

Pheretimoid earthworms (Clitellata: Megascolecidae) from Mt. Apo, Mindanao Island, Philippines with description of eight new species

Nonillon M. Aspe^{1,2*} & Samuel W. James³

Abstract. We report 13 pheretimoid species of earthworms from Mount Apo National Park, Philippines. Mt. Apo is the highest mountain in the Philippine Archipelago, located in Mindanao Island in the southern part of the country. Aside from the two species already reported elsewhere, *Pheretima apoensis* and *P. hamiguitanensis*, we updated on the description of three species, *P. virgata*, *P. monothea*, and *P. urceolata*. We also describe seven new *Pheretima* species, namely *P. floresi*, new species; *P. baracatanensis*, new species; and *P. solisi*, new species, which belong to the *P. sangirensis* group, characterised by having a pair of spermathecal pores at 7/8, and *P. aquila*, new species; *P. gamay*, new species; *P. libradoi*, new species; and *P. davaoensis*, new species, which belong to the *P. urceolata* group, characterised by having a pair of spermathecal pores at 5/6. In addition, we also describe one *Amyntas* species, *A. apongensis*, new species, which has a pair of spermathecal pores at 7/8. Sampling was conducted only in Brgy. Baracatan, Davao City and not all area of the Mt. Apo National Park was represented. Therefore, this report only represents a fraction of the knowledge of the biodiversity of earthworms on Mt. Apo National Park. We believe that many more species remain to be discovered in this area.

Key words. *Pheretima*, *Amyntas*, new species, Mt. Apo, Mindanao, Philippines

INTRODUCTION

Mount Apo is the highest mountain in the Philippine Archipelago, with an elevation of 3,124 m asl, located in Mindanao Island. It is situated between Davao City, Davao del Sur province and Cotabato province. It is a potentially active stratovolcano emitting sulfurous gases. It was declared a National Park in 1936, now covering an area of 54,974 ha. The United Nations placed Mt. Apo on its list of National Parks and Equivalent Reserves in 1982 and the Association of Southeast Asian Nations (ASEAN) named it an ASEAN Heritage Site in 1984. The mountain is home to a number of rare flora, such as the waling-waling orchids *Vanda sanderiana*, and the Philippines' largest flower, *Rafflesia schadenbergiana*, which is second to the world's largest, *Rafflesia arnoldii*. There are over 272 bird species and 104 butterfly species recorded in Mt. Apo, of which 40% of each group are endemic to the area (Mallari et al., 2001; Mohagan et al., 2011). It is also home to one of the world's largest eagles, the critically endangered Philippine eagle *Pithecophaga jefferyi*, the country's national bird.

Indigenous tribes such as the Bagobo, Manobo and Klata consider Mt Apo as their ancestral domain and their home since time immemorial. Two geothermal plants operating on the Cotabato side of Mt. Apo are supplying electricity to the province and the neighboring provinces.

Series of taxonomic studies on the earthworm fauna in the Philippines over the past decade resulted in the identification of approximately 200 species of native earthworms representing eight genera (Aspe & James, 2014, 2015, 2016; Flores, 2007; Hong & James, 2004, 2008a, 2008b, 2009, 2010, 2011a, 2011b; James, 2004, 2005a, 2006, 2009; James et al., 2004). In the present paper, we report 13 pheretimoid species from Mt. Apo. Aside from the two species recently described elsewhere, *Pheretima apoensis* (Aspe & James, 2016) and *P. hamiguitanensis* (Aspe & James, 2016), we updated the description of three species, namely *P. virgata* (James, 2004), *P. monothea* (James, 2004) and *P. urceolata* (Horst, 1893). We also describe seven new species of *Pheretima*, namely *P. floresi*, new species; *P. baracatanensis*, new species; *P. solisi*, new species; *P. aquila*, new species; *P. gamay*, new species; *P. libradoi*, new species; *P. davaoensis*, new species; and one *Amyntas* species, *A. apongensis*, new species.

MATERIAL AND METHODS

As Mt. Apo National Park is a protected area, a Prior Informed Consent certificate was secured from the Protected Area Management Board of the Department of Environment and Natural Resources (DENR) before the collection of specimens. Sampling was conducted in the forest of Barangay Baracatan [barangay = precinct], Davao City at

¹College of Fisheries and Aquatic Sciences, Western Philippines University, Puerto Princesa Campus, Puerto Princesa City, Palawan, Philippines; Email: nonillon_aspe@yahoo.com (*corresponding author)

²Department of Natural History Sciences, Graduate School of Science, Hokkaido University, N10 W8, Sapporo 060-0810, Japan

³Sustainable Living Department, Maharishi University of Management, Fairfield, Iowa, 52557 USA

around 1,500 m asl far from human settlements on 11–14 December 2003. Our sampling activity was interrupted by a military operation due to reports of sightings of non-military armed group around the area and we were advised to leave the site immediately. As a result, our sampling effort was limited. Therefore, this report only represents a fraction of the knowledge of the biodiversity of earthworms on Mt. Apo National Park. We believe that many more species remain to be discovered in this area. All anatomical data were obtained by external examinations and dorsal dissections of 10% formaldehyde-fixed specimens. Measurements are in millimetres. For convenience in species comparison, we initially compared the new species with the other members of the same species group by their sizes and by the spermathecal pores spacing and the male pores spacing. However, we made sure that the combinations of all the morphological characters were used to examine and compare all the members of the species group. Line drawings were prepared with Adobe Illustrator ver. CS5. Types are deposited in the National Museum of the Philippines Annelid Collection (NMP), Manila, Philippines and in the Annelid Collection of the Zoological Reference Collection (ZRC.ANN) of the Lee Kong Chian Natural History Museum (formerly the Raffles Museum of Biodiversity Research), Faculty of Science, National University of Singapore, Singapore.

SYSTEMATICS

Family Megascolecidae (Rosa, 1891)

Genus *Amyntas* (Kindberg, 1867)

Amyntas apongensis, new species (Fig. 1A, B)

Material examined. Holotype: adult (NMP 4628), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, 11–14 December 2003.

Etymology. The species is named after Apong, a nobleman of whom the name of Mt. Apo was said to have derived from.

Diagnosis. Reddish brown worm with body dimension 61 mm × 4–4.7 mm; one pair of spermathecal pores at 7/8; pairs of genital markings in viii and in ix, those in viii closely positioned to the spermathecal pores; pairs of genital markings in xviii and xix, those in xviii presetal, medial to male pores, those in xix mid-ventral on setal line; male sexual system proandric; spermatheca with a small and round ampulla; single, dense, racemose prostates in xvii to xviii.

Description. Reddish brown dorsum, lighter ventrum, equators pigmented. Length 61 mm (n=1 adult); diameter 4 mm at x, 4.7 mm at xx; body cylindrical in cross-section, tail tapering; 77 segments. First dorsal pore 12/13. One pair of spermathecal pores at 7/8, distance between spermathecal pores 1.7 mm (0.13 circumference ventrally apart). Female pore single in xiv, male pore openings paired in xviii, distance between pores 1.8 mm (0.12 circumference apart ventrally),

seven setae between male pores. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 44 setae on vii, 52 setae on xx, dorsal and ventral setal gaps present. Pairs of genital markings in viii and in ix, those in viii closely positioned to the spermathecal pores; pairs of genital markings in xviii and xix, those in xviii presetal, medial to male pores, those in xix mid-ventral on setal line.

Septa 4/5–8/9, 10/11–13/14 thin, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii, intestinal origin in xv, caeca simple originating in xxvii, extending forward to xxv. Typhlosole originating in xxvii, simple fold, 1/3 lumen diameter. Intestinal wall with 32 longitudinal blood vessels.

Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard. Ovaries and funnels free in xiii. Spermathecae paired, postseptal in viii, nephridia on ducts lacking; each spermatheca with a small, round ampulla and a long, slender duct, diverticulum attached ectally to the left face of the right spermathecal duct, and to the right face of the left spermathecal duct, terminating in an elongated receptacle, stalk longer than ampulla. Male sexual system proandric, testes and funnels enclosed in paired sacs in x; seminal vesicles in xi, each with a digitate dorsal lobe, enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvii to xviii; each prostate a single, dense, racemose mass; stout muscular duct widened towards body wall, then slightly narrowed just before body wall. Copulatory bursae lacking.

