally, each male pore area enlarged, slightly C-shaped, with the opening of the C facing the ventral setal line, and length about twice the length of 18, extending to the setal line of 17 and 19, laterally bordered by a thick skin wall and surrounded by circular folds; male apertures situated on the end of the ventral setal line, on the middle or slightly posterior to the middle of the male pore area, a horizontal ridge extending from the setal line to the male apertures, an oval pad situated between the male aperture and the anterior end of the male pore area, linked to the male aperture through a ditch-like structure. Preserved specimens bluish or purplish brown on dorsum, light gray on ventrum.

Internal characters
Septa 5/6-7/8 slightly thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 24. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, each with a slightly tuberculate ampulla, about 7 mm long, and a very short stalk,
Fig. 55. *Metaphire paiwanna piaiwanna*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.

about 1/3 of ampulla length, diverticulum small, with an oval seminal chamber, and a short, twisted stalk, reaching to or beyond the middle of ampulla. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers in 5 and 6. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs pne pair in 10, oval, smooth, medio-ventral in front of 10/11. Seminal vesicles paired in 11, large, enclosed in thin sacs, each one with a folliculate dorsal lobe. Prostate glands paired in 18, large, lobular, extending anteriorly to 17.

**Remarks**

This species is a member of the *M. formosae* species group. *A. kaopingensis* was regarded as a distinct species from *M. piaiwanna piaiwanna* by James *et al.* (2005), but after examining type specimens, Tsai *et al.* (2009) argued that the former is a junior synonym of the latter. This dispute is probably a matter of opinion on morphological variations, with solution relying on new data in the future (S. James, personal communication).

**Reference**

Metaphire paiwanna hengchunensis
(James, Shih & Chang, 2005)

Fig. 56

*Amynthas hengchunensis* James et al., 2005: 1015; - Blakemore et al., 2006: 228.

*Metaphire hengchunensis* - Chang et al., 2008a: 958.

*Metaphire paiwanna hengchunensis* - Chang & Chen, 2008a: 32; - Chang et al., 2008a: 965; - Tsai et al., 2009: 44.

**Type locality**  Nanrenshan, Kending, Pingtung County, Taiwan.

**Deposition of types**  National Museum of Natural Science, Taichung, Taiwan. Cat. no. NMNS 4054-006 for the holotype.

**Distribution**  Endemic to Taiwan, recorded in the Kenting National Park, at elevations below 300 m in Hengchun Peninsula.

**Etymology**  The species was named after Hengchun Peninsula, where this species was discovered.

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Fig. 56. *Metaphire paiwanna hengchunensis*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 200-252 mm, clitellum width 8.0-9.5 mm, segment number 138-148. Number of annuli (secondary segmentation) per segment three in 6-9, five in 10-13, three in body segments behind 17. Prostomium epilobous. Setae 120-170 in 7, 140-164 in 10, 170-208 at 25, 26-28 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, dorsal pores absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, dorsal-lateral, 0.60-0.63 circumference apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores minute, situated on low conical porophores within a copulatory pouch, a longitudinally orientated genital marking (a degraded oval pad) extending anteriorly from the aperture, the male pore area surrounded by circular folds, laterally bordered by a skin lip, partially covering male porophores. Preserved specimens light brown.

Internal characters

Remarks
M. paiwanna hengchunensis is a member of the M. formosae species group. It lives in the mountains where the vegetations are evergreen broadleaf forest and can be found in both virgin and secondary forests. M. paiwanna hengchunensis is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day. The soil of the type locality, Nanrenshan, is ultisol, having sticky and acid characteristics.

Reference
Chang & Chen, 2008a; Chang et al., 2008a; James et al., 2005; Tsai et al., 2009.
Metaphire paiwanna liliumfordi
Tsai, Tsai & Liaw, 2000

Type locality
Mt. Setou in the middle of the Coastal Mountain Range, Hualien County, Taiwan.

Deposition of types
Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Coll. no. 1998-57 for the holotype and paratypes.

Distribution
Endemic to Taiwan, distributed in the Coastal Mountain Range and the regions between the Liwu and Taimali Rivers in the Central Mountain Range, at elevations below 1,000 m in eastern Taiwan.

Etymology
The name “liliumfordi” was given to indicate its type locality at the day lily plantation.

Fig. 57. Metaphire paiwanna liliumfordi. (A-C) Male pores; (D) spermatheca; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 345-356 mm, clitellum width 9-16 mm, segment number 182-183. Number of annuli (secondary segmentation) per segment three in 5-8, five in 9-13, and three in body segments behind 17. Prostomium epilobous. Setae 115-135 in 7, 119-138 in 20, 30-32 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length 8.5-9.7 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores (opening of copulatory pouch) paired, situating on setal line close to lateral border of 18, each male pore area enlarged, slightly C-shaped, with the opening of the C facing the ventral setal line, and length about twice the length of 18, extending to the setal line of 17 and 19, bordered by a thick skin wall and surrounded by circular folds; the male aperture situated on the end of the ventral setal line, on the middle or slightly posterior to the middle of the male pore area, a horizontal ridge extending from the setal line to the male aperture, an oval pad situated between the male aperture and the anterior end of the male pore area, linked to the male aperture through a ditch-like structure. Preserved specimens bluish or purplish brown on dorsum, light gray on ventrum.

