Zoological Studies **38**(4): 435-442 (1999)

Zoological Studies

A Review of the Earthworms (Annelida: Oligochaeta) from Taiwan

Hsi-Te Shih[1,2,*], Hsueh-Wen Chang[2] and Jiun-Hong Chen[3]

[1]*Institute of Marine Biology,* [2]*Department of Biological Sciences, National Sun Yat-sen University, Kaohsiung, Taiwan 804, R.O.C.*
[3]*Department of Zoology, National Taiwan University, Taipei, Taiwan 106, R.O.C.*

(Accepted July 13, 1999)

Hsi-Te Shih, Hsueh-Wen Chang and Jiun-Hong Chen (1999) A review of the earthworms (Annelida: Oligochaeta) from Taiwan. *Zoological Studies* **38**(4): 435-442. The study of earthworms of Taiwan began with the Japanese scholars Goto and Hatai (1898). The collecting sites from available publications are limited to Ilan, Taipei, Taoyuan, Hsinchu, Miaoli, Kaohsiung, and Pingtung. A total of 26 species belonging to 9 genera are recorded in Taiwan: *Drawida japonica* (Michaelsen, 1892), *Aporrectodea trapezoides* (Dugès, 1828), *Bimastus parvus* (Eisen, 1874), *Perionyx excavatus* Perrier, 1872, *Amynthas aspergillum* (Perrier, 1872), *Am. candidus* (Goto and Hatai, 1898), *Am. corticus* (Kinberg, 1867), *Am. formosae* (Michaelsen, 1922), *Am. gracilis* (Kinberg, 1867), *Am. hsinpuensis* (Kuo, 1995), *Am. hupeiensis* (Michaelsen, 1895), *Am. incongruus* (Chen, 1933), *Am. minimus* (Horst, 1893), *Am. morrisi* (Beddard, 1892), *Am. omeimontis polyglandularis* (Tsai, 1964), *Am. papulosus* (Rosa, 1896), *Am. robustus* (Perrier, 1872), *Am. swanus* (Tsai, 1964), *Am. taipeiensis* (Tsai, 1964), *Am. yuhsi* (Tsai, 1964), *Polypheretima elongata* (Perrier, 1872), *Metaphire californica* (Kinberg, 1867), *M. posthuma* (Vaillant, 1869), *M. schmardae schmardae* (Horst, 1883), *Pithemera bicincta* (Perrier, 1875), and *Dichogaster bolaui* (Michaelsen, 1891). Among these species, 9 species were published as new species from Taiwan. Three holotype specimens can be found in the museums, but the rest can not be located. One species, *Amynthas asiaticus* Michaelsen, 1900 was not included in the list because it appeared in non-taxonomic references with no description. The present paper reviews the studies on Taiwanese earthworms, and lists species published from Taiwan according to current classification and their collecting sites. Some mistakes in the literature about Taiwanese earthworms are also discussed.

Key words: *Pheretima*, Taxonomy.

Earthworms are among the most important animals living in soil, both for their role in agriculture and in terrestrial ecology (Edwards and Bohlen 1996). While most species of earthworms are known to be beneficial to agriculture, some species may damage crops (Edwards and Bohlen 1996), e.g., *Polypheretima elongata* in central Taiwan (Gates 1959). In addition, earthworms are important for studying the behavior and ecology of animals which feed on them (Edwards and Bohlen 1996).

In general, earthworms possess the following principal systematic features: bilateral symmetry, external segments with a corresponding internal segmentation, setae borne on all segments except the first 2, and possession of an outer layer of circular muscles and an inner layer of longitudinal muscles. The alimentary canal is basically an anterior-posterior tube with excretion through the anus or specialized organs (nephridia). Respiration is mainly cuticular. Earthworms are hermaphroditic or parthenogenetic (Gates 1972, Reynolds 1974, Edwards and Bohlen 1996).

The study of earthworm fauna of Taiwan is not yet completed. The collecting sites in the literature began with the Japanese scholars Goto and Hatai (1898) and extend to the Taiwanese Chen and Shih (1996) most recently, and are mostly in northern Taiwan (Ilan, Taipei, Taoyuan, Hsinchu, and Miaoli areas), with a few in southern Taiwan (Kaohsiung and Pingtung areas) (see HISTORICAL REVIEW). Because some species were recorded with only a brief or no description, and most type specimens of

*To whom correspondence and reprint requests should be addressed. Tel: 886-7-5252000 ext. 3614. Fax: 886-7-5253614. E-mail: htshih@mail.nsysu.edu.tw

these studies are not extant, it is impossible to determine if some species may have been misidentified. Therefore, it is necessary to provide a list and the collection sites of earthworms in Taiwan for earthworm taxonomists before a thorough revision is possible. In addition, there are some mistakes concerning Taiwanese earthworms in the literature due to the paucity of complete literature and taxonomical training. Therefore, a review of Taiwanese earthworms is important for future earthworm studies. In this study, we provide a complete historical review of studies on Taiwanese earthworms and a list of the Taiwanese earthworms hitherto reported according to the present taxonomic system (mostly based on Easton 1980). In addition, some confusing points about the taxonomy of earthworms of Taiwan are discussed.