Remarks. Currently, there is a total of 17 species of *Amyntas* in the Philippines, including *Amyntas apongensis*, new species. While *Amyntas* species vary in the number of pairs of spermathecae (one to five pairs except *A. dinagatensis* [Aspe & James, 2016], which is athecate), *A. apongensis* is similar to *A. philippinensis* (Hong & James, 2004), *A. heaneyi* (James, 2004) and *A. cagdianaensis* (Aspe & James, 2016) in having only one pair. However, *A. philippinensis* has its pair of spermathecal pores at 4/5 while *A. cagdianaensis* has its pair at 8/9. *Amyntas apongensis* is most similar to *A. heaneyi* in the location of the spermathecal pores, in the shape of the spermathecae and in having a proandric male sexual system. However, *A. heaneyi* is larger (84–111 mm × 4.6–5.7 mm), has dark gray to black pigmentation, has wider distance between the male pores (0.14–0.16 circumference apart), and has a different pattern of genital markings (James, 2004).

Genus *Pheretima* (Kinberg, 1867)

Pheretima apoensis (Aspe & James, 2016)

Diagnosis. Large worm, adult body dimension 163–350 mm × 7.2–12 mm; 102–120 segments; dorsum purplish brown, ventrum pale; equators non-pigmented; spermathecal pores

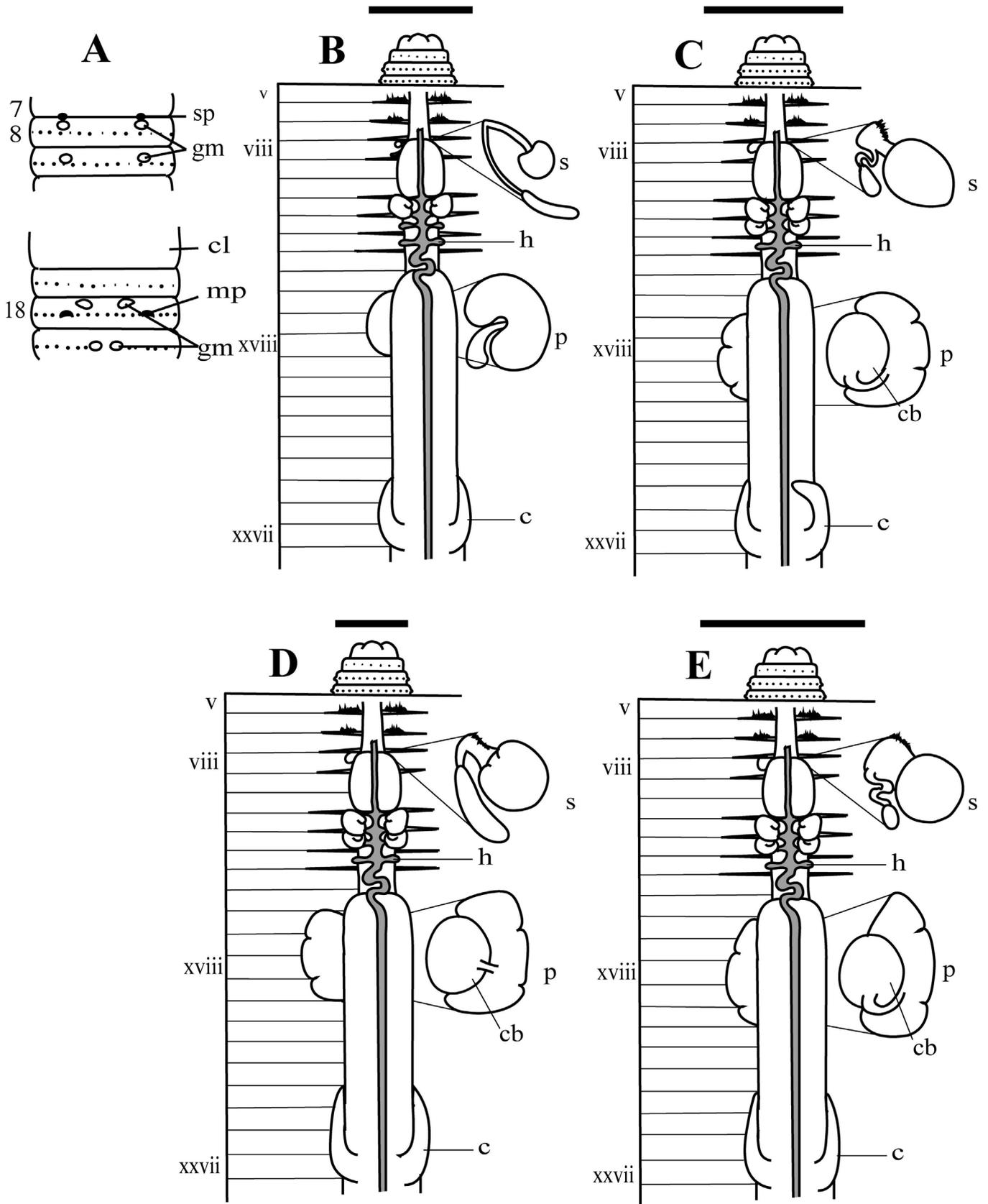


Fig. 1. A, Diagrammatic ventral view of *Amynthus apongensis*, new species showing the spermathecal pores (sp), clitellum (cl), male pores (m), and the pattern of the genital markings (gm). Schematic drawings of the internal morphology in dorsal view: B, *A. apongensis*, new species; C, *Pheretima floresi*, new species; D, *P. baracatanensis*, new species; E, *P. solisi*, new species. Abbreviations: s, spermatheca; h, heart; p, prostate gland; cb, copulatory bursa; c, caecum. Scale bars = 5 mm.

lacking in athecate individuals, at 7/8 in thecate individuals; 37–48 setae on vii, 50–58 setae on xx; 4–5 setae between male pores; male pores 0.15–0.16 circumference apart; penis lacking.

Remarks. *Pheretima apoensis* was also observed in Mt. Kitanglad and Mt. Musuan in Bukidnon Province (Aspe & James, 2016), and in Mt. Timolan, Zamboanga del Sur Province (personal observation).

***Pheretima virgata* (James, 2004)**

Material examined. One adult (NMP 4626), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11–14 December 2003.

Diagnosis. Large worm with length 290–360 mm; with dark purplish brown stripes on dorsum, segmental equator non-pigmented; one pair of spermathecal pores at 7/8; distance between spermathecal pores and male pores 0.08–0.10 and 0.10–0.12 circumference apart ventrally, respectively; spermathecae with round to ovate ampulla, short stout duct expanding ectally; racemose prostates extending from xvii to xviii; penis lacking.

Description. Dark purplish brown dorsal pigment in stripes encircling dorsal 2/3 of circumference, ventral ends of stripes tapering, segmental equators non-pigmented. Length 290–360; diameter 13–17 mm (vii), 11–17 mm (xx); body cylindrical in cross section, tail tapering; 125–128 segments. First dorsal pore 12/13, spermathecal pores at 7/8, distance between spermathecal pores 0.08–0.10 circumference ventrally apart. Female pore single in xiv, openings of copulatory bursae paired in xviii, distance between openings 0.10–0.12 circumference apart ventrally, 4–5 setae between openings. Clitellum annular, from xiv to xvi. Setae on vii 74–76, on xx 80–86, dorsal setal gaps may or may not be present, no ventral gaps. Genital markings lacking.

Septa 4/5–7/8 tough but not thick, 8/9 membranous to posterior of gizzard, 9/10 absent, 10/11–13/14 very muscular. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with densely crowded deep vertical lamellae xi–xiii, intestinal origin in xv or xvi, caeca simple originating in xxvii, extending forward to xxiii or xxi. Typhlosole originating in xxvii, simple fold one-fifth lumen diameter. Intestinal wall with 32–42 longitudinal vessels. Hearts in x–xiii esophageal, hearts of x lacking connection to dorsal vessel but no supra-esophageal vessel visible in x; commissural vessels in vi, vii, ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii, paired spermathecae in viii with nephridia only on posterior face of spermathecal ducts; spermathecae with round to ovate ampulla, short stout duct expanding ectally, diverticulum attached to the ental portion of the left face of the right spermathecal duct,

and to the right face of the left spermathecal duct, stalks short, terminating in large round or with several chambered receptacles. Spermatophores present in each ampulla. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; sacs not connected, sacs of xi enclose seminal vesicles; seminal vesicles in xi, xii, with dorsal lobe; vasa deferentia slightly muscular, free from body wall en route to ental end of prostatic ducts; prostates in xvii to xviii; each prostate racemose with 2–3 major lobes, stout muscular duct entering posterior face of copulatory bursa. Copulatory bursae ovate in xvii–xviii; coelomic surfaces muscular, secretory diverticula lacking in xviii; roofs lined with several blocky pads, floors composed of four or five triangular pads with apices towards bursal openings; penis lacking.

