



Taxonomic status and ecology of Oriental *Pheretima darnleiensis* (Fletcher, 1886) and other earthworms (Oligochaeta : Megascolecidae) from Mt Kinabalu, Borneo

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Abstract

The synonymy of *Perichaeta darnleiensis* Fletcher, 1886, first described from Australian Darnley Island in the Torres Straits, was confused since Beddard (1900) and Michaelsen (1900) wrongly applied the names *Perichaeta cingulata* Schmarada, 1861 (= *Megascolex cingulatus*) and *Megascolex indicus* Horst, 1883 [= *Amyntas corticis* (Kinberg, 1828)], respectively. Taxonomic revision of this species now merges several parthenogenetic morphs, including *Pheretima decipiens* Beddard, 1912 **syn. nov.** from Luzon, Philippines. Final resolution depends on location of missing types or, alternatively, on neotypification, nevertheless new material from Mt. Kinabalu, north Sabah (Borneo) allows augmentation of the description of *Pheretima darnleiensis* from that given by Sims & Easton (1972) who, for its lobate/serrate intestinal caeca, remarked that these “cannot be regarded as taxonomic characters as they are more fully formed in the larger specimens”. Body size range is now 45–700 mm, although this suggests either high plasticity or too wide synonymy. Its distribution in the tropical Indo-Australasian Archipelago and islands of Malaysia, Indonesia and Fiji is attributed to human-mediated introductions in recent and pre-historic times that mask its true provenance; reports from Hawaii, Sri Lanka, South Africa and South America are disputed. Sympatric *Amyntas omeimontis kinabalu* Sims & Easton, 1972 was elevated to species level by Blakemore (2005). Descriptions of *Pheretima* (*Parapheretima*) *saba* Sims & Easton, 1972 and *Polypheretima everetti* (Beddard & Fedarb, 1895: 69) – somewhat similar to *Polypheretima kinabaluensis* (Beddard & Fedarb, 1895: 71) – are augmented and specimens are figured on newly collected material. A new Mt Kinabalu earthworm, *Metaphire paka* Blakemore **sp. nov.** is proposed that compares with *Metaphire cai* (Michaelsen, 1916) from Java [originally “*Pheretima inflata* (Horst) var. *cai*”], bringing the total known earthworms from Mt Kinabalu to six species. Ecological associations are briefly discussed.

Key words: Pheretimoids, earthworm eco-taxonomy, biodiversity, montane

Introduction

The total of pheretimoid earthworms (i.e., *Pheretima* auct.) is currently estimated at 920 valid (sub-)species from about 1,400 nominal taxa (Blakemore, 2004, 2005, 2006a). From Michaelsen’s (1900) listing of 167 species, many previously in the genera *Megascolex* and/or *Perichaeta*, the systematics of *Pheretima* became increasingly unwieldy and chaotic until the long overdue review by Sims & Easton (1972) of all 746 nominal taxa known to them, later updated by Easton (1979) who added 25 new and 16 species omitted from Sims &

Easton. These latter authors reallocated all pheretimoid species and subspecies in their nomenclator (i.e. including both valid and synonymous names) into 'convenient' species-groups within eight genera using computer-based phenetic analysis, and this scheme was amended slightly by Easton (1976, 1979, 1982). However, no attempt was made on the near-impossible tasks to redescribe nor to revise all taxa, for which Sims (1983: 468) regarded only half the nominal species, i.e., ca. 400, as probably valid at that time. Lee (1981) remarked that the generic divisions resulting from Sims & Easton (1972) often had overlapping geographical distributions and diagnostic characters, and he also commented that recourse to computer analysis for systematic resolution requires careful weighting of characters otherwise the results "*can only lead to the substitution of a new kind of confusion for the old*". Naturally, any outcome from such analyses also depends on the reliability of the input data based on the characteristics found in the representative type material.

Sims and Easton (1972) generally did not discriminate between synonyms, but a notable exception (on pages 260–264) was *Pheretima (Pheretima) darnleiensis* (Fletcher, 1886) for which they provided a full synonymy and re-description based on Mt Kinabalu material obtained from a 1964 Royal Society North Borneo Expedition. New specimens recently obtained from the same location enables review of this taxon after 35 years as part of the senior author's wider studies on cosmopolitan earthworms (Blakemore, 2002, 2006b, 2007) and ongoing Asian biodiversity/ecology studies. Its distribution and associations with sympatric species are discussed, and figures are provided for the first time. The current paper illustrates the complexities of taxonomic process whereby the simple answer to a species' name is obtained by systematic elimination of possibilities combined with laborious searches of historic records, resulting in a decrease in names through synonymy, or an increase through restoration and designation of new taxa. The importance of correct determination of species identities relates to regional biodiversity estimates and to baseline data necessary for ecological understanding.

Materials and methods

The types of *Pheretima darnleiensis* are not locatable with Fletcher's material in the Macleay Museum in the University of Sydney (Dr. Margaret Humphrey, Curator, Entomology pers. comm. to RJB, April, 2005) nor are they traceable in records of the Melbourne nor Australian Museum, Sydney where several of his other specimens are stored [Sims & Easton (1972: 264); RJB pers. obs.] and therefore the following description is based on sources given in the synonymy and on newly collected material from Mt Kanabalu, Sabah, Borneo. For the other species studied here, types and vouchers are deposited in the National Museum of Nature and Science (formerly the National Science Museum) Tokyo, Japan with registration numbers beginning NSMT-An. Taxonomic treatment follows the methodology, format, figuring style, and higher level classification of Blakemore (2000, 2002, 2005) and complies with ICZN (1999). Brief discussion follows the species descriptions, and references are restricted to key citations as full lists of earlier taxonomic papers may be readily found elsewhere, e.g. in Sims & Easton (1972).

Taxonomic results

Phylum Annelida; Subphylum (or Superclass) Clitellata, Class Oligochaeta, Order Haplotaxida *sensu* Sims & Gerard (1985, 1999).

Family Megascolecidae Rosa, 1891 *sensu* Blakemore (2000)

Genus *Metaphire* Sims & Easton, 1972

***Metaphire paka* Blakemore sp. nov.**

(Fig. 1)

Diagnosis: *Metaphire* with a single pair of spermathecae in 8/9 ca. 0.25 circumference apart ventrally. Male pores on small penes on 18 ca. 0.25 circumference apart protuberant from small copulatory pouches. Genital markings as paired clusters of 1–9 disc-like papillae anteriorly on 9, 18–19 and sometimes 20 (sessile glands correspond internally). Holandric. Intestinal caeca simple in or near 27.

Distribution: Paka Cave, Mt Kinabalu, Sabah, Malaysia; 2,970 m, 06°05' N, 116° 33' E.

Material examined: Holotype (H) – NSMT-An 366, weakly clitellate, mature specimen, dissected and figured by RJB, stored in 80% ethanol (EtOH) after fixation in dilute formalin at time of collection, from vicinity of Paka Cave collected by Tatsuya Kawaguchi, 13.vii.2005 (sample labelled: “050713 PAKA 5-B”). Paratypes – NSMT-An 367-9, three specimens, one clitellate (P1, dissected), two a clitellate sub-adults (P2-3), all fixed in formalin and stored in 80% ethanol with same collection data as Holotype. An additional specimen “060307 R4-2” collected 07.iii.2006 by T. Kawaguchi along with several other samples from lowlands to east of Mt Kinabalu appears superficially similar to *M. paka*.

Etymology: named after locality of its Paka cave collection site and type locality.

Lengths: range 42–62 mm long, (H) 57, (P1) 62, (P2) 44, (P3) 42 mm.

Width: ca. 2 mm.

Segments: count range 74–120; (H) 104 with first segment poorly differentiated, (P1) 120, (P2) 74 – possibly a posterior regenerate, (P3) 76.

Colour: faint brown pigment dorsally with darker mid-dorsal line after segment 11 or 12; clitellum pale (H, P1).

Prostomium: open epilobous.

First dorsal pore: 11/12.

Setae: range 32–46 per segment; no ventral and dorsal gaps nor crowding; 6 setae intervene between male pores (H, P1); [actual counts: (H) 44–46 on 7, ca. 32 on 20, ca. 40 posteriorly; (P1) 44 on 7, 32 on 20, ca. 40 posteriorly].

Nephropores: diffuse, not detectable.

Clitellum: annular 14–16, weak and setae retained (H) or more pronounced (P1).

Male pores: on 18 ca. 0.25 circumference (1 mm) apart on small penes within small copulatory pouches [(H) 18rhs protruding] with 6 setae intervening (H, P1).

Female pores: single, midventral on 14.

Spermathecal pores: paired in 8/9 approximately 0.25 circumference apart; (P1) has apparent additional pore on 7/8rhs only.

Genital markings: paired clusters of one to nine small papillae below spermathecal pores in 9 and on either side of male pores anteriorly on 18 and 19 and sometimes a single papilla on either or both sides of 20; [actual counts: (H) 9lhs 5–6, 9rhs 7, 18lhs 5, 18rhs 5–6. 19lhs 5, 19rhs 5; (P1) 9lhs 3, 9rhs 1, 18lhs 6, 18rhs 7, 19lhs 4, 19rhs 3; (P2) 9lhs 2, 9rhs 4, 18lhs 4, 18rhs 4, 19lhs 5, 19rhs 5, 20lhs 1, 20rhs 1; (P3) 9lhs 6, 9rhs 4, 18lhs 8, 18rhs 8, 19lhs 4, 19rhs 5, 20lhs 1, 20rhs 0]. Sessile glands correspond internally.

Septa: 8/9 thin, 9/10 absent; 10/11 and subsequent also thin.

Dorsal blood vessel: single.

Hearts: 10,11–13.

Gizzard: large between 8/9 and 10/11 but mostly in 9.

Calciferous glands: none.

Intestine origin (caeca, typhlosole): in 15; caeca simple with slight indentation from 26,27–23; simple lamellar typhlosole present, commencing from about 23. The gut contains yellow soil, woody organic debris and quartz grits.