The localities, as both Chinese and Japanese names, used in this study are shown in Appendixes I and II.

HISTORICAL REVIEW

In the first study of earthworms from Taiwan, Goto and Hatai (1898) published 2 new species of earthworms, *Perichaeta takatorii* (= *Amynthas aspergillum*) and *Perichaeta candida* (= *Amynthas candidus*), from Taipei City. Both species were collected by Y. Takatori of the Department of Agriculture of the Government of Formosa.

Michaelsen (1922) described 1 new species, *Pheretima formosae* (= *Amynthas formosae*), and 1 new variety, *Pheretima papulosa sauteri* (= *Amynthas papulosus*) of earthworm collected by Hans Sauter at Chiahsien (as Dorf Koseypo or Dorf Kosempo), Kaohsiung County in January 1908. The holotype of *Ph. formosae* was deposited at the Nationaal Natuurhistorisch Museum, Leiden, Netherlands (Gates 1959: 9, Reynolds and Cook 1976: 103) and the paratypes were deposited at Zoologisches Institut und Zoologisches Museum, Universität Hamburg, Hamburg, Germany (Reynolds and Cook 1976: 103); the holotype of *Ph. papulosa sauteri* was in the Nationaal Natuurhistorisch Museum (Gates 1959: 18, 1972: 206, Reynolds and Cook 1976: 168).

Takahasi (1932a,b 1933) studied the morphology and variation of an unknown species of *Pheretima* in Taipei. The descriptions and figures of this species agree with the characters of *Amynthas gracilis* (Kobayashi 1939 [as *Ph. hawayana*]).

Kobayashi (1938) published *Perionyx excavatus* collected by Masao Yamanaka in Shinchiku (= Hsinchu) as a new record for Taiwan. Kobayashi (1939 1940a) described some earthworms near the Hsinchu area (Hsinchu, Kuanhsi, and Hsinwu), in which 11 species were new records: *Drawida japonica, Aporrectodea trapezoides* (as *Allolobophora caliginosa* subsp.), *Bimastus parvus, Amynthas corticus* (as *Ph. diffringens*), *Am. gracilis, Am. hupeiensis, Am. minimus* (as *Ph. zoysiae*), *Am. morrisi, Am. robustus, Metaphire californica* and *M. schmardae schmardae*. In addition, *Amynthas aspergillum* (as *Ph. takatorii*), *Am. formosae, Am. papulosus* (as *Ph. papulosa sauteri* and *Ph. rockefellerii*), and *Perionyx excavatus* were also collected. These specimens were collected by M. Yamanaka and his students, A. Kawasaki and M. Aragaki of Shinchiku High School. Kobayashi (1940c) discussed the dispersal passage of *Drawida japonica* from China to Japan and the possibility by way of Taiwan. Kobayashi further reported *Dichogaster bolaui* (1941c) from Taiwan as a new record.

Gates (1959) published 4 species as new records: *Pithemera bicincta* (Yangmingshan [as Green Mountain]), *Polypheretima elongata* (Tsing-Chao Maa), *Amynthas incongruus* (Taipei), and *Metaphire posthuma* (Chaochou). Other species of *Am. aspergillum* (Chaochou), *Am. corticus* (Yangmingshan), *Am. formosae* (Chaochou and Yangmingshan), *Metaphire californica* (Taipei), and *Perionyx excavatus* (Suao) were also collected. Those specimens were collected by D E. Beck and deposited at the American Museum of Natural History (New York). Specimens of *Po. elongata* were provided by the United States Department of Agriculture with a label stating that this species caused serious damage to rice plants near a small village “Tsing-Chao Maa” in central Taiwan. However, the actual locality could not be identified.

A thorough survey of the earthworms in northern Taiwan was reported by Tsai (1964). Four new species, *Pheretima polyglandularis* (= *Am. omeimontis polyglandularis*) (small hill behind the 8th dormitory of NTU [= National Taiwan Univ.]), *Pheretima swanus* (= *Am. swanus*) (campus of NTU), *Ph. taipeiensis* (= *Am. taipeiensis*) (Chungho City), and *Ph. yuhsi* (= *Am. yuhsi*) (Yuantung Temple [as Entong Temple] and Neihu) were found. *Ph. yuhsi* was named after Dr. Yu-Hsi Moltze Wang, then the head of the Department of Zoology, and *Ph. swanus* was named after a friend of Tsai. The other 11 species described were *Am. aspergillum* (campus of NTU and sand bank of Tanshui River [as Tam-sui River]), *Am. corticus* (sand bank of Tanshui River and small hill behind the 8th dormitory of NTU), *Am. gracilis* (sand bank of Tanshui River, campus of NTU,

Yingko, and Wanhua [as Huang-fa]), *Am. hupeiensis* (sand bank of Tanshui River), *Am. incongruus* (campus of NTU), *Am. morrisi* (Yingko), *Am. papulosus* (campus of NTU), *Am. robustus* (the 8th dormitory of NTU) (also as *Ph. lauta* [campus of NTU and Yingko]), *Metaphire californica* (campus of NTU and Yingko), *M. posthuma* (Wanhua Station and sand bank of Tanshui River), and *M. schmardae schmardae* (campus of NTU, sand bank of Tanshui River, and the 8th dormitory of NTU). Most specimens were collected by Tsai, while some were collected by C.-M. Kuo in Yingko. Unfortunately, none of these specimens could be found in NTU now.

