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Biodiversity of Earthworms in Taiwan: a Species Checklist with the Confirmation and New Records of the Exotic Lumbricids *Eisenia fetida* and *Eiseniella tetraedra*

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ABSTRACT: Terrestrial megadrile earthworms variously reported from Taiwan including Lanyu Island (Botel Tobago) number approximately 70 species with 29 of these, or 40%, non-natives for which 69% are Asiatic Megascolecidae and 21% are Lumbricidae of Holarctic origin. An additional 27 unnamed species have been identified from Ilan county north-eastern Taiwan by Chen et al. (2003) that, if published, would bring the total to around 100 known species. The checklist is also provided with the confirmation and new records of the exotic lumbricids *Eisenia fetida* (Savigny) and *Eiseniella tetraedra* (Savigny).

KEY WORDS: Taxonomy, Biodiversity, Megascolecidae, Lumbricidae, Taiwan, Asian earthworms.

INTRODUCTION

Knowledge of earthworm diversity in Taiwan has increased rapidly in recent years. In their review, Shih et al. (1999) listed and mapped 26 Taiwanese species belonging to 9 genera, provided historical reviews for the taxonomy of the region, disputed the occurrence of *Amynthas asiaticus* Michaelsen, 1900, and corrected the identification errors in Kuo (1993). Next, Tsai et al. (1999, 2000a) listed 35 nominal species from Taiwan in the context of biogeography of northeast Asian faunas; they reported 7 new species, recorded *Metaphire hesperidum* (Beddard, 1892) as a new record - although this is a junior synonym of *M. californica* (Kinberg, 1867), and, unlike some other authors, they regarded *A. lautus* and *A. robustus* as separate taxa. Tsai et al. (2000a) also believed that Japanese taxa placed in synonymy by Easton (1981) but with question marks next to their names should be retained until the specific status of each is verified. However, this is taken to be Easton's implied intention by putting "?" and is repeated here with the added advantages of revealing possible species-complexes and of discouraging routine naming by certain authors of each parthenogenetically degraded morph they encounter (see discussion of this problem in Blakemore, 2003b). The exotic *Pontoscolex corethrurus* (Müller) was newly reported from Taiwan by Tsai et al. (2000d) allowing Tsai et al. (2001) to list 37 species (23 exotic), before Shen et al. (2003b) referred to eight new *Amynthas* taxa from Mt. Hohuan and six from Central Taiwan that raised the number of Taiwan earthworms then known to 49. A *nomen nudum* from Lanyu Island published in Shen and Tsai (2002a) was legitimized by Shen and Tsai (2002b). Surveys were also conducted by Chuang et al. (2002), and the *Amynthas masatakae* (Beddard, 1892), synonym of *A. robustus* (Perrier, 1872) was claimed from Taiwan by Chuang and Chen (2002). A new record of *Amynthas papilio papilio* (Gates, 1939) was reported from the campus of the National Taiwan University by Chang et al. (2001), and by Chen and Chuang (2003) who, as with Gates (1972) and Easton (1981), discussed the probable misidentification of this species for *Amynthas glabrus* (Gates, 1932) from Ryukyus by Ohfuchi (1956).

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Most recently, two new *Metaphire* species were described by Tsai et al. (2003, 2004a) and the ecology of these and other montane worms discussed in a transect survey by Tsai et al. (2004b). James et al. (2005) have recognized seven new endemic *Amynthas* species from Taiwan and these authors claim first record of *Metaphire houlleti* plus new reports of *Amynthas incongruus* and *A. robustus*, although *M. houlleti* was published by Shen et al. (2005a), *A. incongruus* was recorded from Taiwan by Gates (1959) and *A. incongruus* and *A. robustus* were reported from Taipei by Tsai (1964), as shown by Shih et al. (1999) and Tsai et al. (2000a). Both latter species were also found in Ilan County by Chen et al. (2003). Shen et al. (2005a) claimed first Taiwan record of *Amynthas carnosus* and, furthermore, Shen et al. (2005b) reported littoral *Pontodrilus litoralis* (Grube, 1855) (Megascolecidae sensu Blakemore, 2000b) from Penghu Island and from southwestern Taiwan shoreline (other specimens pers. obs. by R.J.B.). Finally, Chang and Chen (2004, 2005a, 2005b) described three new *Metaphire* species from Taiwan [one from Ilan, fomerly a *nomen nudum* in Chen et al. (2003), and one a synonym of *M. trutina*] and, made notes on the status of *M. formosae*.