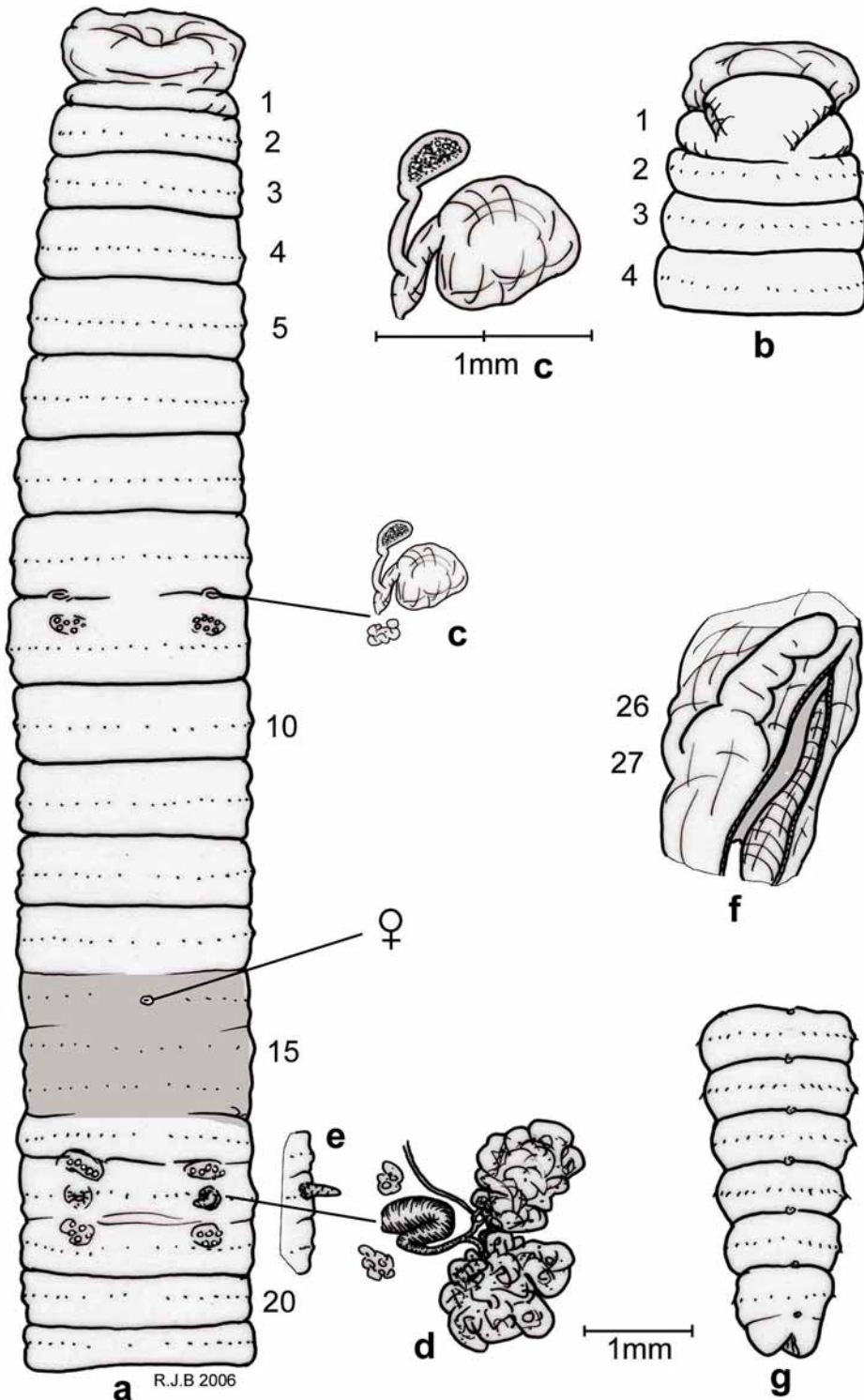


FIGURE 1. *Metaphire paka* *sp. nov.* Holotype showing a, ventral view; b, dorsal view of prostomium; c, a spermatheca (also enlarged) with internal glands; and d, prostate *in situ* also with internal glands; e, lateral view of 18rh penis; f, lateral view of an intestinal caecum also showing lamellar typhlosole; and g, dorsal view of the posterior segments. The weakly developed clitellum is shaded and scale bars are 1mm.

Nephridia: meroic, absent from spermathecal ducts.

Testes/sperm funnels: holandric, testes in 10 and 11 in testis sacs, seminal vesicles paired anteriorly in 11 and 12.

Ovaries: paired in 13 with funnels posteriorly; ovisacs not found.

Prostates: large racemose in 17–19,20; muscular ducts pass into small copulatory pouches concealed within base of each duct containing a small conical penis.

Spermathecae: paired in 9, saccular ampulla on shortish duct with small clavate diverticulum (iridescent); (P1) has an abnormal, adiverticular, spermatheca-like sac on 8lhs (as seen from dorsal dissection) corresponding to extra pore in 7/8rhs (as seen from ventrum).

Remarks. The rudimentary, ancillary spermatheca in segment 8 of paratype (P1) is considered an aberration. Nine previously known pheretimoid species have spermathecae only in 9 (Blakemore, unpublished), viz. *Amyntas antefixus* (Gates, 1935) from Szechuan, *Metaphire cai* (Michaelsen, 1916) from Java, *Amyntas dinghumontis* Zhang *et al.*, 2006 and *Amyntas liaoi* Zhang *et al.*, 2006 from China, *Metaphire michaelseni* (Ude, 1925) from Sarawak Borneo, *Amyntas pataniensis labuhensis* (Michaelsen, 1896: 224) from Moluccas, *Pheretima (Pheretima) racemosa* (Rosa, 1891: 399) from Java, Indonesia and Kalimantan Borneo, *Amyntas supuensis* (Michaelsen, 1896: 225) from Moluccas, and *Pheretima arayataensis* James *et al.* in James, Hong & Kim, 2004 from Luzon, Philippines (and, co-incidentally, several of these species are also montane). Of these, *M. michaelseni* that is also sympatric on Borneo but has a single, dorsal spermatheca with paired diverticula, and *Ph. racemosa* that has nephridia on its spermathecal ducts (thereby qualifying for *Pheretima*) and multiloculate diverticula, perhaps come closest to the present species. Of the *Amyntas* spp., apart from having superficial male pores, each has a different arrangement of genital markings (when present). *Metaphire cai* is especially similar with spermathecal pores in 8/9 (0.2 circumference apart) and penes within small copulatory pouches – thereby just qualifying for inclusion in the genus, as with *M. paka* – but it differs in its lack of genital markings and in other minor respects. *Metaphire cai* (Michaelsen, 1916) was originally a sub-species of *Perichaeta inflata* Horst, 1893 that is now a junior synonym of *Metaphire javanica* (Kinberg, 1867), hence its present elevation to species level. *M. cai* was from Mt Pangerango, Java (in jungle at 1,000 m) and named after the collector, identified only as “C.A. April 1899” (from whence the species name derives); its types are listed in Museums of Stockholm (NHRWS 153) and Hamburg (ZNUH 8503). From this and other *Metaphire* species, *Metaphire paka* appears distinct in its paired spermathecae in 9 combined with its arrangement of genital markings.

Because the primary male pores are on small penes, they are classed as ‘non-superficial’ [i.e. not “discharging directly onto the surface of xviii [18]” (Sims & Easton, 1972: 211) as required for inclusion in *Amyntas*] and therefore this species is attributed to *Metaphire*. However, retraction of the penes (presumably the normal case in life) may result in the male pores being mistaken as ‘superficial’, thus dissection (or suction by syringe) are required for confirmation of this, as for other, marginal species.

Genus *Pheretima* Kinberg, 1867 *sensu* Sims & Easton (1972)

Pheretima (Pheretima) darnleiensis (Fletcher, 1886)

Figs. 2–5

Synonymy:

Perichaeta cingulata (part, cf. *A. robustus*); Vaillant, 1868a: 225, 228; Vaillant, 1868b: 146 – misidentifications. [Non *Perichaeta cingulata* Schmarda, 1861: 14, fig. 163 (= *Megascolex cingulatus* from Sri Lanka as redescribed by Beddard, 1892: 122, figs. 9–13; 1895: 382; Michaelsen, 1900: 229; Stephenson, 1923: 236, fig. 86)].

Perichaeta indica : Horst, 1885: 4 (syn. *cingulata* : Vaillant – misidentification). [Non *Megascolex indicus* Horst, 1883: 186 (= *Amyntas corticis* Kinberg, 1867 according to Easton, 1981: 49)].

Perichaeta Darnleiensis (sic) Fletcher, 1886b: 966. [Dated “1886” e.g. by Michaelsen (1900) or dated “1887” by Sims & Easton (1972: 239, 260); Easton (1983: 732; 1984: 119). “The part containing Fletcher’s paper was actually published on 17 November 1886” – M.L. Augée, Editor, *Proc. Linn. Soc. NSW* (pers. comm. to RJB, Oct. 2004)]. From Darnley Island, Torres Straits, Australia. Types missing.

Perichaeta vaillanti Beddard, 1890: 66; Beddard, 1895: 422 [Beddard (1895: 421, 422) thought *Ph. (Ph.) philippina* (Rosa, 1891) similar except for its two pairs of spermathecae, and *Amyntas enganensis* (Rosa, 1892) similar except