Internal characters
Septa 5/6-7/8 slightly thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 25. Lateral hearts in 11-13. Spermathecae four pairs in 6-9, each with a slightly tuberculate ampulla, and a long stalk, about half ampulla length, diverticulum small, with an oval seminal chamber, and a short, twisted stalk, reaching the base of ampulla. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers in 5 and 6. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs one pair in 10, oval, smooth, medio-ventral in front of 10/11. Seminal vesicles paired in 11, large, each with a folliculate dorsal lobe. Prostate glands paired in 18, large, lobular, extending anteriorly to 17 and posteriorly to 19.

Remarks
M. paiwanna liliumfordi is a member of the M. formosae species group. It lives in the mountains where the vegetations are broadleaf forest and can be found in both virgin and secondary forests. M. paiwanna liliumfordi is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day. It is easily found in day lily plantations.

Reference
Chang & Chen, 2008a; Chang et al., 2008a; Tsai et al., 2000c, 2009.
Metaphire posthuma (Vaillant, 1869)

Type locality  Java.
Deposition of types  Paris Museum.
Distribution  Cosmopolitan. In Taiwan, it is widely distributed in disturbed habitats in plains through the island, especially common in eastern and central Taiwan.

Fig. 58. Metaphire posthuma. (A) Male pore and associate papillae; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 60-210, clitellum width 3-8 mm, segment number 91-124. Prostomium epilobous or tanylobous. Setae 111-130 in 8, 71-83 in 20, 18-19 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, 0.3 circumference apart ventrally. Female pore single, medio-ventral in 14. Male pores paired in 18, within copulatory pouches, genital papillae present in setal line in 17 and 19, in line with male pores, each papillae large, round, with a concave center. Live specimen greenish brown or greenish gray. Preserved specimen light brown on dorsum, light gray on ventrum.

Internal characters
Septa 5/6-8/9, 10/11/12 slightly thickened, 9/10 absent. Gizzard round in 8. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 25 or 24. Oesophageal hearts in 12-13. Spermathecae four pairs in 6-9, ampulla round or heart-shaped with short, stout stalk, diverticulum elongated, heart-shaped with a short and slender stalk. Ovaries paired in 13. Testis sacs two pairs in 10 and 11, posterior pair larger than anterior one. Seminal vesicles paired in 11 and 12, the anterior one included in testis sacs. Prostate glands paired in 18, extending anteriorly to 15-17 and posteriorly to 19-21, ducts long and looped. Accessory glands in 17 and 19, corresponding to external papillae.

Reference
Blakemore, 2002; Tsai, 1964; Tsai et al., 2009.
**Metaphire puyuma** Tsai, Shen & Tsai, 1999

Type locality  
Monhuan Lake shore south of Taitung City, Taitung County, Taiwan.

Deposition of types  
Taiwan Endemic Species Research Institute, Jiji, Nantou County, Taiwan. Holotype: coll. no. 1998-48.

Distribution  
Endemic to Taiwan, only recorded from the shore of Monhuan Lake in Taitung County in southeastern Taiwan.

Etymology  
This species was named with reference to the Puyuma tribe, the aboriginal people living in the north part of the Taitung County.

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**Fig. 59.** *Metaphire puyuma*. (A) Male pore and associate papillae; (B) spermathecae; (C) prostate gland; (D) caecum.
Morphology

External characters

Length 62 mm, clitellum width 3.1 mm, segment number 113. Number of annuli (secondary segmentation) per segment 3 in 6-9, 5 in 10-13. Prostomium epilobous. Setae 115 in 7, 73 in 20, 16 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, 2.6 mm long, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, ventro-lateral, 0.29 circumference apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, ventro-lateral, copulatory pouches with C-shaped openings surrounded by oval swelling area, genital papillae paired in 19 and 20, single in 21, arranged longitudinally, each papilla on setal line, large, occupying nearly entire segment, with a slightly concave center and surrounded by a circular fold. Preserved specimens light brown on head, brown on clitellum, light gray on body.

Internal characters

Septa 8/9 and 10/11 thickened, 9/10 absent. Gizzard in 9 and 10, round. Intestine from 15. Intestinal caeca paired in 27, small, simple, surface wrinkled, extending anteriorly to 25. Lateral hearts in 11-13. Spermathecae four pairs in 6-9, each with a small, round or peach-shaped ampulla, and a short, stout stalk, diverticulum with a large, peach-shaped seminal chamber and a short, straight, stout stalk. Testis sacs two pairs in 10 and 11, medio-ventral, small. Seminal vesicles paired in 11 and 12, large, folliculated, with a large dorsal lobe. Prostate glands paired in 18, large, racemose, extending anteriorly to 16 and posteriorly to 19, prostatic duct coiled.

Reference

**Metaphire schmardae** (Horst, 1883)

Fig. 60, PLATE 7 (A)


*Metaphire schmardae* - Tsai et al., 2000a: 288; - Chang et al., 2001: 77; - Chuang et al., 2002: 68; - Tsai et al., 2004a: 6; - Tsai et al., 2009: 44.

**Type locality** Japan.

**Deposition of types** Leiden (syntype) and Vienna Museums.

**Distribution** Cosmopolitan. In Taiwan, it is distributed in plain and low elevation regions in northern and central Taiwan and the Kinmen Island.