Eisenia fetida (Savigny, 1826), or rather its species-complex, is used around the world in laboratory for ecotoxicological and other studies (e.g., Wu et al., 2004) and sold as fish bait in Taiwan and maintained in laboratory cultures (Dr. J.-H. Chen, pers. comm. and pers. obs. by R.J.B.). It can be included on the list, too. An additional but unconfirmed report from vermiculture operations is for *Amynthas asiaticus* Michaelsen, 1900, e.g., by Kuo (1987) and Chang (1992), that brings the Taiwan earthworm species total to 70 nominal taxa. An additional 27 unnamed species have been identified from Ilan County (Chen et al., 2003) that, if published, would raise the count to nearly 100 species from Taiwan.

Accounts of Taiwanese "red earthworms" used for fish and duck food refer to the microdrile tubificid *Monopylephorus rubroniveus* Levinsen, 1883 rather than a 'true' earthworm.

METHODS

The list of names is compiled from various sources as mentioned in the Introduction, synonymies cited in the References. Nomenclature follows the most recent revisions of Lumbricoidea and pheretimoid taxa by Blakemore (2004a, 2004c) and the present taxonomy complies with recommendations, articles, and ethics of ICZN (1999).

RESULTS

Checklist of described Taiwanese Taxa

FAMILIES after Blakemore (2000b, 2002); remarks and synonyms (syn.) in brackets marked with "?" where there is some uncertainty. Codes: * = exotic/introduced, - = native/endemic, # = uncertain affinities. Taiwan includes Lanyu, Lutao and Penghu Islands. For common exotics not all synonyms are given here as these may be readily found elsewhere (e.g. Sims and Gerard, 1999; Blakemore, 2002, 2003a, b).

Family MONILIGASTRIDAE

1.* ***Drawida japonica*** (Michaelsen, 1892: 232) (syn. *Drawida grahami* Gates, 1935: 3).

Family OCTOCHAETIDAE Michaelsen, 1900 [sensu Blakemore (2000b: 37) wherein it was recognized that some authors consider this "Classical family" a derived grade rather than a clade, meriting only sub-family rank in the Acanthodrilidae Claus, 1880; or, if polyphyletic, it may require restriction to the New Zealand and Australian type-genus *Octochaetus* Beddard, 1893 (see Blakemore, 2000b; 2004b, c, d, 2004e: 124) and other allied Indo-Australasian genera. In recent revisions, Csuzdi (1996, 2000) placed *Dichogaster* subgenera in his redefinition of ACANTHODRILIDAE subfamily BENHAMIINAE Michaelsen, 1897 that itself possibly merits elevation to family level status as "Benhamiidae"; however, such decisions are beyond the scope of this current work].

2.* ***Dichogaster* (*Diplothecodrilus*) *bolaui*** (Michaelsen, 1891: 9) [many synonyms - see Csuzdi (2000: 60); Blakemore (2002)].

Family MEGASCOLECIDAE sensu Blakemore, 2000

3.- ***Amynthas ailiaoensis*** James et al., 2005: 1020 in James, Shih, H.-T. and H.-W. Chang, 2005. [*Nomen nudum* as of January, 2005].

4.* ***Amynthas asiaticus*** Michaelsen, 1900: 13 [a possible misidentification in Taiwan?].

5.* ***Amynthas aspergillum*** (Perrier, 1872: 118) [*Perichaeta takatorii* Goto & Hatai, 1898: 76; *Pheretima paraglandularis* Fang, 1929: 15. Name usually spelt "aspergillum", e.g. Beddard (1895: 430; 1900: 632) and Michaelsen (1900: 253), but Sims & Easton (1972: 234) listed it as "aspergillus"; Michaelsen (1900: 318) first suggested the *takatorii* synonym].

6.# ***Amynthas assacceus*** (Chen, 1938: 382) [syn. *Pheretima medipusillus* Nakamura, 1999: 2 nom. nov. pro *Pheretima pusilla* Ohfuchi, 1956: 138 (non *Perichaeta pusilla* Ude, 1893: 63 = *A. minimus*); ?*Amynthas proasacceus* (sic) Tsai et al., 2001: 282 in Tsai, C.-F., Shen, H.-P. and S.-C. Tsai, 2001].

7.- ***Amynthas binoculatus*** Tsai et al., 1999: 41 in Tsai, C.-F., Shen, H.-P. and S.-C. Tsai, 1999. [Note: the segments in their Fig. 4A are miscounted].

8.- ***Amynthas candidus*** (Goto & Hatai, 1898: 77).