- for its longer spermathecal diverticula]; Michaelsen, 1900: 311. From Manila, Luzon, Philippines. Type in British Museum: BMNH 1904:10:5:173.
- Perichaeta martensi* Michaelsen, 1892: 242; Horst, 1893: 324; Beddard, 1895: 416 (?syn. *darnleiensis*); Michaelsen, 1896: 240 (syn. *eo*); 1900: 282 (syn. *javana, eo*). From Banka Island east of Sumatra. Types in Berlin: 2148.
- Perichaeta bosschae* Horst, 1893: 324; Beddard, 1895: 432; Michaelsen, 1896: 238; 1900: 256; [the two specimens Beddard (1900b) mis-identified as *P. bosschae* were given the new name of *P. baruana* Stephenson, 1942: 209, later included in synonymy of *Metaphire malayana* (Beddard, 1900b) by Gates (1972: 199)]. Name misspelt “*boschae*” by Michaelsen (1896: 238). From Borneo (Baram River, Sambas). Type in Leiden Museum: 1829.
- Perichaeta martensi javana* Michaelsen, 1894: 99. [Sims & Easton (1972: 260) misspelt Michaelsen’s *martensi javana* as “*javanica*” [non *Rhodopis javanica* Kinberg, 1867 (= *Metaphire javanica*)]. From Java. Types missing.
- Perichaeta darnleiensis*: Beddard, 1895: 406.
- Perichaeta padasensis* Beddard & Fedarb, 1895: 73. From Merabah, Padas Valley North Borneo. Types in British Museum: BMNH 1904:10.5:119–26, 1263–4.
- ?*Perichaeta atheca* Rosa, 1896a: 520; Michaelsen, 1900: 254; 1928: 41; Sims & Easton, 1972: 223 [who maintained it as *species incertae sedis* yet noted that Michaelsen (1928: 41) “regarded it as a subspecies of *indica* (= *Pheretima* (*Pheretima*) *darnleiensis*)”]. From Sumatra (Balighe, Si-Rambe and Lake Toba). Types in Genoa: 44026-28-33.
- Perichaeta eo* Rosa, 1896a: 528; Rosa, 1896b: 609. Types in Genoa (44009-11) and Turin (151).
- Perichaeta floweri* Benham 1897: 217. [Spermathecal pores in 5/6/7/8/9; setae 35–45 and male pores superficial according to Michaelsen (1900: 267) but which were “*doubtless*” in copulatory chambers according to Gates (1934: 259) in his inspection of syntypes where he also noted the “*finger-like*” ampullae of the seminal vesicles (see description under *Pheretima floweri* below)]. From Bukit Timah, Singapore. Types in British Museum: BMNH 1896.9.30.9-11. These three softened syntypes were inspected by Gates (1934: 258) and also by Sims & Easton (1972: 180).
- Perichaeta madelinae* Benham 1897: 219. [Described by Michaelsen (1899: 76; 1900: 291) as either *Amyntas* or *Pheretima padasensis madelinae* (Benham); Reynolds & Cook (1976: 132) mistakenly attribute this taxon to Michaelsen (1899 - see below) as well as to Benham (1897)]. From Mt Kinabalu, North Borneo. Types in British Museum: BMNH 1896:9:30:4.
- Perichaeta belli* Rosa 1898a: 286. From Mindoro, Philippines. Type in British Museum: BMNH 1898:10:28.5.
- Megascolex cingulatus* (part cf. *A. robustus*): Vaillant, 1889: 72.
- Amyntas padasensis lokonensis* Michaelsen, 1899b: 74 [miscited by Beddard (1900a: 615) as page “78”. Differs from *madelinae* by smaller size (ca. 45–68 mm) and having fewer setae (ca. 36)]. From Mt Lokon, Tomohon, North Celebes. Type missing from Basel Museum.
- Amyntas padasensis madelinae*: Michaelsen, 1899b: 76. [Differs from *lokonensis* by larger size (ca. 135 mm) and having greater setae (ca. 58)].
- Amyntas padasensis padasensis*: Michaelsen, 1899b: 74. [Cited by Michaelsen (1900: 290) as *P. padasensis (typica)* and differentiated from its sub-species by size >200 mm (ca. 280 mm) and having extra seminal vesicles in segment 13].
- Amyntas martensi*: Michaelsen, 1899b: 87.
- Amyntas cingulatus*: Vaillant (in part); Beddard, 1900a: 615 [miscited by Sims & Easton (1972: 261) as page “625”]; [syns. *darnleiensis, vaillanti, martensi, indica* Horst, *eo, madelinae, padasensis* var. *lokonensis, belli*; also in a footnote Beddard (1900a: 615) says that *Perichaeta cingulata* of Schmarda is of course a *Megascolex* as then defined]; Beddard, 1900b: 892 [syns: *indica* (part), *darnleiensis, vaillanti, martensi martensi, m. javana, eo, madelinae, belli, padasensis lokonensis*). Many of these synonyms were accepted by Sims & Easton (1972) who, however, also added *padasensis* and *bosschae*].
- Amyntas padasensis*: Beddard, 1900a: 624.
- Amyntas bosschae*: Beddard, 1900a: 625; non Beddard, 1900b: 892 (= *M. baruana*).
- Amyntas peregrinus* (?part inc. *floweri*): Beddard, 1900a: 644.
- Pheretima belli*: Michaelsen, 1900: 255.
- Pheretima bosschae*: Michaelsen, 1900: 256.
- Pheretima darnleyensis* (sic, lapsus): Michaelsen, 1900: 263 (illegal emendation).
 “*Pheretima darleyensis* (sic): Michaelsen, 1900, p. 267” reported by Easton (1982: 732) is perhaps a lapsus for the above lapsus.
- Pheretima floweri*: Michaelsen, 1900: 267.
- Pheretima indica* (part): Michaelsen, 1900: 275; Michaelsen, 1910a: 260; Michaelsen, 1922: 41 (syn. *kuchingensis*); Michaelsen, 1923: 2; Michaelsen, 1928: 40 (part inc. *indica typica = padasensis*); Stephenson, 1930b: 1; Stephenson, 1931b: 273; Michaelsen, 1932a: 614; Stephenson, 1932b: 219; Ude, 1932: 147 (part inc. *typica*); Michaelsen, 1935: 108; Gates, 1935b: 82, 83 (syn. *floweri*), 94; Gates, 1936c: 389 (syn. *quadragenaria* (part) s. Michaelsen, 1924); Gates, 1937a: 320; Gates, 1937d: 193; Gates, 1940: 413; Gates, 1949: 26. [Note: Gates (1935b) was referring to a concept of *P. indica* (Horst), 1883 that Gates later re-described as being *P. darnleiensis* (i.e., not as *indica* (= *A. corticis*)].

- Pheretima martensi*: Michaelsen, 1900: 282 (syn. *m. javana*, *eo*).
- Pheretima padasensis typica*: Michaelsen, 1900: 290.
- Pheretima padasensis lokonensis*: Michaelsen, 1900: 290.
- Pheretima padasensis madelinae*: Michaelsen, 1900: 291.
- Pheretima vaillanti*: Michaelsen, 1900: 311.
- Pheretima decipiens* Beddard, 1912: 180. **Syn. nov.** [Beddard said this species, which he described lengthily but poorly, seems to be “exactly like *P. benguetensis*”, he failed to give any convincing argument for their separation and, moreover, since *Ph. benguetensis* was listed in synonymy of *Ph. darnleiensis* by Sims & Easton (1972) then *Ph. decipiens* most probably belongs too. One specimen (of how many?) had only three pairs of spermathecae]. From Luzon, Philippines. Types unknown.
- Pheretima benguetensis* Beddard, 1912: 183, fig. 1. [This name was maintained in synonymy and provisionally separated in a pheretimoid checklist by Blakemore (2004b: 133) because it was erroneously listed in a publication by Nakamura (1999: 27) as having only two pairs of spermathecal pores in 6/7/8 – this now known to be a mistake with reference to Beddard’s original description. Length to 190 mm]. From 1,524m in the Province of Benguet, Luzon, Philippines. Types unknown.
- Pheretima kuchingensis* Stephenson, 1916: 337. From Kuching, Sarawak, Malaysia. Type in Calcutta: 6539.
- Pheretima quadragenaria* (part): Michaelsen, 1924b: 391. [Note: Perrier’s species was originally described with only one pair of spermathecae in 7/8].
- Pheretima borneoensis* Ude, 1925: 108; Michaelsen, 1928: 55 (syn. *?bosschae*); Ude, 1932: 131; Michaelsen, 1934b: 45. From Borneo. Types in British Museum: BMNH 1933:10:6:26.
- Pheretima indica birangi* Michaelsen, 1928: 42. From Borneo. Types missing.
- Pheretima floweri*: Gates, 1934: 258; [Gates, inspected the three macerated British Museum syntypes with this label “*Perichaeta floweri*. [18]96.9.30 9–11. Bukit Timah, Singapore. S.S. Flower”; one specimen was useless and was discarded, his redescription was based on the external characters of an undissected specimen and the internal characters of both remaining specimens were both rather nondescript].
- Pheretima padasensis*: Kobayashi, 1941: 397.
- Pheretima* (*Pheretima*) *darnleiensis*: Sims & Easton, 1972: 260 [syn. *vaillanti*, *martensi*, *m. javanica* [lapsus pro. *javana*], *bosschae*, *padasensis*, *p. lokonensis*, *p. madelinae*, *eo*, *floweri*, *madelinae*, *belli*, *kuchinensis*, *quadragenaria* (part), *benguetensis*, *borneoensis*, *indica birangi*]; Easton, 1982: 732; Easton, 1984: 119 (syn. *indica*: Gates, 1937: 320); Blakemore, 1994: 368 (*vaillanti*, *martensi*, *bosschae*, *padasensis*, *eo*, *floweri*, *madelinae*, *belli*, etc.); 2002: 216 (syn. *vaillanti*, *martensi*, *bosschae*, *martensi javana*, *padasensis*, *eo*, *floweri*, *madelinae*, *belli*, *padasensis lokonensis*, *benguetensis*, *kuchingensis*, *borneoensis*, *indica birangi*); 2004: 136 (syn. *vaillanti*, *martensi*, *m. javana*, *cingulatus* (part), *bosschae*, *padasensis*, *p. lokonensis*, *p. madelinae*, *eo*, *floweri*, *belli*, *kuchinensis*, *quadragenaria* (part), *benguetensis*, *borneoensis*, *indica birangi*).

Diagnosis: *Pheretima* usually with four or, rarely, five (or 3?) pairs of spermathecae in (4/5)5/6-8/9 about 0.2 circumference apart ventrally. Male pores on 18 ca. 0.2 circumference apart in slit-like copulatory pouches. Genital markings lacking. Intestinal caeca in or near 27, simple (or with slightly complex margins). Size range 45–400 (and up to 700 mm in life) by 2.5–6.0 mm.

Distribution: the tropical Indo-Australasian Archipelago and islands: Malaysia, Singapore, Berhala Island east of the Malay Peninsula, Borneo, Brunei, Indonesian Islands: e.g. Sereina (Sipora) of the Mentawai Islands west of Sumatra [(Rosa, 1896b) reported by Sims & Easton (1972: 263) as “*Metawei Is.*”), Krakatau Island, Sumatra, Java, Bali; Australian Territory of Christmas Island south of Java [e.g. by Michaelsen (1935) and Gates (1935b: 94)], Philippines, North Celebes, Moluccas, Caroline Islands of Micronesia north of Papua New Guinea (Kobayashi, 1941), Fiji [Levuka, Ovalau – (Gates, 1937c) as noted by Sims & Easton (1972: 263)], Kei Islands in the Arafura Sea just west of West Papua or Irian Jaya [by (Michaelsen, 1910a) as cited by Sims & Easton (1972: 263)], and Darnley Island in the Torres Straits – after whence it was named but which is unlikely to be its true origin. Whereas, Easton (1982: 732) thought that records from Caroline, Kei, Fiji, and Darnley islands (at least?) were the result of introductions, Sims & Easton (1972: 263) are dismissive of reports from Sri Lanka, Manila [Vaillant (1889) cf. *Perichaeta vaillanti*], and South Africa. Moreover, historical reports from Hawaii and Brazil of “*Perichaeta indica* Horst” are more likely to refer to *Amyntas corticis* than to *Ph. darnleiensis* proper. Full lists for species from various regions, including the Pacific and ‘Papua-sia’, are presented in Blakemore (2005; 2006a).