Reynolds and Cook (1976) in their "Nomenclatura Oligochaetologica" listed names, descriptions, and type specimens of the oligochaetes hitherto published. They included 8 species published as new species from Taiwan. Easton (1976) discussed the taxonomic system of the *Metapheretima elongata* species-complex, and he included the record of earthworm of Taiwan.

Kuo (1987) studied the propagation and composition of "*Amynthas asiaticus*" and its effects on soil fertility. Kuo (1993) provided a key and some genital markings of Taiwanese pheretimas. Kuo (1995) published a new species, *Pheretima hsinpuesis* (= *Amynthas hsinpuensis*), in Hsinpu and described some other species, *Bimastus parvus* (Toufen), *Perionyx excavatus* (Chungli), *Amynthas gracilis* (Hsinpu), *Metaphire californica* (Tsaochiao), and *M. schmardae schmardae* (campus of National Hsinchu Teacher's College) with some scanning electron photomicrographs of genital markings. The specimens are deposited at the National Hsinchu Teacher's College.

Chang (1992) studied how "*Am. asiaticus*" activities affect surface soil infiltration. Kuo and Huang (1993) studied the lethal effects of 5 pesticides on *Bimastus parvus*.

Chen and Shih (1996) surveyed the earthworm fauna in Fushan Botanical Garden and recorded 6 species of *Amynthas*: *Am. corticus, Am. formosae, Am. gracilis, Am. omeimontis polyglandularis, Am. papulosus,* and *Am. taipeiensis*. The specimens were deposited at the Department of Zoology, NTU (Table 1).

DISCUSSION

The *Pheretima* group is the largest group of earthworms in the world, consisting of more than 700 nominal species and subspecies (Sims and Easton 1972). It is also the largest group in Taiwan. Because it is too large to be handled, Sims and Easton (1972) divided the genus into 8 genera by phenetic analysis according to the greatest number of shared morphological attributes. Further, Easton (1979) re-examined the specimens and revised some species without caecum in the *Pheretima* group. In his study, the genus *Ephemitra* was combined into *Metapheretima*, the genus *Polypheretima* was divided from *Metapheretima*, and the genus *Pleionogaster* with intestinal gizzards was considered to be a member of the *Pheretima* group. In addition, *Begemius* was separated from *Amynthas* by Easton (1982) (Fig. 1). The subdivision of the *Pheretima* group is based on body shape, caecum, gizzard, male pore, clitellum, spermathecal diverticula, and spermathecal duct (Sims and Easton 1972, Easton 1979 1982). For a key to the genera of the *Pheretima* group refers to Easton (1979 1982).

A total of 26 species of earthworms is recorded from Taiwan (Tables 1, 2). These species can be classified into 9 genera: *Drawida, Aporrectodea, Bimastus, Perionyx, Amynthas, Polypheretima, Metaphire, Pithemera,* and *Dichogaster*. The *Pheretima* group contains 21 species which are the dominant earthworms in Taiwan. *Amynthas* is the largest genus (16 species), the 2nd is *Metaphire* (3 species), while the other genera are each composed of only 1 species. Most collecting sites were restricted to northern Taiwan, especially Taipei City and County, followed by Hsinchu City, Hsinchu County, and Kaohsiung County; other areas were Ilan, Taoyuan, and Pingtung (Fig. 2). A key to the recorded species of earthworms of Taiwan would be inappropriate until a more thorough survey on the fauna of Taiwan is undertaken.

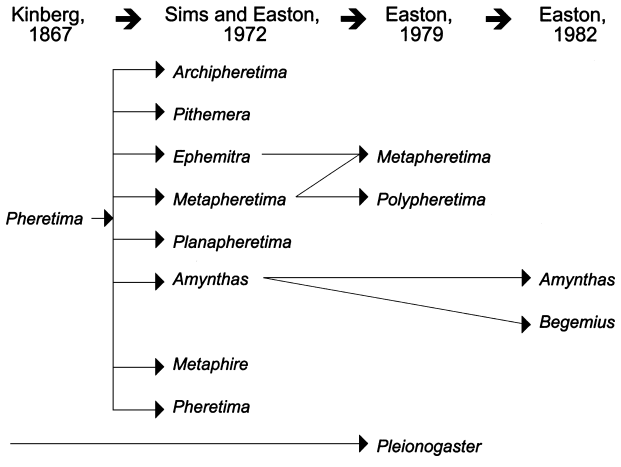

Fig. 1. Change of the taxonomic status of the *Pheretima* group.