9.* ***Amynthas carnosus*** (Goto & Hatai, 1999: 15) [syn. *kyamikia* Kobayashi, 1934; ?*youngtai* Hong and James, 2001; *sangyeoli* Hong and James, 2001; these synonyms from Blakemore (2003b)]. This first Taiwan record by Shen et al. (2005a), although the specimens differ somewhat from the original descriptions (see Blakemore, 2003b).

10.- ***Amynthas catenus*** Tsai et al., 2001: 279 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 2001.

11.- ***Amynthas chaishanensis*** James et al., 2005: 1021 in James, Shih, H.-T. and H.-W. Chang, 2005.

12.* ***Amynthas corticis*** (Kinberg, 1867: 102) [many synonyms - see Blakemore (2002, 2003a,b, 2004c), often mispelt "*corticus*"; Gates (1972: 217) suggested that *Pheretima sheni* Chen, 1935 from Hong Kong may be an athecal morphs of either *A. robustus* or *A. diffringens* (= *A. corticis*), most likely the latter, but C.-F. Tsai (pers. comm.) says it is possibly a Taiwanese native as it is found in natural woodland and should thus be retained].

13.- ***Amynthas exiguus aquilonius*** Tsai et al., 2001: 277 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 2001.

14.- ***Amynthas fenestrus*** Shen et al., 2003: 487 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2003b.

15.* ***Amynthas gracilis*** (Kinberg, 1867: 102) (many synonyms - see Blakemore, 2002, 2003a, b, 2004c).

16.- ***Amynthas hengchunensis*** James et al., 2005: 1015 in James, Shih, H.-T. and H.-W. Chang, 2005.

17.- ***Amynthas hohuanmontis*** Tsai et al., 2002: 758 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 2002 (Notes: an athecal morph, possibly a junior synonym of *A. candidus* that has similar markings around the male pores, but there are other differences in first dorsal pore location and septation).

18.- ***Amynthas huangi*** James et al., 2005: 1014 in James, H.-T. Shih and H.-W. Chang, 2005.

19.* ***Amynthas hupeiensis*** (Michaelsen, 1895: 35) [?*Pheretima hypogaea* Ishizuka, 1999; ?*Pheretima edoensis* Ishizuka et al., 2000. Note: Easton (1981: 53) mispelt the name "*hupiensis*"].

20.* ***Amynthas incongruus*** (Chen, 1933: 270).

21.- ***Amynthas kaopingensis*** James et al., 2005: 1017 in James, H.-T. Shih and H.-W. Chang, 2005.

22.* ***Amynthas minimus*** (Horst, 1893: 66) (*Perichaeta pusilla* Ude, 1893: 63 [non Ohfuchi, 1956 (= *Amynthas assacceus*)]; *Pheretima enchytraeoides* Michaelsen, 1916: 33; *Pheretima humilis* Gates, 1942: 120; *Pheretima zoysiae* Chen, 1933: 288; *Pheretima ishikawai* Ohfuchi, 1941: 248).

23.- ***Amynthas monsoonus*** James et al., 2005: 1012 in James, H.-T. Shih and H.-W. Chang, 2005.

24.* ***Amynthas morrisi*** (Beddard, 1892: 166) [?*Perichaeta barbadensis* (parts ?"a" and "c") Beddard, 1892 (July): 167; ?*Perichaeta mauritiana* Beddard, 1892: 170 (most likely a variety of *gracilis*); ?*Perichaeta pallida* Michaelsen, 1892 (Sept.): 227; ?*Perichaeta amazonica* Rosa, 1894: 14; ?*Perichaeta sanctijacobi* Beddard, 1895: 61; ?*Perichaeta cupulifera* Fedarb, 1898: 445].

25.- ***Amynthas nanrenensis*** James, et al., 2005: 1008 in James, H.-T. Shih and H.-W. Chang, 2005.

26. - ***Amynthas nanshanensis*** Shen, et al., 2003: 482 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2003b.

27.* ***Amynthas papilio papilio*** (Gates, 1930: 316) [non *Pheretima papilio*: Ohfuchi (1956: 140) misidentification from Ryukyus (? = *A. glabrus* (Gates, 1932)].

28.- ***Amynthas penpuensis*** Shen et al., 2003: 481 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2003b.