Remarks. *Pheretima virgata*, which belongs to the *P. sangirensis* group of Sims & Easton (1972), is most similar to *P. tigris* (Aspe & James, 2014) of Mt. Malindang in having large size and in pigmentation pattern. However, *P. tigris* is relatively smaller (230–283 mm × 8–14 mm), the distance between spermathecal pores and male pores are wider (0.13 and 0.14 circumference apart, respectively). Also, there are fewer setae on xx (48–61), more longitudinal vessels (56–58) on the intestinal wall, and the spermathecae have large ovate to pyriform ampulla, with diverticulum terminating in oblong receptacle wider at distal end. *Pheretima virgata* was first recorded in Mt. Kitanglad, about 160 km away from Mt. Apo.

***Pheretima floresi*, new species**

(Fig. 1C)

Material examined. Holotype: adult (NMP 4617), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, 11–14 December 2003. Paratypes: two adults (ZRC.ANN 0070), same collection data as for holotype.

Etymology. The species is named in honor of Dr. Dante Flores, a fellow earthworm taxonomist and a friend, who joined the collecting activity at Mt. Apo.

Diagnosis. Small worm with adult length 48–67 mm; dorsum reddish brown, ventrum pale, segmental equator pigmented; one pair of spermathecal pores at 7/8; distance between spermathecal pores and male pores 0.21 and 0.20 circumference apart ventrally, respectively; spermathecae with an ovate ampulla and a large bulbous, muscular duct expanding ectally; racemose prostates extending from xvii–xx or xxi; penis lacking.

Description. Reddish brown dorsum, lighter ventrum, equators pigmented. Length 48–67 mm (n=3 adults); diameter 3–3.5 mm at x, 3–4 mm at xx; body cylindrical in cross-section, tail tapering; 76–96 segments. First dorsal pore in 12/13. Spermathecal pores at 7/8, distance between spermathecal pores 2–2.3 mm (0.21 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 1.9–2.4 mm (0.20 circumference apart ventrally); 5 setae between

openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 37 setae on vii, 45 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 4/5/6, 8/9, 13/14 thin, 7/8, 10/11–12/13 muscular, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii, intestinal origin in xv or xvi, caeca simple originating in xxvii, extending forward to xxiv, caeca may be folded up or down the intestine to a length equivalent to one segment. Typhlosole originating in xxvi, simple fold, about 1/8 lumen diameter. Intestinal wall with 35 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in viii, with nephridia on ducts; each spermatheca with an ovate ampulla, large bulbous, muscular duct expanding ectally, diverticulum attached to the ental portion of the left face of the right spermathecal duct, and to right face of the left spermathecal duct, stalks thin, short, terminating in elongated receptacles wider at distal end. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvii to xx or xxi; each prostate a single, dense, racemose mass, with three lobes; short, muscular duct entering posterior area of copulatory bursa. Copulatory bursae ovate in xvii–xviii; coelomic surfaces muscular, secretory diverticula lacking; two pads present on roof, pad lacking on floor; penis lacking.

Remarks. *Pheretima floresi*, new species belongs to the *P. sangirensis* species group of Sims & Easton (1972), characterised by having spermathecal pore(s) at 7/8 and having no penial sheaths in the copulatory bursae. Members of the *sangirensis* group have a holandric male system; the copulatory bursae are simple, and some species have short, conical penes. Blakemore (2007) acknowledged three valid subspecies in *P. sangirensis*: *P. s. sangirensis* (Michaelsen, 1891); *P. s. crassicystis* (Michaelsen, 1896); and *P. s. chica* (Michaelsen, 1896). To date, there are 30 species members of the *P. sangirensis* group (Aspe & James, 2016), including the new species described here. Molecular phylogenetic studies conducted by James (2005b) and Aspe et al. (2016) showed that members of the *P. sangirensis* group included in their respective studies are monophyletic.

Pheretima floresi is similar to *P. s. chica* Michaelsen, 1896, *P. mariae* (Hong & James, 2008a), *P. misamisensis* (Aspe & James, 2014), *P. wati* (Aspe & James, 2014), *P. longiprostata* (Aspe & James, 2014), and *P. solisi*, new species in relative size (37–75 mm × 2–4 mm) and in having pigmentation all over the dorsum including the segmental equators. However, *P. s. chica* (0.25 circumference apart) and *P. misamisensis* (0.3 circumference apart) have wider distance between the

spermathecal pores and *P. mariae* (0.04 circumference apart), *P. wati* (0.17 circumference apart), *P. longiprostata* (0.16 circumference apart) and *P. solisi* (0.18 circumference apart) have closer spermathecal pores. With regards to the distance between male pores, *P. misamisensis* (0.23 circumference apart) are wider while those in *P. mariae* (0.09 circumference apart), *P. wati* (0.08 circumference apart), *P. longiprostata* (0.16 circumference apart), and *P. solisi* (0.15 circumference apart) are closer. Mating is effective when two copulating individuals have compatible size and compatible distance between the spermathecal pores and between the male pores. Compared with the new species, *P. wati* has more setae (59–71 in vii, 52–60 in xx), *P. mariae* has fewer setae (32 in vii, 31 in xx), *P. s. chica* has more post-clitellar setae (>60), and *P. misamisensis* has more pre-clitellar setae (42–51 in vii). The prostates are more extensive and the copulatory bursae are larger in *P. misamisensis* (xvi–xxi and xvii–xix, respectively), *P. wati* (xv–xxii and xvii–xxi, respectively) and *P. longiprostata* (xv–xxiii and xvii–xx, respectively) compared with the new species. *Pheretima floresi* also differs in terms of the form of the spermathecae: *P. mariae* has small lenticular spermathecal ampulla, with diverticulum with short duct terminating in small ovate receptacle; *P. s. chica* and *P. misamisensis* both have reniform spermathecae, with *P. s. chica*'s diverticulum with long stalk originating ectally and *P. misamisensis*' diverticulum terminating in blunt ovate receptacle; *P. wati* has pyriform spermathecal ampulla, with diverticulum with short duct terminating in small ovate receptacle; *P. longiprostata* has transversely placed oval spermathecal ampulla, with short thick muscular duct, and with diverticulum terminating in small ovate receptacle; and *P. solisi* has round ampulla and very large bulbous, muscular duct, with diverticulum with long convoluted stalk terminating in small ovate receptacle. In addition, *P. s. chica*, *P. misamisensis*, *P. longiprostata*, and *P. mariae* have penes while the new species has none. No other species in the *P. sangirensis* group closely resemble *P. floresi*.

Pheretima baracatanensis, new species

(Fig. 1D)

Material examined. Holotype: adult (NMP 4618), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, 11–14 December 2003. Paratypes: four adults, amputee (ZRC.ANN 0071), same collection data as for holotype.

Etymology. The species is named after Brgy. Baracatan, its type locality.

Diagnosis. Brown worm with body dimension 100 mm × 4–6.5 mm; segmental equator pigmented; one pair of spermathecal pores at 7/8 positioned at the lateral margins; distance between spermathecal pores and male pores 0.32 and 0.20–0.22 circumference apart ventrally, respectively, a round spermathecal ampulla with diverticulum terminating in a large and elongated eggplant-shaped receptacle; racemose prostates extending from xvi–xix; penis lacking.