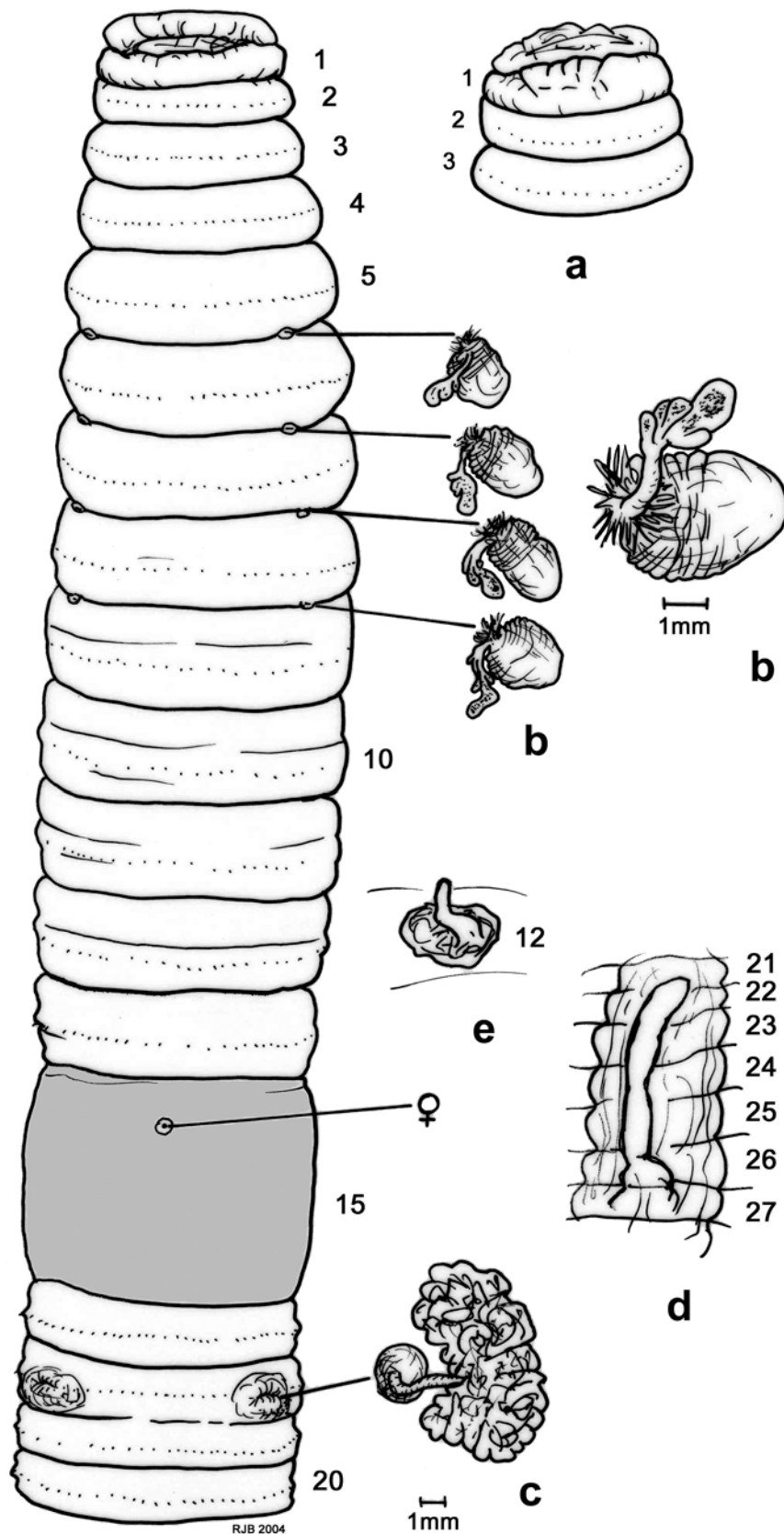


FIGURE 2. *Pheretima (Pheretima) darnleiensis* specimen S1 the larger of two specimens from Mt Kinabalu, Sabah, Borneo collected by M.T. Ito of YNU in 2003. Figure shows a, prostomium; b, spermathecae (with an enlargement of one spermatheca); and c, prostates, *in situ*; d, lateral view of an intestinal caecum; and e, a seminal vesicle in 12hrs with its distinctive appendix.

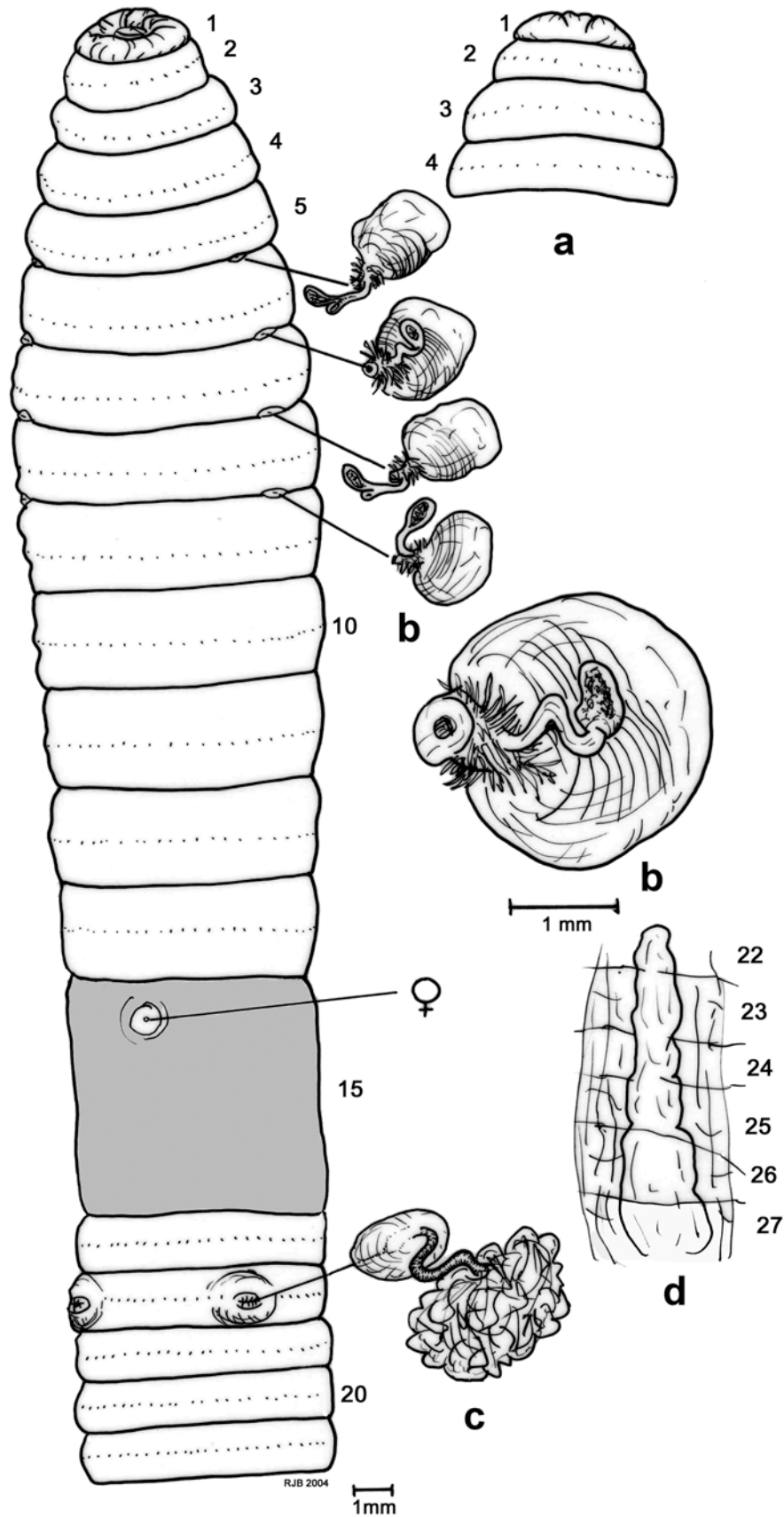


FIGURE 3. *Ph. (Ph.) darnleiensis* – specimen S2 the lesser of two large specimens from Mt Kinabalu with same collection details and anatomy as for Fig. 2 showing a, prostomium; b, spermathecae (with an enlargement of one spermatheca); and c, prostates, *in situ*; d, lateral view of an intestinal caecum.



FIGURE 4. *Ph. (Ph.) darnleiensis*, live specimen Mt Kinabalu – photo courtesy of Dr Menno Schilthuizen (see also <http://www.schilthuizen.org/text/text1.htm>).



FIGURE 5. *Ph. (Ph.) darnleiensis* summary of known distribution (map from CIA).

Material examined: two mature specimens (both dissected and figured by RJB, the larger one at 385 mm designated as S1, the shorter one at 305 mm, S2), from Mt Kinabalu, Sabah, Malaysia collected by Dr M.T. Ito in 2003; several smaller less mature specimens collected from Mt Kinabalu by T. Kawaguchi on 16–17.ix.2004 (e.g. samples labeled: “040916 PAKA 3-C”, “040917 HELI 5-B”), plus numerous immature specimens collected from lowlands East of Mt Kinabalu by T. Kawaguchi (e.g. those labeled: “060305 T3-3”, “060302 R-1-15” and “060302 R-1-2-3”) that although acitellate look like striped and more regularly coloured forms of *Pheretima (Ph.) darnleiensis*. All specimens held in YNU SERG Soil Ecology laboratory collection in Yokohama pending museum deposition.