Nine species were published as new species in Taiwan: *Perichaeta takatorii* (Goto and Hatai, 1898), *Perichaeta candida* (Goto and Hatai, 1898), *Pheretima formosae* (Michaelsen, 1922), *Ph. papulosa sauteri* (Michaelsen, 1922), *Ph. polyglandularis* (Tsai, 1964), *Ph. swanus* (Tsai, 1964), *Ph. taipeiensis* (Tsai, 1964), *Ph. yuhsi*, (Tsai, 1964), and *Ph. hsinpuensis* (Kuo, 1995). However, only 3 holotype specimens can be found in museums: *Ph. formosae, Ph. papulosa sauteri*, and *Ph. hsinpuensis* (Gates 1959 1972, Kuo 1995).

According to Kuo (1987) and Chang (1992), "*Amynthas asiaticus*" was studied as their material. However, *Am. asiaticus* Michaelsen, 1900 was not recorded from Taiwan and is not described in their text. In addition, Kuo (1993) also did not include it in her later publication about Taiwanese earthworms. It might be a misidentification. Therefore, *Am. asiaticus* was not included in our list.

Gates (1959) identified a new record of the earthworm, *Polypheretima elongata*, in central Taiwan. However, the information Kuo (1993) provided about *Po. elongata* was based on various items of literature from Japan (e.g., Ohfuchi 1965, Kamihira 1973). An important character of *Po. elongata* (Perrier, 1872) is that it does not have a caecum, however, Japanese "*Po. elongata*" does have a caecum (Ohfuchi 1956). According to Gates (1972), Sims and Easton (1972), and Easton (1976 1980), Japanese "*Po. elongata*" may be a misidentification of *Amynthas morrisi*, and Japanese "*Pheretima biserialis*" identified by Ohfuchi (1956) is the same as *Po. elongata*.

In Kuo's (1993) paper, the character of the 1st dorsal pore was considered to be the key character. This would be misleading because the 1st dorsal

Table 1. Species of earthworms of Taiwan recorded in the literature

Author(s)	Goto and Hatai	Michaelsen	Kobayashi	Kobayashi	Kobayashi	Kobayashi	Kobayashi	Gates	Tsai	Kuo	Chen and Shih
Year	1898	1922	1938	1939 1940a	1941a	1941b	1941c	1959	1964	1995	1996
Drawida japonica				*	*	*					
Aporrectodea trapezoides				*		*	*				
Bimastus parvus				*			*			*	
Perionyx excavatus			*	*				*		*	
Amynthas aspergillus	*			*				*	*		
Am. candidus	*										
Am. corticus				*	*	*	*	*	*		*
Am. formosae		*		*				*			*
Am. gracilis				*	*		*		*	*	*
Am. hsinpuensis										*	
Am. hupeiensis				*	*	*	*		*		
Am. incongruus								*	*		
Am. minimus				*	*		*				
Am. morrisi				*	*		*		*		
Am. omeimontis polyglandularis									*		*
Am. papulosus		*		*	*		*		*		*
Am. robustus				*		*	*		*		
Am. swanus									*		
Am. taipeiensis									*		*
Am. yuhsi									*		
Polypheretima elongata								*			
Metaphire californica				*	*	*	*	*	*	*	
M. posthuma								*	*		
M. schmardae schmardae				*	*	*	*		*	*	
Pithemera bicincta								*			
Dichogaster bolaui							*				

pore is too variable to be used as a taxonomic character (Gates 1937). In addition, some figures of the caeca and prostates were apparently modified from Kamihira (1973). However, many species names in Kuo's legends are misplaced. For example, in Kuo's paper, Figs. 4A (*Ph. morrisi*), 4B (*Ph. hupeiensis*), 4C (*Ph. posthuma*), 4E (*Ph. taipeiensis*), 4I (*Ph. californica*), 5C (*Ph. californica*), and 5D (*Ph. robusta*) are the same as Kamihira's (1973) Figs. 5 (11) (*Ph. pusilla*), 5(1) (*Ph. carnosa*), 5(2) (*Ph. heteropoda*), 5(16) (*Ph. maculosus*), 5(20) (*Ph. masatakae*), 6(F) (*Ph. riukiuensis*), and 6(D) (*Ph. iizukai*), respectively. The wrong legends will mislead inexperienced researchers in identification work.

Kuo (1995) published *Pheretima hsinpuesis* as a new species from Hsinpu. However, the spelling "*hsinpuesis*" should be replaced by the spelling *hsinpuensis* by the Latinization of Hsinpu. According to the characters described, this species should be placed under the genus *Amynthas*, so its valid name is *Amynthas hsinpuensis*.

Amynthas candida was described as a new species in Taipei by Goto and Hatai (1898) and was not collected for about 100 years since. Therefore, Gates (1959) considered *Am. candida* and regarded it as a *species inquirenda*. Among the species published by Kobayashi (1939 1940a 1941a,b,c), *Drawida japonica, Aporrectodea trapezoides, Amynthas minimus,* and *Dichogaster bolaui* have not been reported since then (Table 1).