Fig. 60. *Metaphire schmardae*. (A) Male pore; (B-C) everted copulatory pouches; (D) spermathecae; (E) prostate gland; (F) caecum.
Morphology

External characters
Length 80-125 mm, clitellum width 2-5 mm, segment number 76-96. Prostomium epilobous. Setae 56 in 8, 12-14 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores two pairs in 7/8/9, ventro-lateral, 0.5 circumference apart ventrally. Female pore single in 14, medio-ventral. Male pores paired in 18, in lateral slits of copulatory pouches, 0.3 circumference apart ventrally, pouches eversible, if everted, forming large inflated and doubled intromittant organs. Live specimens dark olive or dark brownish green. Preserved specimens dark green on dorsum, light gray on ventrum, dorsal blood vessels visible as a deep dark green longitudinal line along mid-dorsal lines.

Internal characters
Septa 5/6-7/8, 10/11-12/13 greatly thickened, 8/9/10 absent. Gizzard in 9 and 10. Intestine from 15. Intestinal caeca in 17, manicate or complex, extending anteriorly to 24. Last hearts in 13. Spermathecae two pairs in 8 and 9, ampulla large, round, stalk short and stout, diverticulum slender, seminal chamber small, oval. Ovaries paired in 13. Testis sacs two pairs in 10 and 11, anterior pair smaller than posterior one. Seminal vesicles paired in 11 and 12, large. Prostate glands paired in 18, racemose, extending anteriorly to 17 and posteriorly to 20, divided into 15-20 lobes.

Reference
Blakemore, 2002; Tsai, 1964; Tsai et al., 2009.
**Metaphire tahanmonta** Chang & Chen, 2005

![Fig. 61](image)

**Type locality**  Jinshuiying Nature Reserve, Pingtung County, Taiwan.

**Deposition of types**  Institute of Zoology, National Taiwan University, Taipei, Taiwan. Cat. Nos. 14-03993 for the holotype, and 14-05898 and 14-05899 for the paratypes.

**Distribution**  Endemic to Taiwan, recorded in the Jinshuiying Nature Reserve in Pingtung County and Tengchih in Kaohsiung County, at elevations between 500 and 2,500 m in southern Taiwan.

**Etymology**  The species name “tahanmonta” was given referring to Mt. Tahan, where this species was collected.

![Fig. 61](image)

Fig. 61. *Metaphire tahanmonta*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters

Length 291-408 mm, clitellum width 12.9-14.7 mm, segment number 122-191. Number of annuli (secondary segmentation) per segment three in 5-9, five in 10-13, and three in body segments behind 17. Prostomium prolobous. Setae 122-144 in 7, 134-156 in 20, 24-30 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length 12.8-15.5 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, lateral, above the lateral-midline, about 0.55 circumference apart ventrally. No genital papillae in the spermathecal region. Female pore single, medio-ventral in 14. Male pore paired, on setal line close to lateral border of 18, each male pore area enlarged, slightly C-shaped, with the opening of the C facing the ventral setal line and length about twice the length of 18, extending to the setal line of 17 and 19, bordered by a thick skin wall and surrounded by circular folds, with the appearance of the anterior part of the skin wall tubercular; male apertures on the extended line of the ventral setal line, slightly posterior to the middle of the male pore area, a horizontal ridge extending from the setal line, backward to the male aperture, an oval pad situated behind the setal line of 17, close to the anterior end of the male pore area, linked to the male aperture through a seminal groove. Live specimens dark purplish gray with metallic luster on dorsum, reddish brown on ventral. Preserved specimens purplish brown on dorsum, light grayish brown on ventral.

Internal characters

Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 26, simple, extending anteriorly to 23. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, ampulla large, about 3.6-5.6 mm in length, with a stalk about 1.2-1.9 mm in length, diverticulum short, usually shorter than one-third of spermathecae length, with a small oval seminal chamber on the tip. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers anterior to the 6/7 septum. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs two pairs in 10 and 11, the anterior pair oval, smooth, medio-ventral in front of 10/11, the posterior pair much larger than the anterior one, filling the space between septa. Seminal vesicles paired in 11 and 12, the anterior pair included in the posterior testis sac, both pairs moderate in size. Prostate glands paired in 18, large, lobular, extending anteriorly to 17.

Remarks

*M. tahanmonta* is a member of the *M. formosae* species group. It lives in the mountains where the vegetations are broadleaf forest or coniferous forest and can be found in both virgin and secondary forests. *M. tahanmonta* is an anecic species, having permanent vertical burrows deeper than 30 cm.

Reference

Chang & Chen, 2005b, 2008a; Chang et al., 2008a.
Metaphire taiwanensis
Tsai, Tsai & Shen, 2004

Fig. 62, PLATE 7 (B)

Metaphire taiwanensis Tsai et al., 2004b: 878; - Tsai et al., 2004a: 6; - Chang & Chen, 2004: 221; - Blakemore et al., 2006: 230; - Chang & Chen, 2008a: 43; - Chang et al., 2008a: 958; - Tsai et al., 2009: 44.

Type locality  Mt Beidongyan, Nantou County, Taiwan.

Deposition of types  Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Coll. no. 1999-9 for the holotype.

Distribution  Endemic to Taiwan, recorded in Meifong Highland Experimental Farm and Mt. Beidongyan, Nantou County, at elevations around 2,000 m in central Taiwan.

Etymology  The species name “taiwanensis” was given with reference to “Taiwan”, to which this species is endemic.