29.* ***Amynthas papulosus*** (Rosa, 1896: 525) [*Pheretima papulosa* var. *sauteri* Michaelsen, 1922: 26 (non *P. papulosa* var. "*sauteria*" Ohfuchi, 1956: 164 - misidentification); *Pheretima composita* Gates, 1932: 430; ?*Pheretima rockefelleri* Chen, 1933: 238; *P. hsinpuensis* Kuo, 1985 corr. of "*hsinpuesis*"]. [First reported from Taiwan by Michaelsen (1922: 36). Gates (1972: 207) thought that the parthenogenetic *rockefelleri* morph (lacking

prostates and sometimes with defective spermathecae) was only distinguished by quantitative differences. Recently Shen et al. (2003a) disputed their earlier inclusion of *A. rockefelleri* in *A. papulosus*: they retained both taxa and suggested adding *A. hsingpuensis* to synonymy of the former].

30.- ***Amynthas polyglandularis*** (Tsai, 1964: 30) (syn. *Amynthas omeimontis polyglandularis*: Sims and Easton, 1972: 244, 258). [Herein, it is returned to specific rank as per Tsai et al. (2000a), separated from its previous nominal sub-species on the basis of the simple intestinal caeca. This character it nevertheless shares with the other two subspecies included by Sims & Easton (1972: 258), however the option of renaming it, along with *A. kinabalu* Sims & Easton, 1972: 259, as a subspecies of *Amynthas kinfumontis* (Chen, 1946: 119) is deferred pending further research].

31.* ***Amynthas robustus*** (Perrier, 1872: 112) [*Perichaeta cingulata* (part) : Vaillant, 1867: 234 (err. non Schmarda, 1861); *Perichaeta masatakae* Beddard, 1892: 761 [note: Sims and Easton, (1972: 181; 244), Reynolds and Cook (1976: 134), and Easton (1981: 56) mispelt Beddard's species "mastakae", while Michaelsen (1900: 282) has it correctly, as here, as *P. masatakae*]; *Pheretima campestris* Goto & Hatai 1898: 67 [non Lee 1952 (= *A. corticis*)]; ?*Amyntas loehri* Michaelsen, 1899: 12 (sometimes mispelt "lohri"); ?*Pheretima lauta* Ude, 1905: 405, 429 [syn. *Pheretima siemsseni* Michaelsen, 1931: 17 (?part.), *Pheretima fokiensis* Michaelsen, 1931: 19 - these synonyms from Chen (1933: 282) and Gates (1935: 15)]; ?*Pheretima zavattarii* Cognetti, 1909: 1 [syn. *zavatarii*: Gates, 1972: 217 (sic lapsus pro *zavattarii*)]; *Pheretima ornata* Gates, 1927: 20; *Pheretima corrugata* Chen, 1931: 131; ?*Pheretima sheni* Chen, 1935: 38 - this last questionable synonym proposed by Gates (1972: 217), cf. *A. corticis*].

32.- ***Amynthas? sexpectatus*** Tsai et al., 1999: 38 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 1999. [Note: probably belongs in *Metaphire* as its male pores (Tsai et al., 1999: figs. 3A-C) are almost indistinguishable from those found in *Metaphire yeni* Tsai et al. (2000c: figs. 1D & E) and in *Metaphire paiwanna* Tsai et al. (2000c: figs. 2A & B); in each case these figures show porophores contracted and then protruded, as also seen in the type *Metaphire javanica* (Kinberg, 1867) - pers. obs. R.J.B].

33.- ***Amynthas swanus*** (Tsai, 1964: 13) [according to the original description, Sims and Easton (1972: 213, 236, 237) divided this taxon between two species-groups: *A. pauxillulus*- group and an *A. swanus*-group].

34.* ***Amynthas taipeiensis*** (Tsai, 1964: 12) [?*Pheretima heterogens* Chen and Hsü, 1975 in Chen, Hsü, Yang, and Fong, 1975 - this tentative synonym from Tsai *et al.*, 2000a: 288 who regarded *A. taipeiensis* as a Taiwan exotic, as do Drs Chen, J.-H. and C.-H. Chang.

35.- ***Amynthas tantulus*** Shen et al., 2003: 484 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2003b.

36.- ***Amynthas tayalis*** Tsai et al., 1999: 36 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 1999.

37.- ***Amynthas tessellatus tessellatus*** Shen et al., 2002: 2, 7 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2002.

38.- ***Amynthas tessellatus paucus*** Shen et al., 2002: 2, 7 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2002.

39.- ***Amynthas tungpuensis*** Tsai et al., 1999: 34 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 1999.

40.- ***Amynthas uvaglandularis*** Shen et al., 2003: 479 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2003b.

41.- ***Amynthas wangi*** Shen et al., 2003: 489 in Shen, H.-P., C.-F. Tsai and S.-C. Tsai, 2003b.

42.- ***Amynthas wulinensis*** Tsai et al., 2001: 285 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 2001.