Kobayashi (1940a 1941b,c) recorded *Allolobophora caliginosa* subsp. from Taiwan. He could not confirm that the Taiwanese specimens were *Al. caliginosa typica* or *Al. caliginosa trapezoides* because the specimens were immature individuals (1940a 1941b). According to Kobayashi (1940b 1941b,d), both subspecies occurred in Manchuria, Korea, and Japan. Kobayashi's "*Al. caliginosa typica*" (1940b) was probably a synonym of *Al. tuberculata* Eisen, 1874, but this needs to be confirmed (Gates 1972: 80). However, Chinese "*Al.*

Table 2. Species list of earthworms of Taiwan. The classification of earthworms follows the classification of Reynolds and Cook (1993)

Phylum Annelida	環節動物門
Class Oligochaeta	貧毛綱
Order Moniligastridae	鏈胃蚓目
Family Moniligastridae	鏈胃蚓科
Drawida japonica (Michaelsen, 1892)	日本杜拉蚓
Order Haplotaxidae	單向蚓目
Suborder Lumbricina	正蚓亞目
Family Lumbricidae	正蚓科
Aporrectodea trapezoides (Dugès, 1828)	梯形阿波蚓
Bimastus parvus (Eisen, 1874)	微小雙胸蚓
Family Megascolecidae	鉅蚓科
Perionyx excavatus Perrier, 1872	掘穴環爪蚓
Amynthas aspergillum (Perrier, 1872)	參狀遠環蚓
Am. candidus (Goto and Hatai, 1898)	光澤遠環蚓
Am. corticus (Kinberg, 1867)	皮質遠環蚓
Am. formosae (Michaelsen, 1922)	臺灣遠環蚓
Am. gracilis (Kinberg, 1867)	纖細遠環蚓
Am. hsinpuensis (Kuo, 1995)	新埔遠環蚓
Am. hupeiensis (Michaelsen, 1895)	湖北遠環蚓
Am. incongruus (Chen, 1933)	參差遠環蚓
Am. minimus (Horst, 1893)	微小遠環蚓
Am. morrisi (Beddard, 1892)	牟氏遠環蚓
Am. omeimontis polyglandularis (Tsai, 1964)	多腺峨嵋遠環蚓
Am. papulosus (Rosa, 1896)	丘疹遠環蚓
Am. robustus (Perrier, 1872)	壯偉遠環蚓
Am. swanus (Tsai, 1964)	絲婉遠環蚓
Am. taipeiensis (Tsai, 1964)	臺北遠環蚓
Am. yuhsi (Tsai, 1964)	友燮遠環蚓
Polypheretima elongata (Perrier, 1872)	長形多環蚓
Metaphire californica (Kinberg, 1867)	加州腔環蚓
M. posthuma (Vaillant, 1869)	土後腔環蚓
M. schmardae schmardae (Horst, 1883)	舒氏腔環蚓
Pithemera bicincta (Perrier, 1875)	雙帶近環蚓
Family Octochaetidae	八毛蚓科
Dichogaster bolaui (Michaelsen, 1891)	包氏重胃蚓

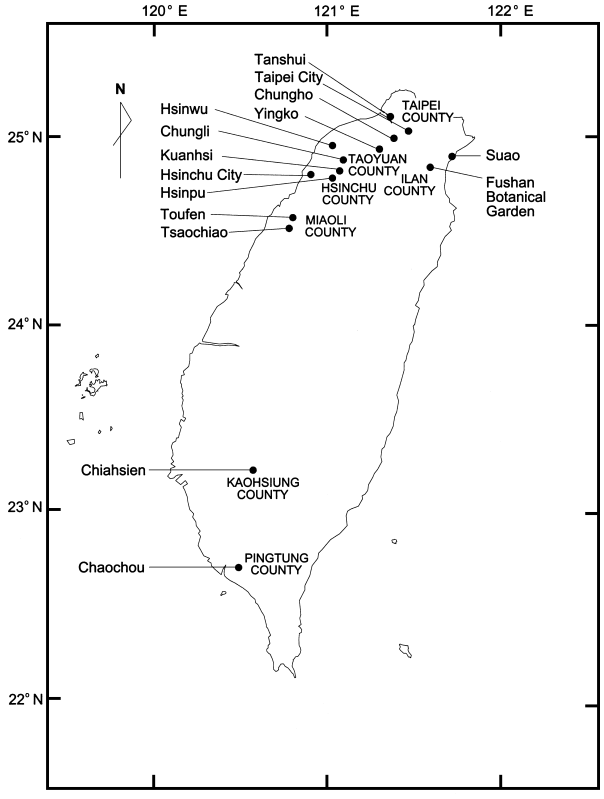

Fig. 2. Recording localities of earthworms of Taiwan. The place "Tsing-Chao Maa" is not included in this map, because we could not locate it in central Taiwan presently.

caliginosa trapezoides" is a synonym of *Al. trapezoides* (Dugès, 1828) (Gates 1972: 77) and is distributed extensively in China (Chen 1931 1933). Therefore, we suggest that *Al. trapezoides* is possibly the species collected by Kobayashi in Hsinchu. However, the best solution to this confusion is to collect earthworm specimens extensively and identify them precisely. Because *Lumbricus trapezoides* Dugès, 1828 is designated as the type species of the genus *Aporrectodea* Oerley, 1885 (Gates 1975: 4), *Allolobophora trapezoides* is displaced by *Aporrectodea trapezoides*.