Fig. 62. Metaphire taiwanensis. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 637-655 mm, clitellum width 16.1-17.2 mm, segment number 183-228. Number of annuli (secondary segmentation) per segment three in 5-13 and on the ventrolateral portion of some body segments. Prostomium prolobous. Setae 159-188 in 7, 135-145 in 20, 15-24 between male pores. First dorsal pore 12/13 or 13/14. Clitellum 14-16, annular, length 16.5–19.9 mm, dorsal pore absent, setae absent. Spermathecal pores four pairs in 5/6-8/9, minute, invisible externally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores paired in 18, small, latero-ventral, 0.27-0.29 circumference apart ventrally, each pore C-shaped or L-shaped, bordered laterally by a thick skin surrounded with circular folds, male aperture inconspicuous, porophore circular, top flat, tuberculated, an oval pad situated anteriorly to the porophore, slightly larger than the porophore, porophore and oval pad surrounded by circular folds. Preserved specimens bluish brown on dorsum, light grayish brown on ventrum, clitellum dark bluish brown on dorsum, greyish brown on ventrum.

Internal characters

Remarks
M. taiwanensis is a member of the M. formosae species group. It is the largest species among Taiwanese earthworms. It lives in the mountains where the vegetations are broadleaf forest and can be found in both virgin and secondary forests. M. taiwanensis is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day.

Reference
Chang & Chen, 2008a; Chang et al., 2008a; Tsai et al., 2004b, 2009.
**Metaphire trutina**
Tsai, Chen, Tsai & Shen, 2003

**Type locality**  Hsiaojiaohsi, Ilan County, Taiwan.

**Deposition of types**  Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Cat. nos. 14-03884 for the holotype, 14-03882 for the paratype.

**Distribution**  Endemic to Taiwan, distributed in the regions northward of the Sheishan Mountain Ridge in northern Taiwan, including the northern tip of the Sheishan Mountain Range and the Tatun Volcano Group, at elevations between 100 and 2,000 m.

**Etymology**  The name “*trutina*” was given to this species with reference to its balance-like structure composed of porophores, seminal grooves and oval pads in its shallow copulatory pouches.

**Morphology**

**External characters**  
Length 215-425 mm, clitellum width 11.0-15.6 mm, segment number 96-189. Number of annuli (secondary segmentation) per segment three in 5-9, five in 10-13, three in body segments behind 17. Prostomium epilobous. Setae 109-122 in 7, 108-162 in 20, 22-35 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, length 9.8-14.1 mm, dorsal pore absent, setae absent. Spermathecal pores three pairs in 6/7-8/9 or four pairs in 5/6-8/9, lateral, about 0.5 circumference apart ventrally. No genital papillae in the spermathecal region. Female pore single, medio-ventral in 14. Male pores paired, situated on setal line close to lateral border of 18, each male pore area enlarged, C-shaped, with the opening of the C facing the ventral setal line and length about twice the length of 18, extending to the setal line of 17 and 19, bordered by a thick skin wall, with several folds on lateral side, the male aperture situated on the end of the ventral setal line, with one oval pad on each side, the two oval pads linked by a vertical bar-shaped structure extending from the male aperture, sometimes partially covered by the skin wall bordered the male pore area. Live specimens bluish brown or dark purplish gray with metallic luster on dorsum, reddish brown on ventrum. Preserved specimens purplish brown on dorsum, light grayish brown on ventrum.

**Internal characters**  
Septa 5/6-7/8 thickened, 8/9 thin, 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 26, simple, extending anteriorly to 23. Lateral hearts in 10-13. Spermathecae three pairs in 6/7-8/9 or four...
Fig. 63. *Metaphire trutina*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.

pairs in 6-9, ampulla large, about 3.5-6.2 mm in length, with a stalk about 0.5-1.3 mm in length, diverticulum short, beyond the middle of spermathecae, with a small oval seminal chamber on the tip. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers anterior to the 6/7 septum. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs two pairs in 10 and 11, the anterior pair oval, smooth, medio-ventral in front of 10/11, the posterior pair much larger than the anterior one, filling the space between septa. Seminal vesicles paired in 11 and 12, the anterior pair included in the posterior testis sac, both pairs moderate in size. Prostate glands paired in 18, large, lobular, extending anteriorly to 17.

Remarks

*M. trutina* is a member of the *M. formosae* species group. It is an anecic species living in the mountains where the vegetations are evergreen or deciduous broadleaf forests. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day. It can be found as deep as 80 cm below ground.

Reference

Metaphire yeni Tsai, Shen & Tsai, 2000

Fig. 64

Metaphire yeni Tsai S.-C. et al., 2000: 8; - Chang & Chen, 2004: 219; - Blakemore et al., 2006: 230; - Tsai et al., 2009: 44.

Type locality  Wutai, at an elevation of 1,000 m, Pingtung County, Taiwan
Deposition of types  Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Coll. no. 1999-27-Shen for the holotype and paratypes.
Distribution  Endemic to Taiwan, recorded in Wutai, Pingtung County.
Etymology  The name “yeni” was given to this species in honor of the former Director Jen-Teh Yen for his endeavour to establish the Taiwan Endemic Species Research Institute.