Description. Brown dorsum, lighter ventrum, equators non-pigmented. Length 100 mm (n=1 adult); diameter 4–5 mm at x, 4.8–6.5 mm at xx; body cylindrical in cross-section, tail tapering; 94 segments. First dorsal pore 12/13. Spermathecal pores at 7/8 positioned at the lateral margins, distance between spermathecal pores 4–5 mm (0.32 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 3.3–4 mm (0.20–0.22 circumference apart ventrally); 4–5 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 43–46 setae on vii, 44–51 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 4/5–7/8 membranous, 8/9, 10/11 thin, 11/12–13/14 muscular, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii, intestinal origin in xv, caeca simple, originating in xxvii, extending forward to xxiv. Typhlosole originating in xxvii, simple fold, about 1/6 lumen diameter. Intestinal wall with 28 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in viii, with nephridia on ducts; each spermatheca with a round ampulla and a bulbous, muscular duct, diverticulum attached to the ectal portion of the left face of the right spermathecal duct, and to right face of the left spermathecal duct, stalks short, terminating in elongated eggplant-shaped receptacles, receptacle longer than ampulla. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvi to xix; each prostate a single, dense, racemose mass, with three lobes; short, muscular duct entering lateral margin of copulatory bursa. Copulatory bursae ovate in xvii–xix; coelomic surfaces muscular, secretory diverticula lacking; three pads present on roof, two foldings on floor surrounding the opening; penis lacking.

Remarks. *Pheretima baracatanensis*, new species belongs to the *P. sangirensis* species group of Sims & Easton (1972). It differs from *P. sangirensis* in having a closer distance between male pores (0.25–0.28 circumference apart in *P. sangirensis*), and in having no penes. It is similar to *P. diesmosi* (James, 2004), *P. baungonensis* (James, 2004), *P. paucisetosa* (James, 2004), *P. boniaoi* (Aspe & James, 2014), *P. nolani* (Aspe & James, 2014), *P. camiguinensis* (Aspe & James, 2016) in relative size. However, the segmental equators for these species are pigmented except those of *P. camiguinensis* and *P. boniaoi*, which are striped, whereas the body of *P. paucisetosa* is entirely unpigmented. The spacing between the spermathecal pores and between the male pores for the other species are much closer (0.23 and 0.15, respectively in *P. diesmosi*, 0.16 and 0.13, respectively in *P.*

paucisetosa, 0.14 and 0.03 circumference apart, respectively in *P. boniaoi*, 0.14 and 0.12 circumference apart, respectively in *P. nolani*, and 0.17 and 0.15–0.18 circumference apart, respectively in *P. camiguinensis*). *Pheretima baungonensis*, *P. paucisetosa*, and *P. nolani* have penes, however, the new species has none. *Pheretima baungonensis* also have its first dorsal pore in 13/14, the spermathecal pores surrounded by thick lips, and the diverticular stalks are long and convoluted, whereas, in the new species, the first dorsal pore is in 12/13, has no thick lips surrounding the spermathecal pores, and the diverticular stalks are short. Although the spacing between the spermathecal pores and male pores in *P. misamisensis* (0.30 and 0.23 circumference apart, respectively) are similar to those of *P. baracatanensis*, the former is smaller (55–65 × 3–4), and has pigmented equators, larger prostate glands (xvi–xxii), and penes. No other species in the *P. sangirensis* group closely resemble *P. baracatanensis*.

Pheretima solisi, new species

(Fig. 1E)

Material examined. Holotype: adult (NMP 4619), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, 11–14 December 2003. Paratypes: two adults (ZRC.ANN 0072), same collection data as for holotype.

Etymology. The species is named after Armando Solis, a friend of the first author, who assisted in the fieldwork.

Diagnosis. Small, brown worm with adult length 68–86 mm; segmental equator pigmented; one pair of spermathecal pores at 7/8; distance between spermathecal pores and male pores 0.18 and 0.15 circumference apart ventrally, respectively; a round spermathecal ampulla with a very large, bulbous muscular duct, diverticulum with a long, convoluted stalk terminating in a small, ovate receptacle; racemose prostates extending from xvi–xx; penis lacking.

Description. Brown dorsum, lighter ventrum, equators pigmented. Length 68–86 mm (n=3 adults); diameter 2.8–3 mm at x, 3.5 mm at xx; body cylindrical in cross-section, tail tapering; 91–98 segments. First dorsal pore 12/13. Spermathecal pores at 7/8, distance between spermathecal pores 1.7 mm (0.18 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 1.7 mm (0.15 circumference apart ventrally); 3–5 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 35 setae on vii, 32–35 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 4/5/6 membranous, 8/9, 10/11 thin, 11/12–13/14 muscular, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii, intestinal origin in xv, caeca simple originating in xxvii,

extending forward to xxiv. Typhlosole originating in xxvii, simple fold, about 1/3 lumen diameter. Intestinal wall with 29 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in viii, with nephridia on ducts; each spermatheca with a round ampulla and a very large bulbous, muscular duct, diverticulum attached to the ental portion of the left face of the right spermathecal duct, and to right face of the left spermathecal duct, stalks long, convoluted, terminating in small, ovate receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvi to xx; each prostate a single, dense, racemose mass, with three lobes; muscular duct entering posterior margin of copulatory bursa. Copulatory bursae ovate in xvii–xix; coelomic surfaces muscular, secretory diverticula lacking; two pads present on roof, one pad present floor; penis lacking.

Remarks. *Pheretima solisi*, new species belongs to the *P. sangirensis* species group of Sims & Easton (1972). It is similar to *P. s. chica*, *P. misamisensis*, *P. wati*, *P. longiprostata*, *P. asurgo* (Blakemore, 2006; James, 2004), and *P. floresi*, new species in relative size and in having pigmentation all over the dorsum, including the segmental equators. However, *P. s. chica* (0.25 circumference apart), *P. misamisensis* (0.3 circumference apart), *P. asurgo* (0.20 circumference apart), and *P. floresi* (0.21 circumference apart) have wider distance between the spermathecal pores and that of *P. longiprostata* is closer (0.16 circumference apart). With regards to the spacing between male pores, it is wide in *P. s. chica*'s (0.20 circumference apart), *P. misamisensis*' (0.23 circumference apart), and *P. floresi*'s (0.20 circumference apart) while that in *P. wati* is closer (0.08 circumference apart). *Pheretima wati* and *P. misamisensis* have more setae in general (52–71 and 42–51, respectively) while *P. s. chica*, *P. longiprostata*, and *P. floresi* have more post-clitellar setae (>60, 37–47, 45, respectively) and *P. asurgo* (24) has fewer pre-clitellar setae. *Pheretima solisi* also differs in the form of the spermathecae: *P. s. chica* and *P. misamisensis* both have reniform spermathecae, with *P. s. chica*'s diverticulum with long stalk originating ectally and *P. misamisensis*' diverticulum terminating in blunt ovate receptacle; *P. wati* has pyriform spermathecal ampulla with diverticulum with short duct terminating in small ovate receptacle; *P. longiprostata* has transversely placed oval spermathecal ampulla, with short thick muscular duct, and with diverticulum terminating in small ovate receptacle; *P. asurgo* has round spermathecal ampulla, with diverticulum terminating in sausage-shaped receptacle; and *P. floresi* has ovate spermathecal ampulla, with diverticulum terminating in elongated receptacle expanding terminally. In addition, *P. s. chica*, *P. misamisensis*, *P. longiprostata*, and *P. asurgo* have penes while the new species has none. No other species in the *P. sangirensis* group closely resemble the new species.

Pheretima urceolata (Horst, 1893)

Material examined. adult (NMP 4620), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11–14 December 2003. Other material: one adult, three preclitellates (ZRC.ANN 0073), same collection data as the adult examined.

Description. Brown dorsum, lighter ventrum, equators non-pigmented. Length 113–114 mm (n=2 adults); diameter 3.5–4 mm at x, 3.5–4.5 mm at xx; body cylindrical in cross-section, tail tapering; 96–99 segments. First dorsal pore 12/13. One pair of spermathecal pores at 5/6, distance between spermathecal pores 1.8 mm (0.16 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 1.2 mm (0.11 circumference apart ventrally); 2 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 20–25 setae on vii, 43 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 5/6/7, 8/9 membranous, 7/8, 10/11–13/14 thick, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii, intestinal origin in xvi, caeca simple originating in xxvii, extending forward to xxiv; typhlosole originating in xxvii, simple fold, 1/3 lumen diameter, intestinal wall with 31 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in vi, with nephridia on ducts; each spermatheca with an elongated ampulla and a very large bulbous, muscular duct expanding ectally, diverticulum attached to the ental portion of the right face of the right spermathecal duct, and to left face of the left spermathecal duct, stalks short, terminating in elongated receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvii to xviii; each prostate a single, dense, racemose mass, with three lobes; short, muscular duct entering anterior margin of copulatory bursa. Copulatory bursae ovate in xviii–xix; coelomic surfaces muscular, secretory diverticula lacking; pads present on roof and floor; penis present, conical.