Length: range 45–385 mm [i.e., reported as 108 mm (Fletcher), 45–280 mm for sub-species of *padasensis*, 111–155 by 6 mm (Michaelson, 1900) and 75–170 mm (Sims & Easton, 1972)]. Largest current specimens measure (S1) 385 and (S2) 305 mm, respectively, with the smaller specimens ca. 100–140 mm long. In

life, specimens are longer – approaching 700 mm when stretched out (T. Kawaguchi and M. Schilthuizen pers. obs., and weblink http://en.wikipedia.org/wiki/Kinabalu_giant_earthworm Feb. 2007).

Width: 2.5–6.0 mm mostly commensurate with length.

Segments: 70–180 [155 by Fletcher, repeated by Beddard (1895: 406), 79–108 by Michaelsen or 70–120 by Sims & Easton]; current specimens had 127 (S1 with possible posterior regrowth) and up to 180 segments in (S2).

Colour: blue-grey (natural) or brown (preserved) with darker clitellum (cf. some immature striped specimens from east of Mt Kinabalu were superficially similar, as noted above).

Prostomium: open epilobous.

First dorsal pore: 12/13 (S1) or, less often 11/12 as in (S2).

Setae: numerous, especially in posterior, ca. 25–66 per segment, no ventral gaps nor crowding; variously 4–14 setae intervene between male pores. The original description had 60–66 setae per segment (as also for *madelinae* and *belli*, cf. 35–45 for *floweri*); current large specimens have 60–70 setae in anterior segments, whereas in smaller specimens 40–60 setae were counted.

Nephropores: not detected.

Clitellum: annular 14–16, setae occluded.

Male pores: on 18 ca. 0.2 circumference (or ca. 3 mm in larger specimens) apart in slit-like copulatory pouches on distinct round porophores with intervening setae numbering 4–8 in smaller specimens to about 14 in larger current specimens.

Female pores: single (or closely paired?) on 14.

Spermathecal pores: usually four, rarely five pairs in (4/5), 5/6–8/9 (?or three pairs in 6/7/8/9) ca. 0.2 circumference apart ventrally approximately in line with 10th setae on each side in current specimens.

Genital markings: none.

Septa: 4/5–7/8 thickened; 8/9 membranous (e.g. S2) or absent (S1 and some current smaller specimens), 9/10 absent; 10/11+ thickened.

Dorsal blood vessel: single.

Hearts: hearts 10, 11–13; supra-oesophageal vessels present.

Gizzard: between 7/8/9 and 10/11; in (S1) occupying 9–10 with equally large ‘crop’ in 7–8.

Calciferous glands: oesophageal pouches absent (but some slight dilations in 11 and 13).

Intestine origin (caeca, typhlosole): 15, ½15 (S1, S2) or 16 (some current smaller specimens); caeca “*simple or with complex margins*” (Sims & Easton, 1972) but only simple form found in current large specimens or slightly incised ventrally in smaller specimens, paired in 27, 26–24, 22, 21; simple lamellar typhlosole present commencing from about 25, 26–28 (new observation on current specimens). Gut contains loamy soil.

Nephridia: merioic; dense, tufted (?pepto-) nephridia on posterior septa in 5 and 6 (S1 and smaller specimens), tubules also present on spermathecal ducts, numerous and diffuse elsewhere.

Testes/sperm funnels: holandric, testes in 10 and 11 in testis sacs, seminal vesicles – each with a distinct finger-like dorsal extension – paired in 11 and 12; elongate pseudovesicles present in 13 (seen in S1, S2 and current smaller specimens that also had smaller pseudovesicles in 14), sometimes reported as “*coelomic sacs*” on 12/13 and 13/14 (Sims & Easton, 1972: 262) [or as “*pseudovesicles*” in 13 and 14 by Gates (1934)].

Ovaries: paired in 13 with densely packed bunches of egg strings; ovisacs not found.

Prostates: large racemose in 17–19, ducts pass into copulatory pouches that each contains a conical penis and an anterior and posterior secretory pad; the coelomic surface of each pouch has small glandular masses above each pad.

Spermathecae: paired in 6–9 (sometimes reported in 5–9); small, duct short and stout and coated with nephridial tubules; diverticulum ectal in origin and typically clavate (in lesser specimens) but sometimes with additional (two or three) lobes to its bulb that is equal in length to the stalk [or “*ampulla*” and “*duct*” by Sims & Easton (1972: 262) although ‘ampulla’ and ‘duct’ usually refer to the main structures of the spermatheca

and on the diverticular appendage are more correctly known as the ‘stalk’ and ‘bulb’].

Other: paired septal glands noted at septal locations on intestinal along dorsal blood vessel (S1). Many nematodes found in coelom of (S2).

Remarks. Fletcher (1886b: 967) first reported “*testes*” in the unusual position of 11 and 12, but later (1887b: 603) corrected these to seminal vesicles. Sims & Easton (1972: 264) found extra spermathecae only infrequently in a few of their Mt Kinabalu specimens but decided not to give them separate taxonomic status. Variations in the intestinal caeca from typically simple to lobate (e.g. in *borneoensis* or *bosschae*) were correlated with growth of specimens and were not deemed of taxonomic value by Sims & Easton (1972: 264) who also thought the glandular masses on the copulatory pouches were possibly homologous to the secretory diverticula diagnostic of *Parapheretima*. Originally *P. padasensis* defined specimens with bi- or tri-lobed spermathecal diverticula, but single lobed specimens were also allowed by Michaelsen (1899; 1900) and by Gates (1935: 83).

Sims & Easton (1972: 266) note that holandric, decathecal *Metaphire fordii* (Michaelsen, 1934) may be confused with *Ph. darnleiensis*, although *M. fordii* lacks nephridia on its spermathecal ducts, and *Ph. darnleiensis* lacks genital markings. Decathecal but metandric species that may be compared are *Metapheretima loriae* (Rosa, 1898) from New Guinea, the Solomons, and Vanuatu and *Me. pickfordii* (Gates, 1959) from the Solomons and Vanuatu – both as redescribed by Lee (1981: 554) and both lacking intestinal caeca.

Approximately 140–152 pheretimoids have spermathecal pores in 5/6/7/8/9 (Blakemore, 2006a and unpublished data) although about 36 of these are *Metaphire*. Similar holandric, octothecal species are *Metaphire bipora* (Beddard, 1900), *Metaphire malayana* (Beddard, 1900) [syns. ?*Amyntas pulauensis* Beddard, 1900: 904; ?*Amyntas evansi* Beddard, 1900: 907; ?*Pheretima baruana* Stephenson, 1932; *Pheretima fovella* Gates, 1949: 21; and *Pheretima strellana* Gates, 1949: 34] from Malaya, Thailand and Myanmar as described by Stephenson (1932) and Gates (1972: 199), possibly including the *Ph. bosschae* Horst, 1893 (part) synonym that had genital markings, cf. the types (now = *Pheretima darnleiensis*)]. *Amyntas juliani* has genital markings but is similar to *Ph. darnleiensis* in retaining septum 8/9 whereas *Metaphire loriae* either has septum 8/9 or lacks it (Lee, 1981: 554). However, none of these latter species with copulatory pouches is yet known to have the nephridia on spermathecal ducts diagnostic of *Pheretima*.

Michaelsen (1928: 40, 41) regarded Sumatran *Perichaeta atheca* Rosa, 1896 as a subspecies of *indica* [= *Pheretima* (*Pheretima*) *darnleiensis*], although Sims & Easton (1972: 223) listed it as *species incertae sedis* because its lack of spermathecae prevented its allocation to *Pheretima*. Another possibly synonymous species is the sixthcal *Pheretima poiana* Michaelsen, 1913 from Mt Poi (1,100 m altitude), Sarawak, North Borneo that Michaelsen (1913: 89) compared to *Ph. philippina* (Rosa, 1891), *Metaphire impudens* (Michaelsen, 1899), *Metaphire merabahensis* (Beddard & Fedarb, 1895) and *Metaphire bindjeyensis* (Michaelsen, 1899). Sims & Easton (1972: 239) have *Ph. poiana* in a *Ph. dubia* (Horst, 1893) species-group that also includes *Ph. callosa* Gates, 1937, and *Ph. korinchiana* Cognetti, 1922 from Korinchi Peak, western Sumatra.

Subgenus *Parapheretima* Cognetti, 1912 sensu Sims & Easton (1972)

***Pheretima* (*Parapheretima*) *saba* Sims & Easton, 1972**

(Fig. 6)

Pheretima (*Parapheretima*) *saba* Sims & Easton, 1972: 265 from region of Mesilau Cave at 2,100–2,400m and ridge between Mesilau Rivers at 2,750m. Syntypes in Natural History Museum, London: BMNH 1971:19: 88–89, 90/93 (not re-inspected here).

Diagnosis: *Parapheretima* occurring on Mt Kinabalu with paired spermathecae in 5/6/7. Genital markings absent. Holandric. Intestinal caeca simple in 27.