Fig. 64. Metaphire yeni. (A) Male pore; (B) preclitellar papillae; (C) spermathecae; (D-E) prostate glands; (F) caecum.
Morphology

**External characters**

Length 53-62 mm, clitellum width 2.3-2.6 mm, segment number 59-75. Number of annuli (secondary segmentation) three in preclitellar segments, five to seven in postclitellar segments. Prostomium epilobous. Setae 37-40 in 7, 41-43 in 20, 7-9 between male pores. First dorsal pore 11/12. Clitellum in 14-16, annular, setae absent, dorsal pore absent. Spermathecal pores four pairs in 5/6-8/9, lateral, each on a tubercle in intersegmental furrow, highly visible, 0.63 circumference apart ventrally. Genital papillae on latero-dorsum, 0.1-0.2 mm dorsal to spermathecal pores adjacent to intersegmental furrows, paired in two longitudinal rows in 7-9 with varying numbers and locations, each papilla circular, flat top with concave center, about 0.2 mm in diameter, surrounded by a circular fold, occupying entire annuli. Female pore single, medio-ventral in 14. Male pores paired in 18, ventral, 0.26 circumference apart ventrally, contracted into copulatory pouches or semi-protruded, if contracted, each male pore with a large oval opening with wrinkled edge surrounded by three or four circular folds, if semi-protruded, each male pore with a large, stout porophore with a flat top and three large papillae around the male aperature, with the base of porophore surrounded by three or four circular folds, each papilla with concave center, about 0.2 mm in diameter, surrounded by a fold like the one in the preclitellar region. Preserved specimens dark brown on dorsum, light yellowish white on ventrum and laterum where spermathecal pores and genital papillae present, dark brown around clitellum, light yellowish white on setal line.

**Internal characters**

Septa 8/9/10 absent, 6/7/8 and 10/11-12/13 thickened. Gizzard in 9 and 10, large, round. Intestine from 15. Intestinal caeca paired in 27, simple, surface wrinkled with a pointed end, extending anteriorly to 24. Esophageal hearts in 11-13. Spermathecae four pairs in 6-9, each with an oval or peach-shaped ampulla and a short, straight, stout stalk, diverticulum with an oval seminal chamber and a straight or slightly bent stalk, with length varying from slightly shorter to slightly longer than that of spermathecal stalk. Accessory glands solitary, round, surface follicular, stalk very short or absent. Testis sacs two pairs in 11 and 12, small, oval, smooth. Seminal vesicles paired in 11 and 12, large, irregular, follicular, with a granulated dorsal lobe. Prostate glands large and lobulated, small and wrinkled, or vestigial, prostatic ducts U-shaped or S-shaped. Accessory glands aggregated in a circular mass around the base of each prostatic duct.

**Reference**

Tsai et al., 2009; Tsai S.-C. et al., 2000.
Metaphire yuhsii (Tsai, 1964)

友變腔環蚓

*Pheretima yuhsi* Tsai, 1964: 5.
*Amynthas yuhsi* - Shih *et al*., 1999: 436.
*Amynthas yushi* - Tsai *et al*., 2000c: 1740.

**Type locality**
Yuantung Temple, Taipei, Taiwan.

**Deposition of types**
The type is missing.

**Distribution**
Endemic to Taiwan, distributed in the regions northward of the Hsinchu County in the Western Foothills, including the Tatun Volcano Group and the Turtle Island, at elevations below 1,000 m.

**Etymology**
The species epithet “yuhsii” was given in remembrance of the Taiwanese zoologist Dr. Yu-Hsi Wang, the former chief of the Department of Zoology, National Taiwan University, Taiwan.

**Morphology**

**External characters**
Length 177-318 mm, clitellum width 11 mm, segment number 80-163. Number of annuli (secondary segmentation) per segment three after 5. Prostomium epilobous. Setae 77 in 4, 103 in 8, 123 in 20, 14-34 between male pores. First dorsal pore 13/14. Clitellum 14-16, annular, dorsal pore absent, setae absent. Spermathecal pores four pairs in 6-9, intrasegmental, medio-dorsal, situated at anterior edge of each segment, about 0.95-0.97 circumference apart ventrally. No genital papillae in the preclitellar region. Female pore single, medio-ventral in 14. Male pores (opening of copulatory pouch) paired, situated on setal line close to lateral border of 18, on large conical porophores, surrounded by several circular folds, about one-thirds circumference apart ventrally. Preserved specimens dark purplish blue on dorsum, light brown on ventrum.

**Internal characters**
Septa 5/6-7/8 thickened, 8/9 and 9/10 absent, 10/11-13/14 greatly thickened. Gizzard in 8-10. Intestine from 15. Intestinal caeca paired in 27, simple, extending anteriorly to 24. Lateral hearts in 10-13. Spermathecae four pairs in 6-9, medio-dorsal, ampulla large, peach-shaped, with a slender stalk about half the ampulla length, diverticulum with a small oval seminal chamber on the tip and tightly coiled stalk. Nephridia tufted, attached to the post-segmental septa, surrounding the segmental chambers in 5 and 6. Ovaries paired in 13, medio-ventral, close to the 12/13 septum. Testis sacs one pair in 10, oval, smooth, medio-ventral in
front of 10/11. Seminal vesicles paired in 11, large, each one with a folliculate dorsal lobe. Prostate glands paired in 18, large, separated into two main lobes, extending anteriorly to 15 and posteriorly to 20.

Remarks

*M. yuhsii* is a member of the *M. formosae* species group. It was previously regarded as a synonym of *M. formosae* but recently resurrected as a valid species using DNA analyses (Chang and Chen, 2005a). It lives in the hills where the vegetations are broadleaf forest and can be found in both virgin and secondary forests. *M. yuhsii* is an anecic species, having permanent vertical burrows. It is active around the upper layer of soil or on the ground at night, but stays 30 cm or more below the ground in the soil at day.