Amynthas swanus was erected as a new species by Tsai (1964). However, Sims and Easton (1972) stated that another new species may be separated from *Am. swanus* according to the original description. Unfortunately, the specimens studied by Tsai were lost.

The present study provides a preliminary review of earthworm studies in Taiwan. A thorough survey of the earthworm fauna of Taiwan, including adjacent small islands (Penghu, Lanyu, and Lutao), is needed.

Acknowledgments: We are grateful to John W. Reynolds of the Oligochaetology Laboratory, Kitchener, Ontario, Canada and Kamihira Yukiyoshi of the Biological Laboratory, Hakodate University, Japan, for reading the manuscript; Chu-Fa Tsai for providing relevant information about Taiwanese earthworms; Cheng-Chien Chen and Meng-Wan Yeh of the Institute of Marine Biology, National Sun Yat-sen University, Chin-Shiang Wang of the Department of Zoology, National Taiwan University, Barrie G. M. Jamieson of the Department of Zoology, University of Queensland, and Ya-Wen Hung for bibliographic help. We also wish to thank 2 anonymous reviewers for greatly improving this manuscript.

REFERENCES

Chang WL. 1992. Study of earthworm activities effects of surface soil infiltration. J. Chin. Agric. Engin. **38:** 62-68. (in Chinese).

Chen JH, HT Shih. 1996. A preliminary study of earthworms in Fushan Botanical Garden. Chin. Biosci. **39:** 52-59. (in Chinese).

Chen Y. 1931. On the terrestrial Oligochaeta from Szechuan, with descriptions of some new forms. Contr. Biol. Lab. Sci. Soc. China **7:** 117-171.

Chen Y. 1933. A preliminary survey of the earthworms of the lower Yangtze Valley. Contr. Biol. Lab. Sci. Soc. China **9:** 177-296.

Easton EG. 1976. Taxonomy and distribution of the *Metapheretima elongata* species-complex of Indo-Australasian earthworms (Megascolecidae: Oligochaeta). Bull. Br. Mus. Nat. Hist. (Zool.) **30:** 31-51.

Easton EG. 1979. A revision of the 'acaecate' earthworms of the *Pheretima* group (Megascolecidae: Oligochaeta): *Archipheretima, Metapheretima, Planapheretima, Pleionogaster* and *Polypheretima*. Bull. Br. Mus. Nat. Hist. (Zool.) **35:** 1-126.

Easton EG. 1980. Japanese earthworms: a synopsis of the megadrile species (Oligochaeta). Bull. Br. Mus. Nat. Hist. (Zool.) **40:** 33-65.

Easton EG. 1982. Australian pheretimoid earthworms (Megascolecidae: Oligochaeta): a synopsis with the description of a new genus and five new species. Aust. J. Zool. **30:** 711-735.

Edwards CA, PJ Bohlen. 1996. Biology and ecology of earthworms. London: Chapman and Hall.

Gates GE. 1937. Indian earthworms. I. The genus *Pheretima*. Rec. Ind. Mus. **39:** 175-212.

Gates GE. 1959. On some earthworms from Taiwan. Am. Mus. Nov. **1941:** 1-19.

Gates GE. 1972. Burmese earthworms. An introduction to the systematics and biology of megadrile oligochaetes with special reference to Southeast Asia. Trans. Am. Phil. Soc., N.S. **62:** 1-326.

Gates GE. 1975. Contributions to a revision of the earthworm family Lumbricidae. XII. *Enterion mammale* Savigny, 1826 and its position in the family. Megadrilogica **2:** 1-5.

Goto S, S Hatai. 1898. New or imperfectly known species of earthworms. No. 1. Annot. Zool. Japan **2:** 65-78.

Kamihira K. 1973. Key to the terrestrial earthworm species of the genus *Pheretima* from Japan. Thesis Res. Hakodate Univ. **7:** 53-69. (in Japanese).

Kobayashi S. 1938. Occurrence of *Perionyx excavatus* E. Perrier in north Formosa. Sci. Rep. Tohoku Imp. Univ. **13:** 201-203.

Kobayashi S. 1939. The earthworms from Shinchiku, Formosa I, II. Zool. Mag. **51:** 659-660, 777-779. (in Japanese).

Kobayashi S. 1940a. The earthworms from Shinchiku, Formosa III, IV, V. Zool. Mag. **52:** 120-121, 274, 390-391. (in Japanese).

Kobayashi S. 1940b. Terrestrial Oligochaeta from Manchoukuo. Sci. Rep. Tohoku Imp. Univ. (B) **15:** 261-315.

Kobayashi S. 1940c. The origin of *Drawida japonica* in Japan. Science (Tokyo) **10:** 504. (in Japanese).

Kobayashi S. 1941a. The terrestrial oligochaete fauna from Kyushu, Japan. Bot. Zool. **9:** 511-518. (in Japanese).

Kobayashi S. 1941b. The distribution of terrestrial oligochaetes from western Japan. Zool. Mag. **53:** 371-384. (in Japanese).

Kobayashi S. 1941c. On the terrestrial oligochaetes from Shikoku, Chugoku, Kinki and central areas of Japan. Zool. Mag. **53:** 258-266. (in Japanese).