43.- ***Metaphire bununa bununa*** Tsai et al., 2000: 1736 in Tsai, C.-F., S.-C. Tsai and G.-J. Liaw, 2000c [originally published as *M. bununa typica* et "*M. bunuma*" Tsai et al., 2000: 287 (lapsus)].

44.- ***Metaphire bununa glareosa*** Tsai et al., 2000: 1738 in Tsai, C.-F., S.-C. Tsai and G.-J. Liaw, 2000c [originally published as *M. bununa glareosus* ("glareosus" is Latin adjective = "gravelly") here corrected to *glareosa*].

45.* ***Metaphire californica*** (Kinberg, 1867: 102) [*Perichaeta ringeana* Michaelsen, 1890: 10; *Perichaeta hesperidum* Beddard, 1892: 169; *Perichaeta guarini* Rosa, 1894: 13; *Pheretima browni* Stephenson, 1912: 274; *Pheretima modesta* Michaelsen, 1927: 88; *Pheretima molesta* Gates, 1931: 420 nom. nov. pro. *P. browni* Gates, 1931: 372 (non Stephenson, 1912 = *M. californica*); ?*Pheretima sakaguchii* Ohfuchi, 1938; ?*Pheretima sonaiensis* Ohfuchi, 1956].

46. - ***Metaphire feijani*** Chang and Chen, 2004: 219, fig. 1.

47. - ***Metaphire formosae*** (Michaelsen, 1922: 39). [Notes: This new combination and the removal from its synonymy of *M. yuhsii* (Tsai, 1964) is by Chang and Chen (2005b) and pers. obs. by R.J.B. cf. Chang & Chen (2005a) where it is maintained in *Amynthas*].

48.* ***Metaphire houlleti*** (Perrier, 1872: 99) [*Perichaeta campanulata* Rosa, 1890: 115; *Perichaeta udekemi* Michaelsen, 1890: 240; *Perichaeta guillelmi* Michaelsen, 1895: 32; *Pheretima crescentica* Fedarb 1898; *Pheretima wimberleyana* Stephenson, 1925: 62 (name mispelt "wimberlayana" by Sims and Easton, 1972: 246 and by Reynolds and Cook, 1976: 190); *Pheretima houlleti tortuosa* Gates, 1926: 454; *Pheretima houletti* var. *rugosa* (sic lapsus pro *houlleti*) Gates, 1926: 459; *Pheretima campanulata* var. *penetralis* Gates, 1931: 435; *Pheretima campanulata* var. *meridiana* Gates, 1932: 457; *?Pheretima yapensis* Ohfuchi 1941]. Notes: *Pheretima houlleti bidenryoana* Ohfuchi, 1956 subspecies is now included in synonymy of *A. flavescens* (Goto and Hatai, 1898); more detailed synonymies are given in Blakemore (2002, 2003a, b, 2004c) where it is noted that the name sometimes is misspelt "houletti". This new Taiwan record is by Shen et al. (2005) and also claimed by James et al. (2005).

49.- ***Metaphire paiwanna liliumfordi*** Tsai et al., 2000: 1734 in Tsai, C.-F., S.-C. Tsai and G.-J. Liaw, 2000c.

50.- ***Metaphire paiwanna paiwanna*** Tsai et al., 2000: 1732 in Tsai, C.-F., S.-C. Tsai and G.-J. Liaw, 2000c (published as *M. paiwanna typica*).

51.* ***Metaphire posthuma*** (Vaillant, 1869: 228) (*Perichaeta affinis* Perrier, 1872: 106).

52.- ***Metaphire puyuma*** Tsai et al., 1999: 42 in Tsai, C.-F., H.-P. Shen and S.-C. Tsai, 1999.

53.* ***Metaphire schmardae schmardae*** (Horst, 1883: 194) (*Perichaeta trityphla* Beddard, 1896: 205; *Pheretima kikuchii* Hatai & Ohfuchi, 1936: 767).

54.- ***Metaphire taiwanensis*** Tsai et al., 2004: 878 in Tsai, C.-F., S.-C. Tsai and H.-P. Shen, 2004a.

55.- ***Metaphire trutina*** Tsai et al., 2003: 84 in Tsai, C.-F., S.-C. Chen, S.-C. Tsai and H.-P. Shen, 2003b (*Metaphire yuanpowa* Chang and Chen, 2005a: 1470 , fig. 2. Syn. nov. Pers. Obs. C.-H. Chang, and R.J.B.).

56.- ***Metaphire yeni*** Tsai et al., 2000: 8 in Tsai, S.-C., H.-P. Shen and C.-F. Tsai, 2000b.