Remarks. The *P. urceolata* of Mt. Apo closely match with the description of the type specimen Horst, 1893 and the other specimens from Sumatra described by Gates (1961). Gates (1961) also described a specimen of *P. urceolata* from Mt. Apo at 1,890 m asl, in which he suspected that human intervention may have helped to attain this extensive distribution. We argue that the distribution of *P. urceolata* in Mt. Apo is not a result of human intervention but it may

be a native here as the locality of the specimens is remote from human disturbances to cause introduction of earthworms from Sumatra or Indonesia. In our collections, only at 1,000 m asl and below where there are human settlements and farm lands, yielded exotic species *Pontoscolex corethrurus* (Müller, 1857) and *Eudrilus eugeniae* (Kinberg, 1867). Gates (1961) defined *P. urceolata* to include specimens with body length ranging from 44–170 mm and body diameter ranging from 2–5 mm but admits that the size range seems unusual. We agree that the size range may be very wide for this species and we suggest to reexamine the other specimens and consider other morphological features for species reevaluation. We recommend that a phylogenetic analysis be conducted for the *P. urceolata* specimens from Sumatra and the Philippines to verify their taxonomic identity and determine their evolutionary relationship. As for now, we update the definition of *P. urceolata*, based on the type specimen, the specimens described by Gates (1961), and the specimens described here.

Definition. Yellowish brown to brown dorsum, equators non-pigmented. Length 66–114 mm; diameter 3.5–4.5 mm at xx; 92–104 segments. First dorsal pore 12/13. One pair of spermathecal pores at 5/6, distance between spermathecal pores 0.16 circumference ventrally apart, distance between openings 0.11 circumference apart ventrally, 2–12 setae between openings. Pre-clitellar setae 20–36, postclitellar setae 40–43, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 9/10 lacking. Large gizzard in viii–x, intestinal origin in xvi, caeca simple originating in xxvii, extending forward to xxiii; Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral. Ovaries and funnels free in xiii. Spermathecae paired, postseptal in vi, with nephridia on ducts; each spermatheca with elongate ampulla, very large bulbous, muscular duct expanding ectally, diverticulum attached to the ental portion of the right face of the right spermathecal duct, and to the left face of the left spermathecal duct, stalks short, terminating in elongated receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; prostates in xvii to xviii; each prostate a single, dense, racemose mass, with three lobes; short, muscular duct entering anterior margin of copulatory bursa. Copulatory bursae ovate in xviii–xix; coelomic surfaces muscular, secretory diverticula lacking; pads present on roof and floor; penis present, conical.

Pheretima monothea (James, 2004)

Material examined. two adults (NMP 4624; ZRC.ANN 0075 amputee), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11–14 December 2003.

Diagnosis. Worm with body dimension 62–81 mm × 2.3–3.7 mm; brown dorsum, lighter ventrum, segmental equators pigmented; single midventral spermathecal pores at 5/6;

distance between male pores 0.11–0.14 circumference apart ventrally; intestinal origin in xvii; spermatheca with an elongated, bean-shaped ampulla and a large bulbous, muscular duct expanding ectally; prostates two lobes with one in xvi and the other in xix to xx; penis present.

Description. Brown dorsum, lighter ventrum, equators pigmented. Length 62–81 mm; diameter 2.3–3.7 mm; body cylindrical in cross-section, tail tapering; 96–105 segments. First dorsal pore 12/13. Single midventral spermathecal pore at 5/6. Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between male openings 0.11–0.14 circumference apart ventrally; 3 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 35–36 setae on vii, 32–41 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 4/5–7/8 thin, 10/11–12/13 slightly toughened but thin, 8/9, 9/10 absent. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii. Intestinal origin in xvii, caeca simple originating in xxvii, extending forward to xxv or xxviii. Typhlosole originating in xxvii, simple fold, 1/3 lumen diameter. Intestinal wall with 26 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Single spermatheca postseptal in the middle of vi, with nephridia on duct; spermatheca with an elongated, bean-shaped ampulla and a large bulbous, muscular duct expanding ectally, two diverticula attached entally to duct, stalks thin, short, terminating in elongated receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates two lobes with one in xvi and the other in xix to xx, racemose; muscular duct entering lateral margin of copulatory bursa from anterior part of the prostate, short, thin duct entering posterior margin of copulatory bursae from posterior part of the prostate. Copulatory bursae ovate in xvii–xix; coelomic surfaces muscular, secretory diverticula lacking; pad present on roof; tapering penis present with sheath entirely within the bursa.

Remarks. *Pheretima monothea*, which belongs to the *P. urceolata* group of Sims & Easton (1972) by the location of its spermathecal pore, is similar to *P. (Parapheretima) boaensis* (Aspe & James, 2016) in having a single spermatheca in the middle of vi. However, the latter species is significantly larger (94–133 mm × 3.5–4.5 mm) and possesses secretory diverticula projecting from its copulatory bursae. Other *Pheretima* species with a single spermatheca are *P. ambonensis* (Cognetti, 1913), *P. monoporata* (James, 2004), *P. arayatensis* (James & Hong, 2004), *P. vergrandis* (Aspe & James, 2014), and *P. concepcionensis* (Aspe & James, 2014). These species differ from *P. monothea* by having

their spermathecal pore at 7/8 except that of *P. arayatensis*, which has its spermathecal pore at 8/9. *Pheretima monothecha* was first recorded in Mt. Kitanglad, about 160 km away from Mt. Apo.

***Pheretima hamiguitanensis* (Aspe & James, 2016)**

Material examined. Paratype: adult (NMA 4604), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11–14 December 2003.

Diagnosis. Worm with adult length 81–90 mm; dorsum brown, ventrum pale, equators non-pigmented; one pair of spermathecal pores at 5/6; setae in vii 38–42; spermathecae with ovate ampulla, spermathecal diverticulum terminating in elongate receptacle that is longer than the ampulla; penis lacking.

***Pheretima aquila*, new species**

(Fig. 2A)

Material examined. Holotype: adult (NMP 4620), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11–14 December 2003. Paratype: one adult, amputee (ZRC.ANN 0073), same collection data as for holotype.

Etymology. The species is the Latin word for 'eagle'. Mt. Apo is known as home of the majestic but critically endangered Philippine eagle *Pithecophaga jefferyi*.

Diagnosis. Dimension 165 mm × 5–5.2 mm; body reddish brown, appearing striped due to its non-pigmented segmental equators; one pair of spermathecal pores at 5/6; distance between spermathecal pores and male pores 0.22 and 0.21 circumference apart ventrally, respectively; intestinal origin in xv; spermatheca with an elongated ampulla and a very large bulbous, muscular duct; prostates extending from xvi–xviii; penis lacking.

Description. Reddish brown dorsum, lighter ventrum, equators non-pigmented making it appear striped. Length 165 mm (n=1 adult); diameter 5 mm at x, 5.2 mm at xx; body cylindrical in cross-section, tail tapering; 94 segments. First dorsal pore 12/13. One pair of spermathecal pores at 5/6, distance between spermathecal pores 3.5 mm (0.22 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 3.5 mm (0.21 circumference apart ventrally); 7 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 39–42 setae on vii, 44 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 5/6, 7/8, 10/11/12 muscular, 6/7, 8/9, 12/13/14 thin, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly

on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii. Intestinal origin in xv, caeca simple originating in xxvii, extending forward to xxiii. Typhlosole very low originating in xxvii, Intestinal wall with 29 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in vi, with nephridia on ducts; each spermatheca with an elongated ampulla and a very large bulbous, muscular duct, diverticulum attached to the ectal portion of the left face of the right spermathecal duct, and to right face of the left spermathecal duct, stalks long, bent, terminating in sausage-shaped receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvi to xviii; each prostate a single, dense, racemose mass, with three lobes; short, muscular duct entering central area of copulatory bursa. Copulatory bursae ovate in xvii–xviii; coelomic surfaces muscular, secretory diverticula lacking; two pads present on roof, one pad present floor; penis lacking.