Reference

Chang & Chen, 2005a, 2008a; Chang et al., 2008a; Tsai, 1964; Tsai et al., 2009.
Perionyx excavatus Perrier, 1872

掘穴環爪蜊


Type locality Saigon (Ho Chi Minh City), Vietnam.

Deposition of types Paris Museum.

Distribution Cosmopolitan, including India, Sri Lanka, southeast Asia, Taiwan, Hawaii, West Indies, Madagascar, Samoa, Fiji, U.K, U.S.A, Australia, and New Zealand. In Taiwan, it is recorded in several localities below the elevation of 1,100 m around the island.

Etymology The name “excavatus” literally means “to make hollow” in Latin.

Fig. 66. Perionyx excavatus. (A) Lateral view; (B) Male pores; (C) spermathecal pores; (D) spermatheca; (E) prostate gland.
Morphology

External characters
Length 50-180 mm, clitellum width 2.5-5 mm, segment number 115-178. No secondary segmentation. Prostomium epilobous. Body dorso-ventrally flattened. Setae perichaetine, 44 in 12, 40-54 in 20 with narrow mid-dorsal gaps, no setae between male pores but tips of black penial setae present around male pores. First dorsal pore 4/5 or 5/6. Clitellum in 13-17, annular, setae present. Spermathecal pores two pairs in 7/8 and 8/9, large, very obvious, closely paired, same width apart as male pores. Female pore single in 14, medio-ventral, anterior to setal line. Male pores closely paired in 18, in deep clefts in a common depressed but tumid field. Live specimens dark red or violet red.

Internal characters

Remarks
This species is frequently cultured with *Eisenia andrei* in earthworm farms and sold with the latter as “red earthworms” for fishing in Taiwan.

Reference Blakemore, 2002; Tsai *et al.*, 2009.
**Pithemera bicincta** (Perrier, 1875)

Type locality  
Philippines.

Deposition of types  
Paris Museum.

Distribution  
Cosmopolitan, including Philippines, Myanmar, Malaysia, India, Japan, Taiwan, Java, Australia, Hawai’i, USA, Mexico and Caribbean. In Taiwan, it is recorded in northern Taiwan and the Lanyu Island.

Etymology  
The specific name “bicincta” literally means “two girdles” in Latin.

Fig. 67. *Pithemera bicincta*. (A) Male pore; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters

Length 33-80 mm, clitellum width 2-3 mm, segment number 77-125. Prostomium epilobous. First dorsal pore 11/12 or 12/13. Clitellum 14-16, annular. Spermathecal pores five pairs in 4/5-8/9, 0.26 circumference apart ventrally. Female pores in 14, ventral, closely paired. Male pores paired in 18, 0.2 circumference apart ventrally, on porophores with variable shapes, minute. Genital markings absent or present, if present, paired smooth areas extending from 18 to 19. Coloration light reddish brown.

Internal characters


Reference

Blakemore, 2002; Shen & Tsai, 2002a, b; Tsai et al., 2009.
**Pithemera lanyuensis** Shen & Tsai, 2002

Fig. 68


**Type locality** Southeastern Lanyu, Taitung County, Taiwan.

**Deposition of types** Taiwan Endemic Species Research Institute, Jiji, Nantou, Taiwan. Holotype: coll. no. 2000-40-Shen. Paratypes: same collection data as for the holotype.

**Distribution** Endemic to Taiwan, recorded only in the Lanyu Island, Taitung County, Taiwan.

**Etymology** The species name “*lanyuensis*” was given referring to the Lanyu Island, where the species was first collected.

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Fig. 68. *Pithemera lanyuensis*. (A) Male pore and associate papillae; (B) spermatheca; (C) prostate gland; (D) caecum.
Morphology

External characters
Length 37-46 mm, clitellum width 1.6-2.0 mm, segment number 79-90. No secondary segmentation. Prostomium epilobous or zygodontous. Setae 52-57 in 7, 46-52 in 20, 9-12 between male pores. First dorsal pore 12/13. Clitellum 14-16, annular, 0.9-1.5 mm long, dorsal pore absent, setae absent. Spermathecal pores five pairs in 4/5-8/9, ventro-lateral, 0.25-0.33 circumference apart ventrally. No genital papillae in the spermathecal region. Female pores closely paired, medio-ventral in 14. Male porophores paired in 18, latero-ventral, about 0.23 circumferences apart ventrally, round or oval, smooth, slightly elevated, surrounded by several slight circular folds, male aperture not visible; genital papillae present in 19,20-21, paired in 20, occupying nearly entire pre-setal part of 20 between setal line and 19/20 intersegmental furrow, each papilla round, center concave, about 0.4 mm in diameter, 7-12 intersetal distance apart from each other, paired in 19 if present, single in right 21. Preserved specimens dark brown on dorsum, dark gray on ventrum, brown around clitellum.

Internal characters
Septa 8/9 absent, 9/10-12/13 thick. Gizzard round in 9. Intestinal caeca paired in 22, small, short, bent. Esophageal hearts in 10-12. Spermathecae five pairs in 5-9, small, ampulla peach-shaped, 0.4-0.5 mm long, about 0.2 mm wide, stalk straight about 0.2 mm long, diverticulum small or vestigial, stalk short, straight to slightly bent, seminal chamber rudimentary or absent. Testes two pairs in 10 and 11, small, round. Seminal vesicles paired in 11 and 12, rudimentary. Prostate glands paired in 18, large, wrinkled, extending anteriorly to 16 and posteriorly to 22, with C-shaped ducts. Accessory glands in 20, round, sessile, pad-like, about 0.2 mm in diameter, each corresponding to external genital papillae.