Kobayashi S. 1941d. Earthworms of Korea. II. Sci. Rep. Tohoku Imp. Univ. (B) **16:** 147-156.

Kuo TC. 1987. The propagation and composition of Taiwan red earthworm (*Pheretima asiatica*) and its effects on soil fertility. Chin. Biosci. **30:** 7-15. (in Chinese).

Kuo TC. 1993. On some genital markings of the Taiwan earthworm genus *Pheretima* Kinberg, 1867, wih key to species reported from Taiwan. Spec. Bull. Dep. Math. Sci. Educ. Nat. Hualien Teach. Coll. **1:** 1-13. (in Chinese).

Kuo TC. 1995. Ultrastructure of genital markings in some species *Pheretima, Bimastus* and *Perionyx* in northern Taiwan. Nat. Hsinchu Teach. Coll. J. **8:** 181-199.

Kuo TC, YT Huang. 1993. Lethal effects of five commonly used pesticides on the earthworm *Bimastus parvus* Eisen. J.

Agric. Assoc. China **162:** 33-41. (in Chinese).
Michaelsen W. 1922. Oligochäten aus dem Rijks Museum van Natuurlijke Historie zu Leiden. Cap. Zool. **1:** 1-72. (in German).
Ohfuchi S. 1956. On a collection of the terrestrial Oligochaeta obtained from the various localities in Riu-kiu Islands, together with the consideration of their geographical distribution (part I). J. Agric. Sci. Tokyo Nogyo Daigaku **3:** 131-176.
Ohfuchi S. 1965. Annelida: Oligochaeta. *In* Y Okada, S Uchida, T Uchida, eds. New illustrated encyclopedia of the fauna of Japan. Tokyo: Hokuryu-Kan Publ. Co., pp. 533-563. (in Japanese).
Reynolds JW. 1974. Are oligochaetes really hermaphroditic amphimictic organisms? Biologist **56:** 90-99.
Reynolds JW, DG Cook. 1976. Nomenclatura Oligochaetologica: a catalogue of names, descriptions and type specimens of the Oligochaeta. Fredericton, Canada: Univ. of New Brunswick.
Reynolds JW, DG Cook. 1993. Nomenclatura Oligochaetologica Supplementum Tertium: a catalogue of names, descriptions and type specimens of the Oligochaeta. Saint John, Canada: New Brunswick Museum Monographic Series (Natural Science) No. 9.
Sims RW, EG Easton. 1972. A numerical revision of the earthworm genus *Pheretima* auct. (Megascolecidae: Oligochaeta) with the recognition of new genera and an appendix on the earthworms collected by the Royal Society North Borneo Expedition. Biol. J. Linn. Soc. **4:** 169-268.
Takahasi S. 1932a. The body length and segments of an earthworm (*Pheretima* sp.) from Taihoku. Nat. Hist. Mag. **30:** 10-14. (in Japanese).
Takahasi S. 1932b. On the morphological variation of a *Pheretima* sp. from Taihoku. Zool. Mag. **44:** 343-360. (in Japanese).
Takahasi S. 1933. On the immature specimens of a *Pheretima* sp. Nat. Hist. Mag. **32:** 17-22. (in Japanese).
Tsai CF. 1964. On some earthworms belonging to the genus *Pheretima* Kinberg collected from Taipei area in north Taiwan. Quart. J. Taiwan Mus. **17:** 1-35.

Appendix I:

Taiwanese localities in Chinese and their Romanizations used in the text are listed as follows:

Romanization	Chinese
Chaochou	潮洲 (in Pingtung County)
Chiahsien	甲仙 (in Kaohsiung County)
Chungho	中和 (in Taipei County)
Chungli	中壢 (in Taoyuan County)
Dorf Kosempo	甲仙庄 (= Chiahsien)
Dorf Koseypo	甲仙庄 (= Chiahsien)
En-tong temple	圓通寺 (= Yuantung Temple)
Fushan Botanical Garden	福山植物園 (betwen Taipei and Ilan Counties)
Green Mountain	草山 (= Yangmingshan) (in Taipei City)
Hsinchu City	新竹市
Hsinchu County	新竹縣
Hsinpu	新埔 (in Hsinchu County)
Hsinwu	新屋 (in Taoyuan County)
Huang-fa station	萬華車站 (= Wanhua Station)
Ilan County	宜蘭縣
Kaohsiung County	高雄縣
Kuanhsi	關西 (in Hsinchu County)
Lei-hu	內湖 (= Neihu)

Romanization	Chinese
Miaoli County	苗栗縣
National Taiwan University	國立臺灣大學 (in Taipei City)
Neihu	內湖 (in Taipei City)
NTU	國立臺灣大學 (= National Taiwan Univ.)
Pingtung County	屏東縣
Shinchiku	新竹 (= Hsinchu)
Shinchiku High School	新竹中學校
Suao	蘇澳 (in Ilan County)
Taipei City	臺北市
Taipei County	臺北縣
Tam-sui River	淡水河 (= Tanshui River)
Tanshui River	淡水河 (in Taipei County)
Taoyuan County	桃園縣
Toufen	頭份 (in Miaoli County)
Tsaochiao	造橋 (in Miaoli County)
Wanhua Station	萬華車站 (in Taipei City)
Yangmingshan	陽明山 (in Taipei City)
Yingko	鶯歌 (in Taipei County)
Yuantung Temple	圓通寺 (in Taipei County)