Remarks. *Pheretima aquila*, new species belongs to the *P. urceolata* group of Sims & Easton (1972) characterised by having spermathecal pores opening only at 5/6. To date, there are 24 species members of the *P. urceolata* group, including the new species described here. According to Aspe et al. (2016), the phylogeny of the *P. urceolata* group formed a weakly-supported clade. However, we do not support any conclusion as to the monophyly of this group and we recommended in future studies to include more data to resolve the relationship among its members.

Among the members of the *P. urceolata* group, *P. aquila* is relatively similar to *P. libradoi*, new species (185 mm × 7.3–8 mm), *P. buhiensis* (Hong & James, 2009) (120–221 mm × 4.0–7.5 mm), and *P. gorasi* (Hong & James, 2009) (155–177 mm × 6.2–7 mm) in body size. But the latter three have more body segmentations (112–119), have much closer distance between spermathecal pores (0.04–0.1 circumference apart) and between male pores (0.07–0.12 circumference apart), and have no setae between male pores. In addition, *P. buhiensis* and *P. gorasi* have penes while the new species has none. *Pheretima aquila* is relatively close to *P. heaneyi* James, 2004 and *P. balettei* James, 2004 in the spacing between spermathecal pores with 0.19–0.22 circumference apart for the former and 0.25 circumference apart for the latter. However, the latter two have relative smaller body size (83–116 mm × 3.9–5.4 mm for *P. heaneyi* and >78 mm × 4.3–4.5 mm for *P. balettei*). *Pheretima balettei* has faint pink colouration. We observed that the spermathecal diverticula for members of the *P. urceolata* group, at least for the Mindanao Island species (these morphological features were not observed or described in other *Pheretima* species of Luzon Island), are located on the left face of the duct of the left spermathecae and on the right face of the duct of the right spermathecae. In contrast, the spermathecal

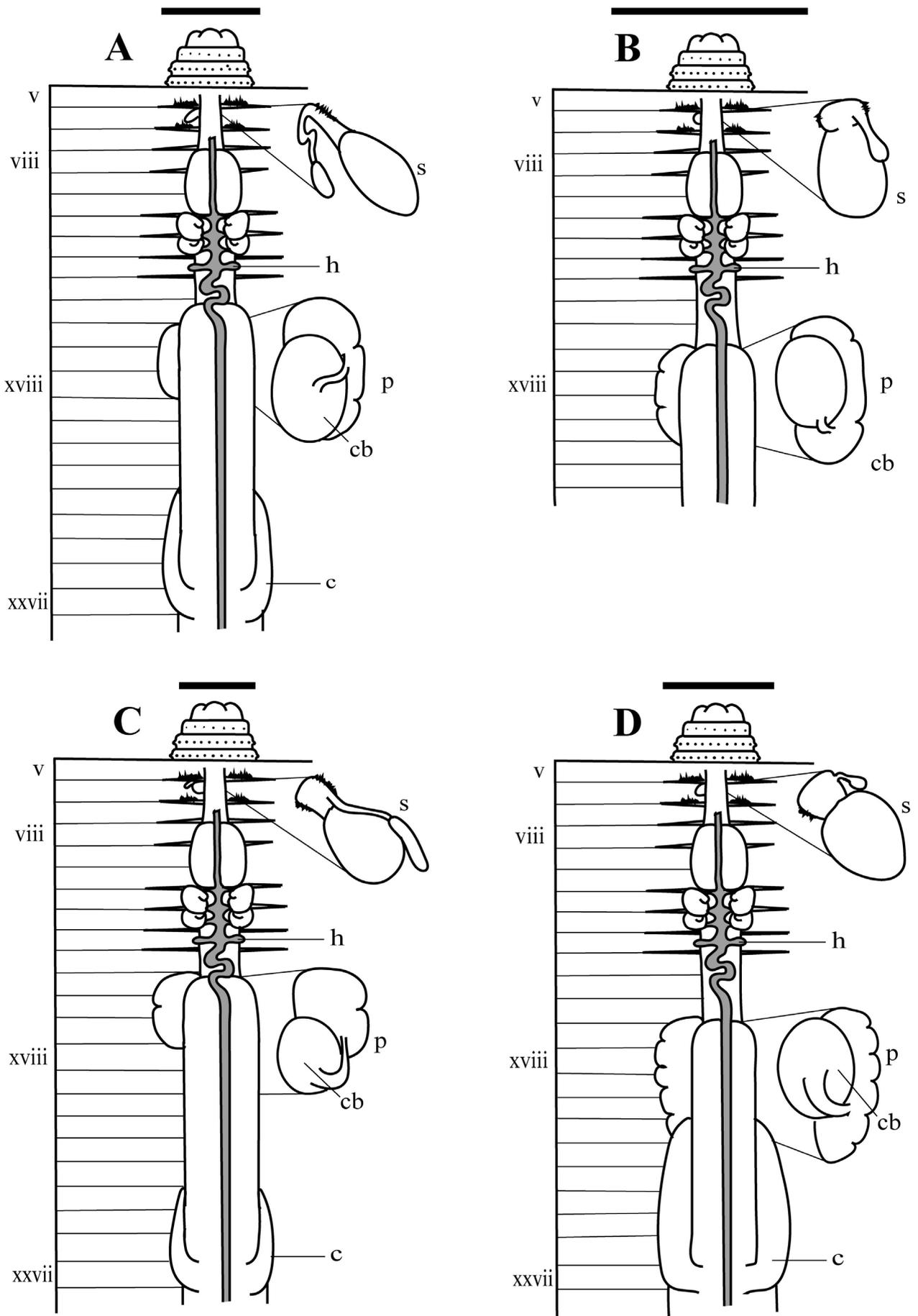


Fig. 2. Schematic drawings of the internal morphology in dorsal view. A, *Pheretima aquila*, new species; B, *P. gamay*, new species; C, *P. libradoi*, new species; D, *P. davaoensis*, new species. Abbreviations: s, spermatheca; h, heart; p, prostate gland; cb, copulatory bursa; c, caecum. Scale bars = 5 mm.

diverticula for members of the *P. sangirensis* group are located on the left face of the duct of the right spermathecae and on the right face of the duct of the left spermathecae. *Pheretima aquila* is different from the other members of the *P. urceolata* group of Mindanao Island as its spermathecal diverticula are located on the left face of the duct of the right spermathecae and on the right face of the duct of the left spermathecae. No other species in the *P. urceolata* group closely resemble *P. aquila*.

***Pheretima gamay*, new species**
(Fig. 2B)

Material examined. Holotype: adult (NMP 4621), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11–14 December 2003. Paratype: one adult (ZRC.ANN 0074), same collection data as for holotype.

Etymology. The species name 'gamay' is a word which means 'small' in Bisaya, a dialect used by most people of Mindanao.

Diagnosis. Very small worm with adult length 38–51 mm; dorsum purplish brown, ventrum pale; one pair of spermathecal pores at 5/6; distance between spermathecal pores and male pores 0.19 and 0.13 circumference apart ventrally, respectively; intestinal origin in xvii; spermatheca with an ovate ampulla and a very large bulbous, short, muscular duct; racemose prostates extending from xvii–xx; penis lacking.

Description. In living animals, purplish brown dorsum, lighter ventrum, equators pigmented. Length 38–51 mm (n=2 adults); diameter 1.5–2 mm at x, 2 mm at xx; body cylindrical in cross-section, tail tapering; 63–87 segments. First dorsal pore 12/13. One pair of spermathecal pores at 5/6, 0.9 mm apart (0.19 circumference apart ventrally). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 0.8 mm (0.13 circumference apart ventrally); 1–5 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 38–40 setae on vii, 36–45 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 5/6–9/10 thin, 10/11–13/14 muscular. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii–x, esophagus with low vertical lamellae x–xiii. Intestinal origin in xvii, caeca, typhlosole and longitudinal blood vessels were not observed due to damage of the intestine around the area in both holotype and paratype. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in vi, with nephridia on ducts; each spermatheca

with an ovate ampulla and a short, very large bulbous, muscular duct, diverticulum attached to the ental portion of the right face of the right spermathecal duct, and to the left face of the left spermathecal duct, stalks short, terminating in small, ovate receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testes sac; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvii to xx, one individual has asymmetrical prostates, with the right prostate in xvi to xx; each prostate a single, dense, racemose mass, with three lobes; short, muscular duct entering posterior margin of copulatory bursa. Copulatory bursae ovate in xvii–xix; coelomic surfaces muscular, secretory diverticula lacking; roof with two pads, floor pads lacking; penis lacking.