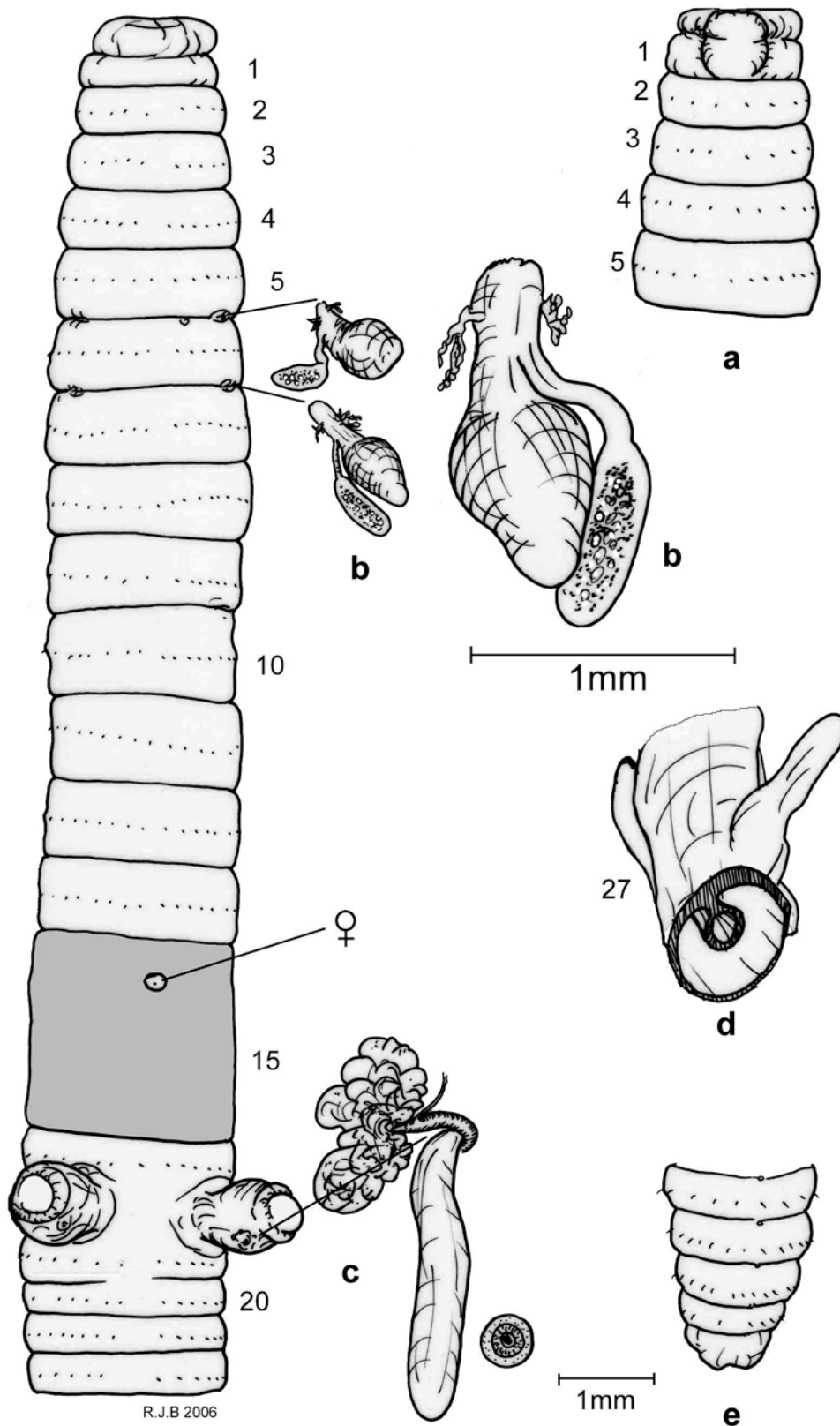


FIGURE 6. *Pheretima (Parapheretima) saba* from region of Paka Cave, Mt Kinabalu; figure shows a, prostomium; b, a spermatheca (with an enlargement to show nephridia on duct); and c, prostate gland and accessory diverticulum *in situ* (with section of diverticulum); d, a dorso-lateral section of intestine to show caeca and typhlosole; and e, dorsal view of posterior segments. Note: the copulatory pouches that everted on preservation would normally in life be withdrawn into body leaving only slits of male pores visible externally.

Distribution: Mt Kinabalu, Sabah, Malaysia. [Type locality near Mesilau Cave].

Material examined: mature specimen, dissected and sketched by RJB – NSMT-An 370, fixed in formalin at collection and stored in 80% ethanol with a spermatheca removed to a separate vial in jar; from vicinity of Paka Cave, Mt Kinabalu, Sabah, Malaysia collected by Tatsuya Kawaguchi, 13.vii.2005 (original sample labeled “050713 PAKA 5-B” also contained specimens of *Metaphire paka* as described above).

Lengths: 60–119 mm; current specimen 60 mm, Sims & Easton (1972) had size range 87–119 mm.

Width: ca. 2–4 mm.

Segments: 107–135; current specimen 107, Sims & Easton (1972) had range 112–135.

Colour in formalin: faint brown anteriorly; clitellum yellow/buff.

Prostomium: open epilobous.

First dorsal pore: 11/12–13/14 (12/13 in current specimen).

Setae: 28–40 per segment; Sims & Easton (1972) had range 34–40; current specimen has 28–30 [actual data ca. 31 on 7, 28 on 20, 22–26 posteriorly; no setae between male pores (pers. obs. not previously noted by Sims & Easton)].

Nephropores: diffuse, not found.

Clitellum: annular 14–16, setae obscured.

Male pores: on 18 ca. 0.3 circumference apart on large eversible copulatory structures protruding from male pores described by Sims & Easton “*as large crenellate copulatory pouches 0.3 of the body circumference apart*” with no setae intervening (current specimen); actual male pores seem to be just antero-medial to large sucker-like pads (pers. obs. and see sketch).

Female pores: single, midventral on 14.

Spermathecal pores: paired in 5/6/7 approximately 0.3 circumference apart.

Genital markings: absent.

Septa: 4/5–7/8 slightly thickened, “8/9, ?9/10 absent” according to Sims & Easton and both absent in current specimen; 10/11 and subsequent thin.

Dorsal blood vessel: single (pers. obs.).

Hearts: 10–13 (cf. Sims & Easton who just state “*Last lateral heart in xiii [13]*”).

Gizzard: “*between 7/8–?9/10, 10/11*” according to Sims & Easton, found to be large between 7/8–10/11 in current specimen.

Calciferous glands: none.

Intestine origin (caeca, typhlosole): in “*xv [15]*” (Sims & Easton) or 18 where it thins and greatly dilates (pers. obs. on current specimens); caeca small, simple from 27–25,23; small spherical typhlosole present from about 27 (pers. obs. on current specimens – this not noted by Sims & Easton); gut contents not noted.

Nephridia: merioic, “*present on spermathecal ducts*” according to Sims & Easton, but in current specimen found to be few in number and scarcely present on duct as they can almost be teased back to origins on body wall; nevertheless, when a spermatheca was removed they are seen attached to the duct where it too enters the body wall.

Testes/sperm funnels: holandric, testes in 10 and 11 in testis sacs, seminal vesicles paired in 11 and 12; with pseudovesicles in 10 and 13 (pers. obs. in current specimen not noted by Sims & Easton).

Ovaries: paired, palmate in 13 with funnels posteriorly; ovisacs not found.

Prostates: large racemose in 17–20; muscular ducts pass into large copulatory pouches that each contains a large penis and externally bears a long tubular (?secretory) diverticulum that is perhaps related to eversible pads on copulatory organs.

Spermathecae: paired in 6 and 7 each with ovoid ampulla on shorter duct with small clavate diverticulum; two or three nephridia attach near the base of duct (pers. obs. as noted above).

Remarks. Sims and Easton (1972: 266) compared their species with *Ph. (Ph.) koellikeri* (Michaelsen, 1928) from Japan for which it is not surely known whether nephridia are apparent on the spermathecal ducts,

thus, according to Blakemore (2006a), it ‘defaults’ to *Metaphire* rather than qualifying for *Pheretima*. Both taxa have what are called ‘secretory diverticula’ on their copulatory pouches and, at least in *Ph. saba*, this qualifies it for *Parapheretima* sub-genus. In *Ph. (Pa.) saba* these diverticula may relate to the large eversible copulatory organs that seem to have (?adhesive) pads whereas in *M. koellikeri* they exit near penial setae (Michaelsen, 1928). The attached sketch is the first time *Ph. (Pa.) saba* has been figured.

Genus *Polypheretima* Michaelsen 1934 *sensu* Easton (1979)

Polypheretima everetti (Beddard & Fedarb, 1895)

Figs. 7–8

Perichaeta everetti Beddard & Fedarb, 1895: 69; Beddard, 1895: 428 (non *Amyntas stelleri everetti*: Michaelsen, 1899: 43; 1900: 306 where *P. everetti* was combined with *P. kinabaluensis*). Type locality stated by Beddard & Fedarb as “Mount Kina Balu”, but based on type labels Easton (1976: 43) redesignated it under what is now ICZN (1999: 76A) as on the adjacent Balabac Island, Palawan southern Philippines. Syntypes in Natural History Museum, London: BMNH 1904: 10.5:38–40 inspected by Easton (1976: 51). [GMs paired on 19–21; spermathecal batteries of 12–17 in segments 6 and 7].

Perichaeta papillata Beddard & Fedarb, 1895: 70, 71; Beddard, 1895: 428 (redescription). From Merabah, Borneo. Syntypes British Museum: BMNH 1904:10.5.1265–70 inspected by Easton (1976: 52). [GMs paired on 19–29; spermathecae 7 per segment in 6 and 7].

Perichaeta sarawacensis Beddard and Fedarb, 1895: 71; Beddard, 1895: 429. From Labuan, Sarawak. Holotype British Museum: BMNH 1904.10.5.150 inspected by Sims & Easton (1972: 254). [GMs paired on 19–22; spermathecae 14 in segments 6 and 7].

?*Perichaeta barami* Michaelsen, 1896: 203. From Baram River, Sarawak and/or (Minahassa) North Celebes – Michaelsen was unsure. Holotype Hamburg: v3835 inspected by Sims & Easton (1972: 254) and they only give the former locality; same specimen listed by Easton (1976: 51) as from “Minahassa” and Easton (1976: 52) as “Baram River”. [Grey, setae 42–55 per segment, GMs on 19,20, spermathecae absent (as in *Po. elongata*)].

Amyntas stelleri seriatus Michaelsen, 1899: 44 (originally spelt *seriata*). From either Uangkahulu Valley or Buol, North Celebes. Paratype Hamburg: v5197 inspected by Sims & Easton (1972: 254); and v.5198 inspected by Easton (1976: 51). [Brownish with violet shimmer, setae 42–111, GMs 19–22,23, spermathecal groups of 3–6 in segments 6 and 7].

?*Amyntas stelleri klabatensis* Michaelsen, 1899: 46. From Klabat, North Celebes, 1,800m. Paratype Hamburg: v.5196 inspected by Sims & Easton (1972: 254) and claimed as “Holotype” by Easton (1976: 51). [Setae 72–120, no GMs, spermathecal groups of 8–11 in 6 and 7 (lack of GMs is a departure from *Po. everetti* diagnosis below and is therefore similar to *Po. annamensis* (Stephenson, 1931) that however is bithecal].

?*Amyntas stelleri bonensis* Michaelsen, 1899: 45. From Bone Valley, North Celebes. Types lost. [Blue in life, setae ca. 130, GM paired in 19, spermathecal groups of 18–26 in 6 and 7 (as in *Po. stelleri* s. stricto)].

Amyntas stelleri everetti (part): Michaelsen, 1899: 43 (where *P. everetti* was combined with *P. kinabaluensis*).

Pheretima stelleri everetti (part): Michaelsen, 1900: 306.

