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## On Some Earthworms from Taiwan

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Three species, all in the genus *Pheretima*, have been erected on material from Taiwan. None of them has been seen or recognized subsequently. As so little is known of the earthworm fauna of an area that presumably comprises a number of endemics, the casual collections made by Prof. D. E. Beck for the American Museum while on duty in the island are of considerable interest. A series of another species, which is accused of causing "serious damage" to rice cultivation, has been received from the United States Department of Agriculture.

The author's thanks are extended to Dr. Beck and to the authorities of the Museum for the opportunity of examining this collection as well as for assistance rendered in various ways.

### MEGASCOLECIDAE

#### *PHERETIMA* KINBERG, 1866

#### *Pheretima aspergillum* (Perrier, 1872)

*Pheretima aspergillum*, GATES, 1939, Proc. U. S. Natl. Mus., vol. 85, p. 420.

*Perichaeta takatorii* GOTO AND HATAI, 1898, Annot. Zool. Japonensis, vol. 2, p. 76. Type locality, Taipei-fu, Formosa. Depository of types, if extant, unknown.

*Amyntas takatorii*, MICHAELSEN, 1899, Mitt. Mus. Hamburg, 1899, vol. 16, p. 90.

*Amyntas aspergillum*, BEDDARD, 1900, Proc. Zool. Soc. London, p. 631.

*Pheretima takatorii*, MICHAELSEN, 1900, Das Tierreich, vol. 10, p. 318.

SPECIMENS EXAMINED: Chao-Chow, Ping-Tung, November 1956, 0-0-2; June 17, 1957, 0-0-2; D. E. Beck. (A.M.N.H. No. 3571.)

**EXTERNAL CHARACTERISTICS:** Length, 100–168 mm. (contracted). Diameter, 5–8 mm. (in gizzard region, clitellum narrowed). Segments, 74 (with tail regenerate? No. 4), 76 (No. 1, a posterior amputee), 128 (No. 2), 133 (No. 3). (A posterior portion of No. 4, with metameric abnormalities and comprising five or six segments in which setae are unrecognizable, may be a tail regenerate. Setae are unrecognizable in the last three segments of No. 3.) Color rather brownish in dorsum behind clitellum, anteriorly much darker, almost blue in dorsum and in ventrum of first few segments. Prostomium epilobous, tongue open and with a deep median furrow that is continued out onto the prostomium. Setae present from ii, seemingly much smaller in dorsum behind x but retracted so that tips are almost indistinguishable, 38, 40/iii, 54 (a fairly large gap), 62/viii, 66, 72/xii, 74, 78/xx, viii/19 gap), 21, 23, 22, xviii/13, 12, 12, 10. First dorsal pore at 11/12 (two specimens), 11/12? (one specimen), 12/13 (one specimen). Clitellum annular, red (formalin preservation), not at maximal tumescence (Nos. 1–2), dorsal pores functional or their sites recognizable, furrows not quite obliterated, possibly some setae present in ventrum (Nos. 1–2), dorsal pores, setae and furrows unrecognizable (Nos. 3–4), on xiv–xvi.

Quadrithecal, pores minute and superficial, well towards mL at 7/8–8/9. Female pore median (four specimens). Male pores minute, superficial, each on a rather conical porophore only slightly if at all larger than adjacent markings.

Genital markings very small tubercles, each with a central pore-like depression, in transverse rows of three or four, two rows median to each male porophore of which one is just in front of and one is just behind eq/xviii, one row on each side at anterior margin of ix just median to spermathecal pore. One marking on each side of viii, slightly median to spermathecal pore and close to 8/9.

**INTERNAL ANATOMY:** Septa 5/6–7/8 thickly muscular, 8/9–9/10 aborted, 10/11–13/14 thickly muscular, 14/15 slightly muscular. Pigment brownish, in circular muscle layer, lacking or very sparse underneath intersegmental furrows and unrecognizable in longitudinal muscle band at mD.