Remarks. *Pheretima gamay* belongs to the *P. urceolata* group of Sims & Easton (1972). It is relatively similar to *P. acia* (Aspe & James, 2016) (33–47 mm × 1–1.2 mm), *P. dinagatensis* (Aspe & James, 2016) (65 mm × 2.5–3 mm), *P. abiadai* (Hong & James, 2008b) (33–60 mm × 2.2–3 mm), *P. nagaensis* (Hong & James, 2008b) (36–53 mm × 2.4–3 mm), *P. viracensis* (Hong & James, 2009) (38–61 mm × 1.9–2.6 mm), *P. doriae* (Hong & James, 2009) (34–45 mm × 2–2.4 mm), *P. batoensis* (Hong & James, 2009) (45–65 mm × 2.4–3.2 mm), and *P. camarinensis* (Hong & James, 2009) (54–61 mm × 2.2–3.5 mm) in body size. However, the other species have wider distance between spermathecal pores (0.21–0.36 circumference apart) except in *P. camarinensis* (0.18–0.19 circumference apart), and between male pores (0.15–0.32 circumference apart), have more setae between male pores (5–14) except in *P. acia* (3), have intestinal origin in xiv–xvi, and have penes. The other species also have unpigmented setal rings except *P. batoensis* and *P. dinagatensis*, which are striped, and *P. viracensis*, which has pigmented setal rings. *Pheretima gamay* also differs from *P. acia* by the latter having very small prostate, and the muscular duct connecting the prostate and the copulatory bursa at the anterior margin of the bursa. No other species in the *P. urceolata* group closely resemble *P. gamay*.

***Pheretima libradoi*, new species**
(Fig. 2C)

Material examined. Holotype: adult (NMP 4623), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, 11–14 December 2003.

Etymology. The species is named after Randolph Librado, a relative of the first author, who assisted in the fieldwork.

Diagnosis. Purplish brown worm with body dimension 185 mm × 7.3–8 mm; one pair of spermathecal pores at 5/6; distance between spermathecal pores and male pores both 0.10 circumference apart ventrally; intestinal origin in xv; spermatheca with a large ovate ampulla and a slender duct; prostates extending from xv–xvii anterior to the copulatory bursae; penis lacking.

Table 1. Comparison of species in the *Pheretima sangirensis* group in Mt. Apo.

Characters	<i>Pheretima sangirensis</i> * (Michaelsen 1891)	<i>Pheretima apoensis</i> (Aspe & James, 2016)	<i>Pheretima virgata</i> (James, 2004)	<i>Pheretima floresi</i> , new species	<i>Pheretima baracatanensis</i> , new species	<i>Pheretima solisi</i> , new species
Length	54–240	163–350	290–360	48–67	100	68–86
Width x, xx	4–8	7.2–11, 8–12	13–17, 11–17	3–3.5, 3–4	4–5, 4.8–6.5	2.8–3, 3.5
Dorsal pigmentation	variation of purple	purplish black	purplish brown, striped	reddish brown	brown	brown
Segment equator	?	Unpigmented	unpigmented	pigmented	unpigmented	pigmented
Segments	?	102–120	125–128	76–96	94	91–98
Spermathecal pores	Paired at 7/8	–, Paired at 7/8	Paired at 7/8	Paired at 7/8	Paired at 7/8	Paired at 7/8
Distance between sperm pores	0.25–0.28	0, 0.16	0.08–0.10	0.21	0.32	0.18
Distance between male pores	0.17–0.25	0.15–0.16	0.10–0.12	0.20	0.20–0.22	0.15
Setae between male pores	6–10	4–5	4–5	5	4–5	3–5
Setae vii, xx	40; 60+	37–48, 50–58	74–76, 80–86	37, 45	43–46, 44–51	35, 32–35
Intestinal origin	xv	xv	xv	xv or xvi	xv	xv
Caeca	xxvii–?	xxvii–xxvi or xxvii–xxiv	xxvii–xxiii or xxvii–xxi	xxvii–xxiv	xxvii–xxiv	xxvii–xxiv
Prostate	xvii–xix	xv–xix or xvii–xix	xvii–xviii	xvii–xx or xvii–xxi	xvi–xix	xvi–xx
Copulatory bursae	present	xvii–xix	xvii–xix	xvii–xviii	xvii–xix	xvii–xix
Penes	+	+	–	–	–	–

*including the subspecies; data based on Michaelsen (1891, 1899, 1900)

Table 2. Comparison of species in the *Pheretima urceolata* group in Mt. Apo.

Characters	<i>Pheretima urceolata</i> (Horst, 1893)	<i>Pheretima monotheca</i> (James, 2004)	<i>Pheretima hamiguitanensis</i> (Aspe & James, 2016)	<i>Pheretima aquila</i> , new species	<i>Pheretima gamay</i> , new species	<i>Pheretima libradoi</i> , new species	<i>Pheretima davaoensis</i> , new species
Length	66–114	62–81	81–89	165	38–51	185	86–98
Width x, xx	3.5–4, 3.5–4.5	2.3–3.7	3–3.5, 3.5–4	5, 5.2	1.5–2, 2	7.3, 8	3.5–4.5, 3.5–4.2
Dorsal pigmentation	brown	brown	brown	reddish brown	purplish brown	purplish brown	brown
Segment equator	unpigmented	pigmented	unpigmented	unpigmented	pigmented	unpigmented	pigmented
Segments	96–99	96–105	108–111	94	63–87	112	93–95
Spermathecal pores	Paired at 5/6	Single midventral at 5/6	Paired at 5/6	Paired at 5/6	Paired at 5/6	Paired at 5/6	Paired at 5/6
Distance between sperm pores	0.16	0	0.07	0.22	0.19	0.10	0.28
Distance between male pores	0.11	0.11–0.14	0.12	0.21	0.13	0.10	0.27
Setae between male pores	2	3	2	7	1–5	0	10
Setae vii, xx	20–25, 43	35–36, 32–41	38–42, 44–47	39–42, 44	38–40, 36–45	30, 59	44, 43–49
Intestinal origin	xvi	xvii	xv or xvii	xv	xvii	xv	xvii
Caeca	xxvii–xxiv	xxvii–xxv	xxvii–xxiv	xxvii–xxiii	?	xxvii–xxiv	xxvii–xx
Prostate	xvii–xviii	two parts, in xvi & xix–xx	xvii–xx or xv–xix	xvi–xviii	xvii–xx	xv–xvii	xvii–xxi
Copulatory bursae	xviii–xix	xvii–xviii	xvii–xix	xvii–xviii	xvii–xix	xvii–xix	xvii–xix
Penes	+	+	–	–	–	–	+

*including the description of Gates (1961)

Description. Purplish brown dorsum, lighter ventrum, equators non-pigmented. Length 185 mm (n=1 adult); diameter 7.3 mm at x, 8 mm at xx; body cylindrical in cross-section, tail tapering; 185 segments. First dorsal pore 12/13. One pair of spermathecal pores at 5/6, distance between spermathecal pores 2.3 mm (0.10 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae depressed, paired in xviii, distance between openings 2.5 mm (0.10 circumference apart ventrally); no setae between openings. Clitellum annular, from xiv to xvi. Setae on ventrum more closely spaced compared with that of the dorsum, 30 setae on vii, 59 setae on xx, dorsal and ventral setal gaps present. Genital markings lacking.

Septa 4/5/6, 12/13/14 membranous, 6/7/8, 10/11/12 muscular, 8/9 thin, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii-x, esophagus with low vertical lamellae x-xiii. Intestinal origin in xv, caeca simple originating in xxvii, extending forward to xxiv. Typhlosole originating in xxvii, simple fold, 1/3 lumen diameter. Intestinal wall with 32 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in vi, with nephridia on ducts; each spermatheca with a large ovate ampulla and a slender duct, diverticulum attached to the ental portion of the right face of the right spermathecal duct, and to left face of the left spermathecal duct, stalks long, slender, terminating in sausage-shaped receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates located anterior to copulatory bursae in xv to xvii; each prostate a single, dense, racemose mass, with two lobes; thick duct entering posterior margin of copulatory bursa. Copulatory bursae ovate in xvii-xix; coelomic surfaces muscular, secretory diverticula lacking; one pad present on roof, floor with folding; penis lacking.