57.- ***Metaphire yuhsii*** (Tsai, 1964: 5) ***Emend.*** (corr. of "*yuhsi*"). [Previous synonymy of this name in *Metaphire formosae* (Michaelsen, 1922) by Tsai et al. (2000a: 286) who spelt the name "yushi" but, because it was a stated patronym for Dr Yu-His Wang, it is herein corrected to *yuhsii*. This new combination and re-elevation to specific status is by Chang, C.-H. and J.-H. Chen, 2005b].

58.- ***Metaphire nanaoensis*** Chang and Chen, 2005a: 1473, fig. 3. [Formerly a *nomen nudum* also mispelt as "***nanauensis***" from Ilan cited in Chen et al. (2003: 58)].

59.- ***Metaphire tahanmonta*** Chang and Chen, 2005a: 1475, fig. 4.

60.* ***Perionyx excavatus*** Perrier, 1872: 208 (*Perionyx gruenewaldi* Michaelsen, 1891: 33; ?*Perionyx koboensis* Stephenson, 1914: 391; *Perionyx fulvus* Stephenson, 1916: 322; ?*Perionyx turaensis* Stephenson, 1920: 216).

61.* ***Pithemera bicincta*** (Perrier, 1875: 1044) [?*Perichaeta violacea* Beddard, 1895: 407; ?*Pheretima aimerikiensis* Ohfuchi, 1941: 302 - this synonymy from Blakemore (2003a, b)].

62.- ***Pithemera lanyuensis*** Shen, H.-P. and C.-F. Tsai, 2002: 2, 2002b.

63.* ***Polypheretima elongata*** (Perrier, 1875: 124) (*Perichaeta biserialis* Perrier, 1875: 1044; *Perichaeta acystis* Beddard, 1895: 423 [nom. nov. pro *biserialis* : Beddard, 1890 (non Perrier, 1872)]; *Perichaeta monocystis* Horst, 1899: 202 (lapsus pro *acystis* Beddard, 1895); *Pheretima aelongata* Gates, 1926: 444 - misspelling or illegal emendation).

64.* ***Pontodrilus litoralis*** (Grube, 1855) [syn. *marionis*; *bermudensis*, *matsushimensis*, *albanyensis*, *cygni*, *indica*, *gracilis*; full synonymy in Blakemore (2002)]. This new Taiwan record is by Shen et al. (2005b) and claimed by James et al. (2005) also Taiwan specimens from Drs. Chen, J.-H. and C.-H. Chang pers. obs. by R.J.B. April, 2004. Note previous records from Japan, Hainan and Hong Kong in Easton (1984: 115) and distribution and ecology discussed by Blakemore (2002).

Family GLOSSOSCOLECIDAE

65.* ***Pontoscolex corethrurus*** (Müller, 1856: 113) [*Pontoscolex arenicola* (part.) Schmarda, 1861: 11

(residue = *Diachaeta littoralis* Beddard 1892); *Urochaeta dubia* Horst, 1885: 7; *Urochaeta australiensis* Beddard, 1891: 278; *Pontoscolex hawaiensis* Beddard, 1895: 660; *Pontoscolex corethrurus mexicana* Eisen, 1896: 8; *Urochaeta hystrix* Perrier, 1872: 142].

Family LUMBRICIDAE

66.?* ***Aporrectodea caliginosa*** (Savigny, 1826: 180) [many synonyms for this species-complex, see Blakemore (2002, 2004a); the Taiwan report by Kobayashi (1940, 1941) was thought by Gates (1972: 80) and Shih et al. (1999) to actually be either *Ap. tuberculata* or *Ap. trapezoides*, both of which have been variously combined within the *Ap. caliginosa* species-complex].

67.* ***Aporrectodea trapezoides*** (Dugès, 1828: 289) [many synonyms - see Blakemore (2002; 2004a); this taxon claimed by Tsai et al. (2000a: 286, 289) and recently confirmed from Chiayi County by H.-P. Shen and C.-H. Chang (pers. com. November, 2004)].

68.?* ***Aporrectodea tuberculata*** (Eisen, 1874: 43) [originally *Allolobophora turgida tuberculata* Eisen, 1874 [non Tzelepe, 1943 (= *Spermophorodrilus tzelepei* Blakemore, 2004a: 78 nom. nov.), nec *Eophila antipae* var. *tuberculata* Cernosvitov, 1935].