Intestinal origin in xv. Typhlosole simply lamelliform, 1+ mm. high from xxvii, gradually becoming smaller posteriorly, unrecognizable behind fifty-sixth segment (posterior amputee). Intestinal caeca simple, ventral faces with several incisions, in xxvii–xxiv. Postgizzard (glandular?) collar on esophagus low.

Dorsal blood vessel complete, apparently bifurcating under brain, but branches not traceable. Ventral trunk complete, bifurcating over

subpharyngeal ganglion. Subneural trunk complete, still recognizable under subpharyngeal ganglion, adherent to parietes. Hearts of x-xiii (latero?)-esophageal, no blood in filaments passing to dorsal trunk. Heart of ix lateral, on right side (three specimens), left side (one specimen). Segmental loops of vii-v, slender, apparently without "joints," have been traced from dorsal to ventral trunks and accordingly are lateral. Lymph glands unpaired, U-shaped, and horizontally placed, unrecognizable anteriorly but large in last 10 segments of the posterior amputee, present in the other worms from xv. Brain in iii.

Holandric. Testis sacs unpaired and subesophageal, ventral blood vessel suspended from roof in interior of sacs. Male funnels plicate. Male gonoducts, without epididymis, uniting in xii, passing into anterior bifurcation of prostatic duct. Seminal vesicles medium-sized, nearly filling coelomic cavities of xi-xii, each with a fairly large and flat dorsal lobe. Prostates large, in xvi-xxiii. Ducts 4-5 mm. long, muscular, narrowing near parietes, a short ental portion softer. Pseudovesicles of xiii rudimentary, elongate, attached vertically to septum, the ental ends slightly widened and softer. Pseudovesicles of xiv still smaller or unrecognizable.

Spermathecae rather small, subesophageal, the anterior pair in vii. Duct muscular, slightly shorter than ampulla, inner wall with annular ridging. Diverticulum, from anterior face of duct at parietes, longer than main axis, comprising a stalk with muscular sheen and a much longer seminal chamber. Latter with several short, tight, and irregular loops, a slightly wider and sausage-shaped ental portion nearly straight. Ovaries fan-shaped, none with long egg strings.

GM glands stalked and coelomic, stalks of medianmost glands on each side of xviii longest, stalks of glands in spermathecal region almost confined to parietes.

REPRODUCTION: Spermatozoal iridescence unrecognizable on male funnels (testis sacs of Nos. 3-4 not opened) and in spermathecal seminal chambers which are filled with a translucent whitish coagulum (Nos. 1-4). The clitellum of the first two specimens certainly is not at maximal tumescence. Aggregates of brown debris are present, in June specimens, in dorsal lobes of seminal vesicles. Sexual reproduction is anticipated in absence of good contra-indications.

INGESTA: Earth.

REMARKS: Information as to method of reproduction and as to variation in characters of taxonomic importance, especially as regards genital markings and male porophores, is needed for determination of relationships with *P. robusta* (Perrier, 1872).

*Pheretima bicincta* (Perrier, 1875)

*Pheretima bicincta*, GATES, 1937, Bull. Mus. Comp. Zool. Harvard College, vol. 80, p. 346.

SPECIMENS EXAMINED: Taipei, at Green Mountain, July 20, 1956, 0-0-2; D. E. Beck. (A.M.N.H. No. 3572.)

EXTERNAL CHARACTERISTICS: Length, 70, 65 mm. Diameter, 2 mm. Segments, 97, 92. Colorless (formalin preservation). Prostomium epilobous, tongue open. Setae begin on ii on which the circle is complete, 38/iii, 50/viii, 49/xii, 46/xx, vi/15, 16, vii/16, 20, viii/15, 18, xviii/8. First dorsal pore at 12/13 (two specimens). Clitellum red, annular, possibly not at maximal tumescence, furrows obliterated, sites of dorsal pores still recognizable, (setae?), extending from 13/14 nearly to setal circle of xvi which is complete (two specimens).

Decathecal, pores minute, superficial, fairly well towards mL, at 4/5-8/9. Female pores not certainly identifiable. Male pores minute, superficial, each on a slight protuberance near lateral margin of a porophore. Latter longitudinally elliptical, reaching halfway to 17/18 and 18/19, each containing a single seta near median margin. Each spermathecal pore is in a slightly raised area of translucence. Other genital markings lacking.