Remarks. *Pheretima libradoi*, new species belongs to the *P. urceolata* species group of Sims & Easton (1972). The new species is relatively similar to *P. aquila*, new species, *P. buhiensis* and *P. gorasi* in body size. However, the latter three have significantly fewer body segmentations (94 in *P. aquila* and 117-119 in *P. buhiensis* and *P. gorasi*). The distance between spermathecal pores in *P. buhiensis* (0.04-0.06 circumference apart) and *P. gorasi* (0.06-0.07 circumference apart) are closer while it is significantly wider in *P. aquila* (0.22 circumference apart). Likewise, the distance between male pores in *P. aquila* are significantly wider (0.22 circumference apart). In addition, *P. buhiensis* and *P. gorasi* have penes while the new species has none. No other species in the *P. urceolata* group closely resemble *P. libradoi*.

***Pheretima davaoensis*, new species**
(Fig. 2D)

Material examined. Holotype: adult (NMP 4625), Brgy Baracatan, Davao City, Mt. Apo National Park (7°00'04"N, 125°21'55"E), 1,524 m asl, Mindanao Island, Philippines, coll. N. Aspe, A. Solis, D. Flores, R. Librado, 11-14 December 2003. Paratype: one adult (ZRC.ANN 0076), same collection data as for holotype.

Etymology. The species is named after Davao City, its type locality.

Diagnosis. Brown worm with body dimension 86-98 mm × 3.5-4.5; one pair of spermathecal pores at 5/6; distance between spermathecal pores and male pores 0.28 and 0.27 circumference apart ventrally, respectively; intestinal origin in xvii; spermatheca with an ovate ampulla and a large bulbous, muscular duct expanding ectally; racemose prostates extending from xvii-xxi; penis present.

Description. Brown dorsum, lighter ventrum, equators pigmented. Length 86-98 mm (n=2 adults); diameter 3.5-4.5 mm at x, 3.5-4.2 mm at xx; body cylindrical in cross-section, tail tapering; 93-95 segments. First dorsal pore 12/13. One pair of spermathecal pores at 5/6, distance between spermathecal pores 4 mm (0.28 circumference ventrally apart). Female pore single in xiv. Openings of copulatory bursae paired in xviii, distance between openings 3.6 mm (0.27 circumference apart ventrally); 10 setae between openings. Clitellum annular, from xiv to xvi. Setae unevenly distributed around equators in some segments; 44 setae on vii, 43-49 setae on xx, dorsal setal gaps present, no ventral gaps. Genital markings lacking.

Septa 5/6-8/9 thin, 10/11-13/14 muscular, 9/10 lacking. Dense tufts of nephridia on anterior faces of 5/6 and 6/7; nephridia of intestinal segments located mainly on body near septum/body wall junction. Large gizzard in viii-x, esophagus with low vertical lamellae x-xiii. Intestinal origin in xvii, intestine thinner before the origin of caeca; caeca simple originating in xxvii, extending forward to xx. Typhlosole originating in xxvii, low simple fold. Intestinal wall with 36 longitudinal blood vessels. Hearts in x to xiii, esophageal; commissural vessels in vi, vii, and ix lateral; those in viii extending to gizzard.

Ovaries and funnels free in xiii. Spermathecae paired, postseptal in vi, with nephridia on ducts; each spermatheca with an ovate ampulla and a large bulbous, muscular duct expanding ectally, diverticulum attached to the ental portion of the right face of the right spermathecal duct, and to the left face of the left spermathecal duct, stalks short, terminating in small, ovate receptacles. Male sexual system holandric, testes and funnels enclosed in paired sacs in x, xi; seminal vesicles in xi, xii, each with a digitate dorsal lobe; vesicles of xi enclosed in testis sacs; vasa deferentia slender, free from body wall en route to ental end of prostatic ducts; prostates in xvii to xxi; each prostate a single, dense, racemose mass; thick, muscular duct entering the central area of copulatory

bursa from the posterior part of the prostate. Copulatory bursae ovate in xvii–xix; coelomic surfaces muscular, secretory diverticula lacking; roof with two pads; large conical penis present within the bursa.

Remarks. *Pheretima davaoensis*, new species belongs to the *P. urceolata* group of Sims & Easton (1972). It is relatively similar to *P. urceolata*, *P. bukidnonensis* (James, 2004), *P. baletai*, *P. heaneyi*, *P. kitangladensis* (James, 2004), *P. simsi* (James & Hong, 2004), and *P. bicolensis* (Hong & James, 2009) in body size. However, *P. urceolata* (0.16 circumference apart), *P. baletai* (0.25 circumference apart), *P. heaneyi* (0.19–0.23 circumference apart), *P. kitangladensis* (0.13 circumference apart) and *P. bicolensis* (0.05–0.06 circumference apart) have closer spacing between the spermathecal pores while that of *P. bukidnonensis*, is significantly wider (0.38 circumference apart). The distance between the male pores in these species is also shorter (0.11–0.24 circumference apart). There was no information on the distance between spermathecal pores and the distance between male pores in *P. simsi*. *Pheretima simsi* and *P. baletai* have fewer pre-clitellar setae (31–33 and 24, respectively) and fewer setae between male pores (6–8) compared to the new species. In addition, *P. baletai* has faint pink colouration while *P. simsi* has significantly shorter caeca (xxvii–xxvi) and smaller prostates (xvii–xix). No other species in the *P. urceolata* group closely resemble *P. davaoensis*.

KEY TO THE EARTHWORMS OF MT. APO, MINDANAO ISLAND, PHILIPPINES

1. Nephridia on spermathecal ducts present; copulatory bursae present..... (*Pheretima*) 2
 - Nephridia on spermathecal ducts lacking; copulatory bursae lacking; one pair of spermathecal pores at 7/8 *Amyntas apongensis*, new species
2. Spermathecal pore(s) at 5/6 (*Pheretima urceolata* group) 3
 - One pair of spermathecal pores at 7/8 (*Pheretima sangirensis* group) 4
3. Spermathecal pore single, male pores paired; brown worm with length 96–105 mm *Pheretima monothea*
 - Spermathecae paired..... 6
4. Large worm with body length >160 mm 5
 - Worm with body length 48–67 mm, distance between spermathecal pores and between male pores 0.21 and 0.20 circumference apart, respectively *Pheretima floresi*, new species
 - Worm with body length 68–86 mm, distance between spermathecal pores and between male pores 0.32 and 0.20–0.22 circumference apart, respectively *Pheretima baracatanensis*, new species
 - Worm with body length 100 mm, distance between spermathecal pores and between male pores 0.18 and 0.15 circumference apart, respectively..... *Pheretima solisi*, new species
5. Worm with body length 163–350 mm, penis present, purplish black, dorsum pigmented all over except equators..... *Pheretima apoensis*

- Purplish black, body with stripes, body length 290–360 mm, penis lacking..... *Pheretima virgata*
- 6. Segmental equator pigmented..... 7
 - Segmental equator unpigmented..... 8
- 7. Worm with body length ~165 mm, distance between spermathecal pores and between male pores 0.22 and 0.21 circumference apart, respectively, 7 setae between male pores, penis absent *Pheretima aquila*, new species
 - Worm with body length 66–114 mm, distance between spermathecal pores and between male pores 0.16 and 0.11 circumference apart, respectively, 2 setae between male pores, penis present..... *Pheretima urceolata*
 - Worm with body length 81–89 mm, distance between spermathecal pores and between male pores 0.07 and 0.12 circumference apart, respectively, 2 setae between male pores, penis absent *Pheretima hamiguitanensis*
- 8. Worm with body length 86–98 mm, distance between spermathecal pores and between male pores 0.28 and 0.27 circumference apart, respectively, 10 setae between male pores, penis present..... *Pheretima davaoensis*, new species
 - Very small worm with body length 38–51 mm, equators pigmented, distance between spermathecal pores and between male pores 0.19 and 0.13 circumference apart, respectively, 1–5 setae between male pores, penis absent *Pheretima gamay*, new species
 - Worm with body length ~185 mm, equators unpigmented, both distance between spermathecal pores and between male pores 0.10, no setae between male pores, penis absent..... *Pheretima libradoi*, new species

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