Pheretima stelleri koroensis Michaelsen, 1910: 109. From Koro Valley, Celebes (Sulawesi). Holotype listed on Basel Museum type website: <http://www.nmb.bs.ch/NaturmuseumBasel/LinksNMB/Sammlung/Kataloge/Guertelwuermer.xls>].

Pheretima stelleri mahakkami Michaelsen, 1922: 25. From Mahakkam River, Sarawak. Holotype Leiden: 1897 inspected by Sims & Easton (1972: 254).

Pheretima (Pheretima) beranensis Michaelsen, 1928: 23. From Birang River, Beran district, Kalimantan. Type(s) Hamburg: v.10576 inspected by Easton (1976: 52).

Pheretima (Pheretima) baritoensis Michaelsen, 1932: 9. From Boentok on the Barito River, Kalimantan. Types lost.

Pheretima (Polypheretima) beranensis tinjarana Michaelsen, 1934: 25. From Tinjar River, Long Lejok, Sarawak. Syntypes British Museum: BMNH 1933.10.6.12–20 and Hamburg: v.11951 inspected by Sims & Easton (1972: 254) and Easton (1976: 52).

Metapheretima everetti: Sims & Easton, 1972: 233; Easton, 1976: 41, fig. 5 [syns. *papillata*, *sarawacensis*, *barami*, *stelleri seriatus* (originally spelt *seriata*), *stelleri klabatensis*, *stelleri bonensis*, *stelleri koroensis*, *stelleri mahakkami*, *beranensis*, *baritoensis*, *beranensis tinjarana*].

Polypheretima everetti: Easton, 1979: 54; Blakemore, 2000, 2004: 137, 2006b.

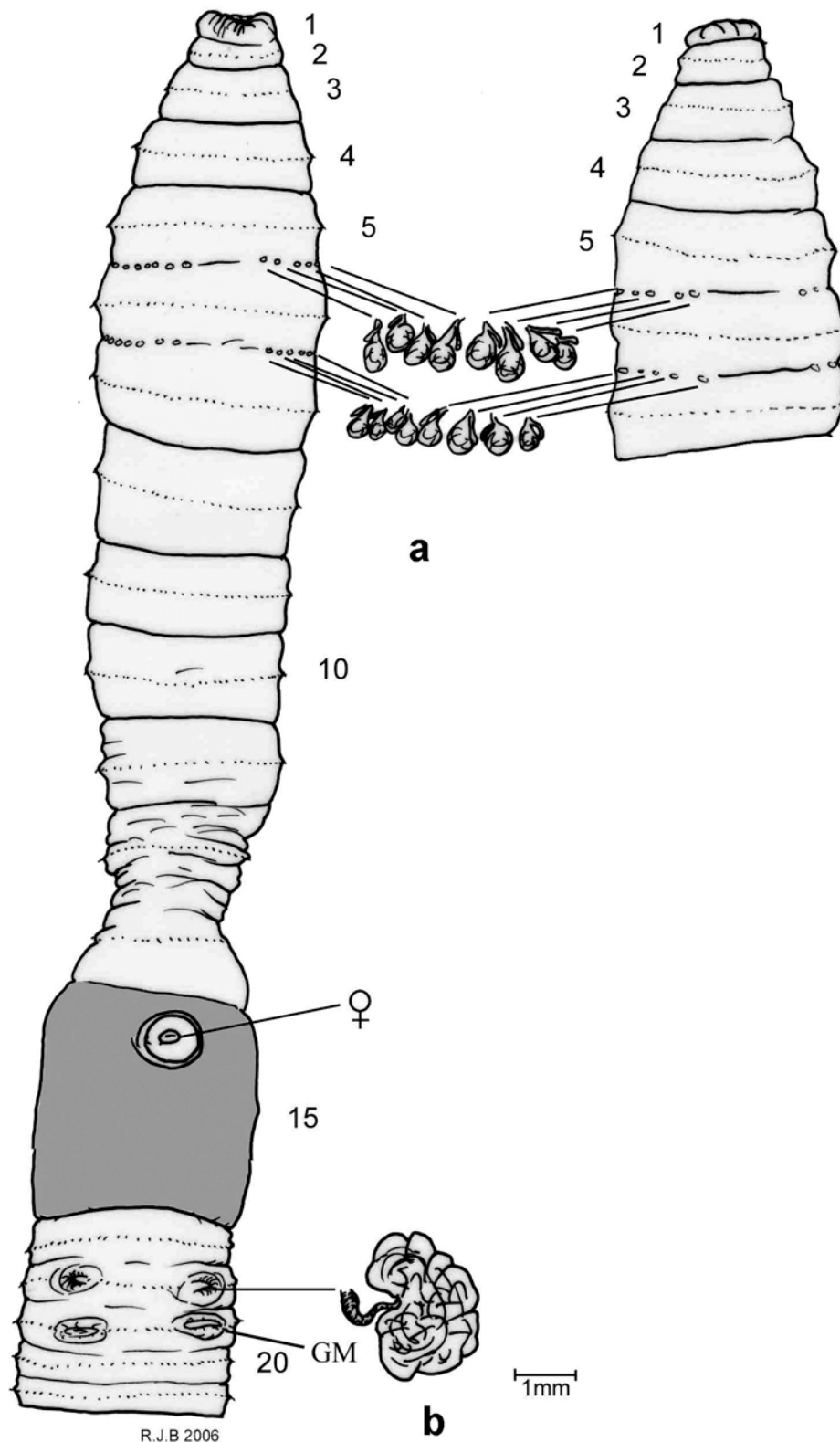


FIGURE 7. *Polypheretima everetti* showing ventral view and antero-dorsal view with a - spermathecal batteries *in situ*, paired genital markings (GM) in 19 and b - prostate ducting to male pores (original sketch by RJB from from YNU Mt Kinabalu/north Borneo specimens).

Taxonomic Note: two of Easton's synonyms, at least, must be questioned as *P. barami* lacked spermathecae (as in *Po. elongata*) and *P. stelleri bonensis* had high numbers of spermathecal batteries of 18–26 (as in *Po.*

stelleri); moreover, *A. stelleri klabatensis* lacked genital markings as described in the diagnosis below.

Diagnosis: *Polypheretima* with male pores in copulatory pouches without stalked glands. Colour reddish-purple. Length up to 300 mm with up to 260 segments. Spermathecal batteries (each usually with 3–12 spermathecae) in 5/6/7. Setae numerous (up to 130 per segment in large specimens). Genital markings paired, pre-setal in line with male pores in some or all of 19–21,22,23. Holandric. Intestinal caeca absent. (Cf. *Po. elongata*, *Po. stelleri* and *Po. kinabaluensis*).

Distribution: Balabac Island south of Palawan, Philippines (new type locality rather than Mt Kinabalu designated by Easton, 1976: 43); north and west Celebes; Borneo including Mt Kinabalu (from 1,200–2,400m); and Lombok, Indonesia (350–450m only). Easton (1976: 43) claims that this species is unknown outside its indigenous range, although this is quite extensive and some of the island records (eg. Balabac and Lombok) may be due to transportation. It occurs on lowlands of Sabah, Borneo (current specimens) yet is sympatric with *Po. kinabaluensis* at higher altitude on Mt. Kinabalu (Easton, 1976). Current specimens examined were from lowlands East of Mt Kinabalu, collected by T. Kawaguchi 01.iii.2006 (labeled: “060301 T-3” and “I-2S”), along with other samples (labeled: “060307 R4-2”, “060308 R1L”, “060307 R4-2”, and “060308 ET”), of *Pontoscolex corethrurus* plus other immature pheretimoids, and samples of immature specimens (labeled: “060305 T3-3”, “060302 R-1-15” and “060302 R-1-2-3”) that look like striped and more regularly coloured forms of *Pheretima* (*Ph.*) *darnleiensis* (as noted in its description above).

Remarks. Although it is similar to *Po. elongata*, and sympatric with this and other members of the *Po. elongata* species-complex, e.g. Easton (1976: fig. 6) shows it to occur throughout Borneo and with *Po. elongata* on Lombok; with *Po. phacellotheca* and *Po. stelleri* in northern Celebes; and with *Po. kinabaluensis* on Mt Kinabalu, yet Easton (1976: 42) states that there is no indication of hybridization among the species. Easton (1976: 52) further separated off one Lombok specimen (Berlin: 7214) from the type series of *Po. badia* (Ude, 1932) as *Po. everetti*.

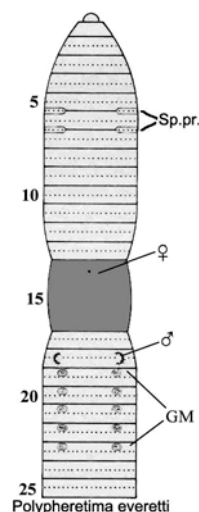


FIGURE 8. *Polypheretima everetti* with more extensive genital markings (GM); Sp. pr. – position of spermathecal pore batteries (modified after Easton, 1976: fig. 5).

Discussion

Taxonomy

This paper demonstrates some finer divisions between current pheretimoid systematics whereby *Metaphire paka* just qualifies for inclusion in this genus, rather than in *Amyntas*, by virtue of its non-superficial male pores; and *Ph. saba* barely qualifies for inclusion in *Pheretima*, rather than *Metaphire*, due to the

presence of a few nephridia on its spermathecal ducts. Note that current definitions of *Amyntas* also permit nephridia on the spermathecal ducts (e.g. Sims & Easton, 1972: 211) but exclude specimens without copulatory pouches, or, more strictly, those with male pores that are ‘non-superficial’. Moreover; *Amyntas* Kinberg, 1867: 97 is the page priority genus overriding allocation to *Pheretima* Kinberg, 1867: 102 (and discounting the preoccupied alternate spelling of *Amyntas* Kinberg, 1867: 101), whereas *Pheretima* priority yields to *Metaphire* Sims & Easton, 1972 in specimens with copulatory pouches only when nephridia are not recognized on their spermathecae.