Remarks
Pithemera lanyuensis is the only endemic species of Pithemera in Taiwan.

Reference
Shen & Tsai, 2002a; Tsai et al., 2009.
**Polypheretima elongata** (Perrier, 1872)

*Fig. 69*

**Long-term Multilingual Medical Dictionary**


**Type locality**  Peru.

**Deposition of types**  Paris Museum.

**Distribution**  Cosmopolitan, including South and Central America, Caribbean, Africa, Madagascar, Sri Lanka, India, Pakistan, Bangladesh, Myanmar, Philippines, Taiwan, Papua New Guinea, Australia, New Caledonia, Caroline Islands and Hawaii. It is distributed in plain and hill regions at elevations below 500 m in central and southern Taiwan and in the Lanyu Island.

**Etymology**  This species was named after its elongated body shape.

**Morphology**

**External characters**

Length 75-300 mm, clitellum width 3-6 mm, segment number 136-297. Prostomium prolobous or epilobous. Setae 67-104 in 8, 55-75 in 20. First dorsal pore 12/13 or 13/14. Clitellum 14-16, annular, setae present ventrally or absent, dorsal pore absent. Spermathecal pores absent. Female pore single in 14, medio-ventral. Male pores paired in 18, on raised poropores. Genital papillae paired in 19-23,24, pre-setal, large, raised, with smooth center. Live specimens light grey with pink anterior.

![Fig. 69. Polypheretima elongata](image-url)

(A) Male pore; (B) male pores and associate papillae; (C) prostate gland.
**Internal characters**


**Reference**

Blakemore, 2002; Gates, 1972; Tsai et al., 2009.
Pontodrilus litoralis (Grube, 1855)

Fig. 70

Pontodrilus litoralis - Shen et al., 2005a: 12; - James et al., 2005: 1022; - Blakemore et al., 2006: 230; - Tsai et al., 2009: 38.

Type locality South France.
Deposition of types Humbolt Museum, Berlin, Germany.
Distribution Cosmopolitan, widely distributed in warm beaches throughout the world. In Taiwan, it is recorded in the beaches of western Taiwan and the Penghu and Kinmen Islands.
Etymology The species was named with reference to its littoral habitats.

Morphology

External characters
Length 50-130 mm, clitellum width 1-2 mm, segment number 81-115. Prostomium epilobous. Setae lumbricine, ab absent in 18. Dorsal pore absent. Clitellum 13-17, saddle-shaped, setae present. Spermathecal pores two pairs in 7/8 and 8/9, ventro-lateral, in line with seta b. Female pores paired, medio-ventral in 14, each anterior to seta a. Male pores minute, paired in 18, each on inner wall of a longitudinal depression, median to a longitudinal ridge extending the entire segment 18. Genital marking large, medio-ventral, transversely oval across 19/20, center depressed. Preserved specimens pale, light brown around clitellum.

Fig. 70. Pontodrilus litoralis. (A)Ventral view of the anterior body; (B) male pores.
Internal characters

Remarks
P. litoralis dwells in sandy beaches, salty mud, or mangrove swamps of the intertidal zone.

Reference
Blakemore, 2002; Shen et al., 2005a; Tsai et al., 2009.
**Eukerria saltensis** (Beddard, 1895)

Fig. 71, PLATE 8 (B)


**Type locality**   Salto, Valparaiso, Chile.


**Distribution**   Cosmopolitan. In Taiwan, it is recorded at elevations below 1,770 m in the mountain and hill regions throughout the island.

**Etymology**   The species was named after its type locality, Salto.

Fig. 71. *Eukerria saltensis*. (A)Lateral view of the anterior half of the body; (B) male pores; (C) female pores; (D) spermatheca; (E) prostate glands.
Morphology

External characters

Internal characters
Septa present from 5/6, 6/7-8/9 thickened. Gizzard in 7. Calciferous glands one pair in 9, thick-walled with numerous capillaries. Intestine from 12. Esophageal hearts in 9-11. Spermathecae two pairs in 8 and 9, small, adiverticulate, ampulla round or oval, duct slender, twist near ampulla. Nephridia avesiculate. Ovaries paired in 13, small. Testes one pair in 10, small, flowery, shiny. Seminal vesicles paired in 9 and 11, small. Prostate glands two pairs with prostatic pores in 17 and 19, each thin, elongate, tubular, extending four to five segments.

Remarks
This species is frequently found along forest roads in Taiwan.

Reference
Shen et al., 2008a; Tsai et al., 2009.
**Dichogaster affinis** (Michaelsen, 1890)

乳突重胃蚓  

**Type locality**  
Quelimane, Zanzibar.

**Deposition of types**  
Hamburg Museum, Germany.

**Distribution**  
Cosmopolitan, widely distributed in the tropical and temperate regions around the world. It is recorded in Yunlin County in central Taiwan.