69.* ***Bimastos parvus*** (Eisen, 1874: 46) [?*beddardi* Michaelsen, 1894: 182 non Ribaucourt, 1896: 53 (= *Aporrectodea trapezoides*); *parva udei* Ribaucourt 1896: 80 [non Sapkarev, 1972 (= *Serbiona joncesapkarevi* Blakemore, 2004a: 78 nom. nov.)]; *consticta geminata* Friend 1897: 1; ?*longicinctus* Smith and Gittins, 1915: 548 Note: Drs. S. James and Cs. Csuzdi (pers. comms.) believe all three taxa: *parvus*, *beddardi* and *longicincus* merit separate species status, although Easton (1981: 41; 1983: 475) had the former two taxa in synonymy and Gates (1972: 86, 88) had all three in synonymy saying they "intergrade without known ways of delimiting each from the others"].

70.* ***Eisenia fetida*** (Savigny, 1826: 182) [many synonyms for this species-complex (Blakemore, 2002, 2003a, b, 2004a); some authors include *E. andrei* Bouché, 1972 as either a synonym, morph, 'variety', sub-species, or maintain it as a separate species; *E. nordenskioeldi* (Eisen, 1874) is also debatably within the *E. fetida* complex]. **New confirmation for Taiwan**: in culture; unknown from the field.

71.* ***Eiseniella tetraedra*** (Savigny, 1826: 183) (syn. *quadrangularis* Risso, 1826; *amphisbaenus* Dugès, 1828; *agilis* Hoffmeister, 1843; *tetraedrus luteus* Eisen, 1871; *dubius* Michaelsen, 1890; *tetragonurus* Friend, 1892; *macrurus* Friend, 1893; *flavus* Friend, 1893; *tetraedrus bernensis* Ribaucourt, 1896; *tetraedrus novis* Ribaucourt, 1896; *tetraedrus infinitesimalis* Ribaucourt, 1896; *tetraedra hammoniensis* Michaelsen, 1900; *mollis* Friend, 1911; *intermedia* Jackson, 1931; *tetraedra popi* Zicsi, 1960; *tetraedra phorogenesa* Qiu and Bouche, 1998: 104, *tetraedra proporandra* Qiu and Bouche, 1998: 105 - for full synonymy see Blakemore, 2002, 2004a). Collected from running water of Chichiawan Stream on Wuling farm, Shei-Pa National Park, NE Taiwan, 2.xiii. 2004 by National Chung Hsing University team, i.e. Dr. Sheng-Hai Wu and his collaborators and passed on via National Taiwan University team (J.-H. Chen, C.-H. Chang and S.-C. Chuang) for identification by R. Blakemore.- **Confirmation for Taiwan and for east Asia** (cf. Shen et al., 2005b).

DISCUSSION

Regional comparisons of the various earthworm faunas were summarized by Tsai et al. (2000a). From the current reckoning, there are a total of 71 earthworm species in Taiwan, with 29, or approximately 40%, of these non-natives and, of these, 69% are Asiatic Megascolecidae and 21% are Lumbricidae of Holarctic origin. Total land area of Taiwan is approximately 36,000 sq. km compared to Tasmania that is about double the size (68,000 sq. km) yet has triple the number of described species (228) with only 12% exotic and, of these, 18% Megascolecidae and 61% Lumbricidae (Blakemore, 2000b, 2004d). In comparison, Okinawa and other Ryukyu Islands (4,790 sq. km) have about 26 species with 40% endemic and no known Lumbricidae, while from the whole of Japan including the Ryukyus (377,727 sq. km) only about 80 species are known with 50% endemic (Blakemore, 2003b). Contrast this with the fauna of New Zealand (267,000 sq. km) that numbers about 200 species with 86% endemic (Lee, 1959; Blakemore, 2004e). Such differences are accounted for by geological and societal histories, current topography and climate, and by the intensity of taxonomic treatment. Interestingly, a recent local Taiwanese transect study by Tsai et al. (2004b) found 34 species consisting of 18-19 natives and 14-15 exotics while a similar study at Lake Pedder in Tasmania (Blakemore, 2000a) found 24 species with 16 natives and 5 exotics plus 3 aquatic microdriles.