A fuller synonymy of *Ph. darnleiensis* is presented due to taxonomic confusion since Beddard (1900: 625) and Michaelsen (1900: 275) wrongly applied through misidentification the names *Perichaeta cingulata* Schmarda, 1861 (= *Megascolex cingulatus*) and *Megascolex indicus* Horst, 1883 (= *Amyntas corticis*), respectively – names that Sims & Easton (1972: 264) say are “invalid” [but they mean that the later application of these names were incorrect - see below] and should thus yield to the next available name which is *Ph. darnleiensis* Fletcher, 1886. In essence, identification of *Perichaeta cingulata* Schmarda, 1861: 14, fig. 162 was confounded by Vaillant (1867; 1868a, b) who confused several *Pheretima* species under this name (eg. *robustus*, *darnleiensis*, *quadragenaria*) – it is actually *Megascolex cingulatus* (Schmarda, 1861) from Sri Lanka as redefined by Beddard (1892b: 122; 135, figs. 9–13) from inspection of two specimens in the Vienna Museum [#3959] one of which was the type of Schmarda's “*Perichaeta cingulata*”. [Note that Reynolds & Cook (1976: 88) mistakenly cite Schmarda's types in the Paris Museum; and list Beddard's 1892 redescription (of the Vienna type) as a new and valid name]. Whereas the taxon *Amyntas indicus indicus* (Horst, 1883: 186) as listed by Sims & Easton (1972: 235), who tended to present all names irrespective of synonymies, has now been placed under *A. corticis* (Kinberg, 1867), e.g. by Easton (1981: 49) and by Sims & Gerard (1985; 1999: 128, fig. 45). As noted above, several authors give authority of *Ph. darnleiensis* as “Fletcher (1887)” here corrected to Fletcher (1886).

The current *Ph. darnleiensis* synonymy largely follows, but modifies, that of Sims & Easton (1972: 260–264, 266) who give a full distribution, discussion and descriptions of types and of other material they inspected. The current account makes a few corrections, adds the synonym *Pheretima decipiens* Beddard, 1912, and augments the description from various sources listed in the synonymy and from inspection of new material [cf. Gates (1935b) and Shen & Yeo (2005: 26) who, in their initial draft, attempted to again misapply the name “*Pheretima indica* (Horst, 1883)” with “*Perichaeta darnleiensis* Fletcher, 1887” its junior synonym–RJB pers. comms. 16.viii.2004 and 5.x.2004).

Despite these revisions, the current paper presents just the *status quo* as full resolution of the status, extent, and synonymy of *Pheretima darnleiensis* proper primarily depends on exact delimitation of this taxon, either by discovery of its missing type(s), or by neotypification, preferably on a specimen from the Darnley Island type-locality. Only then can progressive, serial and chronological delimitation of its synonyms commence, again using their types, and possibly employing molecular (DNA) and behavioural identification methods.

Biodiversity

Several similarly large earthworm, often metallic coloured as the current *Ph. darnleiensis* specimens, are found in Oriental mountain regions. Examples are *Amyntas feae* (Rosa, 1888) at elevations to 2,000 m on Mt Kambaiti (Myanmar), also several species mentioned by Tsai *et al.* (2001; 2004) and Shen *et al.* (2003). Gates (1943: 103) described *Amyntas pingi* (Stephenson, 1925) from Kuantun, Fukien Province, China at altitudes up to 1,700 m, but this taxon is now considered a junior synonym of *A. carnosus* (Goto & Hatai, 1898). Examples of smaller, dull coloured mountain species are: *Amyntas himalayanus* (Stephenson, 1925), *Metaphire bianensis bianensis* (Stephenson, 1931) and *Polypheretima annamensis* (Stephenson, 1931), the latter two originally from 6,000 ft (2,000 m) on Lang Bian Peaks, Southern Vietnam, which contrast to the brightly coloured species of *Polypheretima* recorded from Mt Kinabalu (below).

The current surveys add to a Royal Society North Borneo Expedition in 1964 that collected four species as recognized by Sims & Easton (1972: 249) and by Easton (1976) who redefined the *Polypheretima elongata* species-complex [series A (smaller specimens) and series B (larger specimens)] *sensu* Sims & Easton (1972: 252–255) thereby refining the earlier locality details. A summary list of earthworm species now known from Mt Kinabalu is:

1. *Amyntas kinabalu* Sims & Easton, 1972: 259, fig. 3D, originally *Amyntas omeimontis kinabalu* from region of Mesilau Cave at 2,100–3,100 m, elevated to specific rank and separated from its previous sub-species on the basis of its simple intestinal caeca by Blakemore (2005), see also Blakemore *et al.* (2006). The worm is 80–150 mm long, with 89–100 segments, and has a simple intestinal caeca; it is readily recognized by numerous small papillae between the spermathecal pores in 7/8/9 and between its superficial male pores on 18 although it is similar to *Amyntas kinfumontis* (Chen, 1946: 119) from Szechuan and Laos.

2. *Metaphire paka* Blakemore sp. nov. from vicinity of Paka Cave (ca. 3,000 m).

3. *Pheretima* (*Parapheretima*) *saba* Sims & Easton, 1972: 265 from region of Mesilau Cave at 2,400m. Figured herein for the first time from specimens from Paka Cave (ca. 3,000 m) with same collection data as *M. paka*.

4. *Pheretima* (*Pheretima*) *darnleiensis* (Fletcher, 1886) from region of Mesilau Cave at altitudes between 1,650–3,100m (Sims & Easton, 1972), and vicinity of Paka Cave (3,000 m) in current studies. Also known from adjacent lowlands.

5. **Polypheretima everetti* (Beddard & Fedarb, 1895), as redescribed by Beddard (1895) *sensu* Easton (1976: 41), series B (part) of larger specimens from Mesilau Cave and River area that Sims & Easton (1972: 254–255) described as “*brightly coloured when received, ... a light sap-green, somewhat paler below, with a lilac to claret-coloured, longitudinal mid-dorsal stripe and broad intersegmental bands which were incomplete ventrally*”. Also known from adjacent lowlands.

6. **Polypheretima kinabaluensis* (Beddard & Fedarb, 1895: 71), originally from Tamburungare, Mt Kinabalu, redescribed by Beddard (1895) and *sensu* Sims & Easton (1972: 254–257, Tab. 13) series A and series B (part) specimens from the Mesilau Cave and River area at altitudes between 2,100–2,750 m. As originally described, “*This species comes nearest to P. everetti: it has (in spirits) the same purple red colour above with white lines where the setae are unplanted [= implanted?]*”. Michaelsen (1899: 43: 1900: 306) combined *P. kinabaluensis* with *P. everetti* but Easton (1976) retained both. Its length is about 150 mm with ca. 200 segments, 5–9 spermathecae in each battery in 5/6/7, and genital markings in 19–21 (from Sims & Easton, 1972: Tab.13), i.e., very similar to *Po. everetti*.

7. Cosmopolitan exotic *Pontoscolex corethrurus* (Müller, 1857) (Glossoscolecidae), from South America and now common in the tropics, was also collected from the base of Mt Kinabalu in present studies, but not from high altitudes.

*Species in a *Polypheretima elongata* species-complex (all combined under *Metapheretima elongata* complex by Sims & Easton, 1972: 255), full synonymies are given by Easton (1976; 1979) and Blakemore (2002, 2006b). Easton (1976: 43) noted “*although samples collected at 2100 and 2400 m on Mt Kinabalu contained both everetti and kinabaluensis there is no indication of hybridisation between these two forms*”.

Ecology

Mount Kinabalu (approx. 06° 05' N, 116° 33' E) is within a National Park and proposed World Heritage Area renowned for its rainforest vegetation and high species endemism (Anon, 2005). Mt Kinabalu is one of the highest summits in southeast Asia: Lows Peak, on Kinabalu is 4,095 m; Hkakabo Razi in Myanmar/China is 5,881 m; others are Puncak Jaya (also known as Carstenz Pyramid is 5,030–4,884 m), Trikora (4,862 m), Naga Pulu (4,751 m), and Mandala (4,701 m) all on Western New Guinea. Gunung (Mount) Mulu (2,377 m) in Sarawak is also a National Park that had its soil mesofauna surveyed by Collins (1980) who found an ecological termite-earthworm transition. The casting activity of earthworms (*Ph. darnleiensis* and *Po. everetti*)

were observed by Gould *et al.* (1987) in Sepitok Forest, Sabah. Comparative ecological surveys by Ashton (2003) implied that earthworms were implicated in, or were at least indicative of, floristic zonation on this wet tropical mountain habitats such as Mt Kinabalu:

“It is concluded that soil changes, mediated only in part by temperature and associated climatic factors, may play a more direct and diverse role than has previously been indicated. The soil factors emphasized are the increase in organic matter content in lower montane soils as opposed to lowland, accompanied by a change from termite-dominance to earthworm-dominance, and the frequent occurrence of a dense moss layer and mor humus in upper montane soils.”

Independent ecological observations by Dr Menno Schilthuisen (<http://www.schilthuisen.org/text/text1.htm>) have reported high worm casting activity in the deep cloud-forest soils around Paka Cava, and also revealed a <30 cm long bright orange-red coloured leech, *Mimobdella buettikoferi* Blanchard 1897 (tentatively identified by Dr F. Govedich), predatory on the large Mt Kinabalu earthworms (see also http://en.wikipedia.org/wiki/Kinabalu_giant_red_leech). A study in adjacent localities to altitudes of 1,200m by Wong *et al.* (2002) reported that the diet of the Malayan sun bear (*Helarctos malayanus*) includes earthworms and that: “Other mammals (eg., bearded pig [*Sus barbatus*], pangolin [*Manis javanica*], and Malayan badger [*Mydaus javanensis*]) created similar feeding evidence when they feed on termites, earthworms (*Pheretima spp.*), and other invertebrates from decayed wood or soil (Payne *et al.*, 1985, Yasuna and Andau, 2000)”. Further studies by the YNU co-authors will add ecological data that is to be published separately now that the earthworm samples have been identified to species.

Acknowledgements

This work was undertaken with tenure of COE fellowship at YNU by the senior author who compiled the text, made the oligochaete taxonomic determinations, and prepared the figures. Dr Cs. Csuzdi provided information on Michaelsen's *Metaphire cai*; Dr Menno Schilthuisen supplied data on the Kinabalu Giant Leech and its prey; Drs M.T. Ito and N. Kaneko gave administrative and logistic assistance at YNU, while Tatsuya Kawaguchi conducted collection surveys as part of his doctoral thesis. Dr Hironori Komatsu, curator at the National Museum of Nature and Science, Shinjuku, is thanked for accepting type specimens hand delivered on 20th June, 2007. Some useful comments and minor corrections by the editors and anonymous referees are appreciated.

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(for brevity not all taxonomic sources cited – see Sims & Easton, 1972 for earlier reports).

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