Fig. 72. *Dichogaster affinis*. (A) Dorsal view; (B) ventral view of clitellum and male pores; (C) male pores; (D) preclitellar genital markings; (E) spermathecae; (F) prostate glands.
Morphology

External characters

Internal characters
Septa weakly developed. Gizzards paired in 7 and 8, muscular, displaced posteriorly to 9 and 10, each barrel-shaped. Calciferous glands three pairs in 15-17, digiform, the first two pairs transparent with comb-like streaks, the last pair yellowish white and slightly lobed. Intestine from 17. Esophageal hearts in 11-13. Spermathecae two pairs in 8 and 9, small, ampulla oval, about 0.2 mm long, with a wide, stout, short duct, diverticulum small, short-stalked with a bulbous seminal chamber. Accessory glands absent. Nephridia meroic, saccular, four rows on each side. Ovaries paired in 13. Testes two pairs in 10 and 11, small, round. Seminal vesicles absent or vestigial in 11 and 12. Prostate glands two pairs in 17 and 19, long, tubular with penial setae close to short, muscular ducts.

Reference
Shen et al., 2008b; Tsai et al., 2009.
Dichogaster bolau (Michaelsen, 1891)

包氏重胃蚓


Type locality Bergedorf near Hamburg, Germany.
Deposition of types Hamburg Museum, Germany.
Distribution Cosmopolitan, pan-tropical around the world. In Taiwan, it is recorded in central Taiwan and the Kinmen Island.
Etymology This species was named after Mr. Bolau.

Fig. 73. Dichogaster bolau. (A)Dorsal view; (B) male pores; (C) spermathecae; (F) prostate glands.
Morphology

External characters

Internal characters

Reference
Blakemore, 2002; Tsai et al., 2009.
Fig. 74. *Dichogaster saliens*. (A)Lateral view; (B) male pores; (C) spermathecae; (D) prostate gland.
Morphology

External characters
Length 25-40 mm, clitellum width 1.4-2.3 mm, segment number 103-125. Prostomium epilobous. Setae lumbricine, small and closely paired on ventrum, ab modified as penial setae in 17 and usually lacking in 18. First dorsal pore 4/5 or 5/6. Clitellum 13-19, annular but thinner in aa, 1.7-3.2 mm in length. Spermathecal pores two pairs in 7/8 and 8/9, medio-ventral, in line with seta a. Female pores paired in 14, each medial to seta a. Genital marking medio-ventral, round, across 15/16. Male pores at posterior ends of grooves within closely paired, transversely diamond-shaped porophores in 17. Preserved specimens brown on anterior dorsum and yellow around clitellum.

Internal characters
Septa thickened from 1/2, 5/6-7/8 missing. Crop large in 6. Gizzards two pairs in 7 and 8, muscular, barrel-shaped, displaced posteriorly to 9 and 10. Calciferous glands three pairs in 15-17, digiform, the last pair without external lamellae. Intestine from 17. Esophageal hearts in 10-12. Spermathecae two pairs in 8 and 9, small, ampulla oval, about 0.3 mm long, with a twist stalk bearing small, spherical, shiny diverticulum. Nephridia meristic, saccular, four rows on each side. Ovaries flowery in 13. Testes two pairs in 10 and 11, small, round. Seminal vesicles lacking or very small in 11 and 12, or only in 12. Prostate glands one pair in 17, long, tubular to tapered, twist duct with penial setae at the end.

Reference
Shen & Tsai, 2007; Tsai et al., 2009.
**Drawida japonica (Michaelsen, 1892)**

日本杜拉蛔


**Type locality**
Japan.

**Deposition of types**
Zoologisches Institut und Zoologisches Museum, universität Hamburg, Germany

**Distribution**
Widespread in Asia, including India, China, Korea, Japan and Taiwan. It is recorded in northern Taiwan.

**Etymology**
The species was named after its type locality, Japan.

**Morphology**

**External characters**
Length 30-200 mm, clitellum width 2-5.5 mm, segment number 165-195. Prostomium prolobous. Setae lumbricine. Dorsal pore absent. Clitellum in 10-13, setae present in some of the glandulated regions. Spermathecal pores one pair in 7/8. Female pores paired in 11/12. Male pores in 10, near 10/11, on a transversely raised ovoid tubercle. Genital papillae present or absent, if present, numbering 1-6, irregularly placed in 7-13, usually near male pores and spermathecal pore regions, each papilla small, round, with dark center, surrounded by a circular fold. Live specimens light bluish gray, bluish green or greenish violet on dorsum, grayish pale on ventrum, flishy on clitellum. Preserved specimens deep grape or bluish violet on dorsum, light greyish pale on ventrum, purplish red or flishy on clitellum.

**Internal characters**

**Remarks**
This species was recorded in Taiwan by only Kobayashi 70 years ago and was never recorded in the past ten years.

**Reference**
Chen, 1933; Tsai *et al*., 2009.
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PLATE 1

A. Pontoscolex corethrurus  
B. Aporrectodea caliginosa  
C. Eiseniella tetraedra
PLATE 2

A. Amynthas aspergillum
B. Amynthas corticis
C. Amynthas gracilis

Photo by S-C Chuang
A. *Amynthas incongruus*
B. *Amynthas lini*
C. *Amynthas minimus*
PLATE 4

A. *Amynthas papulosus*
B. *Amynthas robustus*
C. *Amynthas rockefelleri*
A. *Amynthas sexpectatus*

B. *Metaphire californica*

C. *Metaphire formosae*
A. *Metaphire glareosa*

B. *Metaphire paiwanna paiwanna*

C. *Metaphire posthuma*
A. Metaphire schmardae  
B. Metaphire taiwanensis  
C. Metaphire trutina  
D. Metaphire yuhsii
A. *Perionyx excavatus*

B. *Eukerria saltensis*

C. *Dichogaster bolauj*