Some taxonomic uncertainties remain for the checklist presented here. Although Chen (1936), Ljungström (1971), and Easton (1981) had *Amynthas lautus* (Ude, 1905) and *A. masatakae* (Beddard, 1892) in synonymy of *A. robustus* (Perrier, 1872), this was disputed by Tsai et al. (2000a), although there is no mention of inspection of type specimens held in Hamburg, London, and Paris.This resolution is yet required based on the types and consideration of parthenogenetic polymorphism. On the other hand, Chen (1933) thought *Pheretima* (*P.*) *siemsseni* Michaelsen 1931 and *P.* (*P.*) *fokiensis* Michaelsen, 1931 were synonymous with *Pheretima lauta* Ude, 1905. Meanwhile, Gates (1935) had *P. lauta*, *P. paraglandularis* and *P. siemsseni* in synonymy of *P. aspergillum*, and Chen (1936, 1946) placed his own *Pheretima corrugata* in synonymy of *P. robusta*, but Chen (1936) deliberately excluded *P. aspergillum* and his *P. corrugata kulingensis* Chen, 1933 subspecies, which presumably qualified for elevation to species level (in *Amynthas*). Michaelsen's *Amynthas loehri* is possibly synonymous with *Metaphire californica* according to Chen (1931) or more likely with *A. robustus* according to Chen (1936) and Gates (1972). However, Chen (1935) expressed some doubt about his earlier inclusion of *siemsseni* and *fokiensis* in *P. robustus*.

Regarding *A. papulosus*, Gates's (1972) synonymies of both *Pheretima papulosa sauteri* Michaelsen, 1922 and *Pheretima rockefelleri* Chen, 1933 in *A. papulosus* were accepted by Easton (1981), Shih et al. (1999), and Tsai et al. (2000a). The *sauteri* variety was originally distinguished by location of caeca from 29 extending forward to 26 in a single specimen that may have been abnormal (Gates, 1972). More recently Shen et al. (2002, 2003a) and Tsai et al. (2004b) disputed inclusion of *A. rockefelleri* in *A. papulosus* and retained both taxa based on morphometry and distributional records in Taiwan. This too has yet to be confirmed from inspection of type specimens in Genoa Museum (# 44034) with other material in Natural History Museum, London according to Sims and Easton (1972), and in the U.S. National Museum (#20176), respectively.

Tsai et al. (2002) described an athecate earthworm of an "*Amynthas illotus* species-group" that now excludes various components of the Japanese and Korean *Metaphire hilgendorfi / Amynthas tokioensis* species-complex Blakemore (2003a, b). However, in their discussion of phylogeny and biogeography of this athecate species-group they overlooked *A. glabrus* (Gates, 1932) that is widespread in the region, *Amynthas imperfectus* (Ishizuka, 1999), *Amynthas koreanus* (Kobayashi, 1938), *Amynthas soulensis* (Kobayashi, 1938), *'Pheretima' palarva* Blakemore, 2003 [nom nov.], and the Sumatran *Pheretima atheca* (Rosa, 1896) which Sims and Easton (1972) listed as *species incertae sedis* because its lack of spermathecae prevented determination in *Metaphire* or *Pheretima*. They also omitted their own *Amynthas proasacceus* (*sic*) that Tsai et al. (2001) thought to be: "an intermediate form [of *A. assacceus* (Chen)] which evolved from the sexthecal ancestor with bisexual reproduction to the present athecal form with parthenogenetic reproduction". Consequently, *A. proasacceus* is provisionally considered a synonym of *A. assacceus* although there is some argument for retention of this taxon if the characteristics of its peristomium are shown to be other than artefacts of preservation. Alternatively it may be a parthenogenetically degraded morph of some other as yet unidentified taxon, again highlighting the major difficulty in classification of parthenogenetically degraded morphs as discussed by Gates (1972) and Blakemore (2003a, b).

The current review recognizes the rapid advances in understanding of Taiwan and Lanyu earthworm biodiversity in recent years, but there is still need for continued study of the native and exotic fauna, for surveys of the small islands of Penghu and Lutao, and for comparison with related species occurring in adjacent countries.

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臺灣蚯蚓多樣性：種名名錄包括鑑種確認及新紀錄外來種 Lumbricids *Eisenia fetida* 和 *Eiseniella tetraedra*

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摘　　要

目前臺灣（包含蘭嶼）的大型蚯蚓大約有 70 種，其中 29 種（約 40%）為非原生種，在這些種類中 69%為亞洲分佈的巨蚓科蚯蚓，21%為全北區的正蚓科蚯蚓。在陳（2003）文中記錄了臺灣東北部的宜蘭縣蚯蚓，尚有 27 種未命名種類，若將其發表，則臺灣會有超過 100 種蚯蚓。這份臺灣蚯蚓名錄同時也記錄及鑑種確認兩個外來種 *Eisenia fetida* (Savigny)及 *Eiseniella tetraedra* (Savigny)。

關鍵詞：分類、多樣性、巨首蚓科、正蚓科、臺灣、亞洲蚯蚓。

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