Appendix II:

Some English spellings of Chinese or Japanese names used in the text are listed as follows:

English spelling of name	Chinese or Japanese name
Aragaki, Morimasa	新垣盛正
Chang, Wen-Liang	張文亮
Chen, Jiun-Hong	陳俊宏
Goto, Seitaro	五島清太郎
Hatai, Shinkishi	畑井新喜司
Huang, Yi-Tien	黃益田
Kamihira, Yukiyoshi	上平幸好
Kawasaki, Asaharu	川崎淺治
Kobayashi, Shinjiro	小林新二郎
Kuo, Chin-Ming	郭欽明
Kuo, Teng-Chih	郭登志
Ohfuchi, Shinryu	大淵真龍
Shih, Hsi-Te	施習德
Takahasi, Sadae	高橋定衛
Tsai, Chu-Fa	蔡住發
Yamanaka, Masao	山中正夫

臺灣產蚯蚓 (環節動物門：貧毛綱) 之回顧

施習德[1,2]　張學文[2]　陳俊宏[3]

臺灣蚯蚓的研究自 1898 年日人 Goto 和 Hatai 開始, 歷年來的調查範圍僅侷限在宜蘭、臺北、桃竹苗、高雄、屏東等地區, 至今共確定有 26 種的蚯蚓, 歸類於 9 屬之下。其中環毛蚓屬 (genus *Pheretima*) 是蚯蚓中種類最多的屬， Sims and Easton (1972) 和 Easton (1979 1982) 將全世界的環毛蚓類細分為 10 屬: *Amynthas* 遠環蚓屬， *Archipheretima* 古環蚓屬， *Begemius* 畢環蚓屬， *Metapheretima* 間環蚓屬， *Metaphire* 腔環蚓屬， *Pheretima* 環毛蚓屬， *Pithemera* 近環蚓屬， *Planapheretima* 扁環蚓屬， *Pleionogaster* 多胃蚓屬和 *Polypheretima* 多環蚓屬，目前臺灣的 21 種環毛蚓可歸類於其中的 4 個屬之下。臺灣的 26 種蚯蚓如下: *Drawida japonica* (Michaelsen, 1892) 日本杜拉蚓， *Aporrectodea trapezoides* (Dugès, 1828) 梯形阿波蚓， *Bimastus parvus* (Eisen, 1874) 微小雙胸蚓， *Perionyx excavatus* Perrier, 1872 掘穴環爪蚓， *Amynthas aspergillum* (Perrier, 1872) 參狀遠環蚓， *Am. candidus* (Goto and Hatai, 1898) 光澤遠環蚓， *Am. corticus* (Kinberg, 1867) 皮質遠環蚓， *Am. formosae* (Michaelsen, 1922) 臺灣遠環蚓， *Am. gracilis* (Kinberg, 1867) 纖細遠環蚓， *Am. hsinpuensis* (Kuo, 1995) 新埔遠環蚓， *Am. hupeiensis* (Michaelsen, 1895) 湖北遠環蚓， *Am. incongruus* (Chen, 1933) 參差遠環蚓， *Am. minimus* (Horst, 1893) 微小遠環蚓， *Am. morrisi* (Beddard, 1892) 牟氏遠環蚓， *Am. omeimontis polyglandularis* (Tsai, 1964) 多腺峨嵋遠環蚓， *Am. papulosus* (Rosa, 1896) 丘疹遠環蚓， *Am. robustus* (Perrier, 1872) 壯偉遠環蚓， *Am. swanus* (Tsai, 1964) 絲婉遠環蚓， *Am. taipeiensis* (Tsai, 1964) 臺北遠環蚓， *Am. yuhsi* (Tsai, 1964) 友燮遠環蚓， *Polypheretima elongata* (Perrier, 1872) 長形多環蚓， *Metaphire californica* (Kinberg, 1867) 加州腔環蚓， *M. posthuma* (Vaillant, 1869) 土後腔環蚓， *M. schmardae schmardae* (Horst, 1883) 舒氏腔環蚓， *Pithemera bicincta* (Perrier, 1875) 雙帶近環蚓和 *Dichogaster bolaui* (Michaelsen, 1891) 包氏重胃蚓。其中產於臺灣的模式標本有 9 種, 然而僅有 3 種的模式標本保留下來, 其餘均不存在。另外 *Amynthas asiaticus* Michaelsen, 1900 亞洲遠環蚓由於缺乏正式的分類描述，有鑑定錯誤的可能，因此暫不列入臺灣的種類。本報告整理歷年來研究臺灣蚯蚓自然史的完整文獻，列出發表過的種類以及採集地，並依照目前的分類系統給予適當的分類地位， 另外對歷來文獻中的錯誤之處也加以討論。

關鍵詞：環毛蚓，分類。

[1] 國立中山大學海洋生物研究所
[2] 國立中山大學生物科學系
[3] 國立臺灣大學動物系