INTERNAL ANATOMY: Septa 5/6-7/8 muscular, 8/9 aborted, 9/10-11/12 thickly muscular, 12/13 muscular, 13/14-14/15 slightly strengthened. Pigment unrecognizable in circular muscle layer or in longitudinal muscle band at mD.

Intestinal origin in xv (two specimens). Intestinal caeca small, short, arising in xxii, ventrally directed (one specimen) or reaching halfway through xxi (one specimen). Typhlosole, beginning rather abruptly in xxii, rather high, simply lamelliform, becoming smaller posteriorly, unrecognizable behind seventy-third segment (97 segments).

Dorsal trunk probably complete, having been traced nearly to brain. Ventral trunk complete, bifurcating over subpharyngeal ganglion. Subneural trunk quite unrecognizable. Hearts of x-xii (latero?)-esophageal, no blood recognizable in filaments passing to dorsal trunk. Hearts of ix slender, possibly passing to ventral trunk on both sides, lateral. Segmental loops of viii apparently completely aborted. Loops of vii-v recognizable dorsally but not traceable to ventral trunk.

Holandric. Testis sacs unpaired, probably annular or horseshoe shaped, posterior sac including anterior seminal vesicles as well as hearts. Male funnels fairly large, plicate. Male gonoducts, without epididymis, pass into ental ends of prostatic ducts. Seminal vesicles medium sized, each with a finely acinous dorsal portion. Pseudovesicles

of xiii rudimentary. Pseudovesicles of xiv fairly large, lobed, rather like lumbricid ovisacs in appearance. Prostates in xvi-xix in which the gut is compressed by these organs. Ducts with marked muscular sheen, C-shaped, 2+ mm. long, narrowed in parietes.

Spermathecae small, subesophageal. Duct shorter than ampulla. Diverticulum, from anterior face of duct at parietes, shorter than main axis, with slender stalk and slightly shorter, slightly thicker, ovoidal to ellipsoidal seminal chamber. Ovaries fan-shaped, each with several egg strings.

No special tissue present on body wall over sites of male porophores.

REPRODUCTION: Spermatozoal iridescence, as in previous specimens examined by the author, is lacking on male funnels and in spermathecal seminal chambers. No indications of postreproductive regression were recognized. These specimens may not have reached full maturity. However, parthenogenesis is suspected.

INGESTA: Earth.

REMARKS: Setae of the anterior segments do not appear to be large, though inability to recognize enlargement could be due to retraction. Number of setae between levels of spermathecal pores is definitely larger than previously recorded. GM glands usually have been recognizable in the coelom of specimens previously examined by the author. In these Formosan worms if any glands are present they must be buried deeply in the body wall.

The original home of this rather widely transported species still is unknown.

The bodies that fill a pseudovesicle of xiv do not appear to be earthworm ova and presumably are of a parasitic nature. Although the pseudovesicles of xiv, like those of xiii, occasionally have been mistaken for ovisacs, the resemblance only very rarely is as close as in these worms.

*Pheretima californica* Kinberg, 1866

*Pheretima californica*, GATES, 1937, Bull. Mus. Comp. Zool. Harvard College, vol. 80, p. 348.

SPECIMEN EXAMINED: Taipei, May 9, 1956, 0-0-1; D. E. Beck. (A.M.N.H. No. 3573.)

EXTERNAL CHARACTERISTICS: Segments, 103. Prostomium epilobous, tongue open. Color nondescript, darker in dorsum of first few segments, behind clitellum unrecognizable ventrally.

INTERNAL ANATOMY: Septa 5/6-7/8, 10/11-12/13 muscular to fairly thickly muscular, 13/14-14/15 slightly muscular, 8/9-9/10 aborted.

Pigment reddish, in circular muscle layer, lacking immediately underneath intersegmental furrows. Longitudinal muscle band at mD distinct from 11/12.

Glandular (?) collar on esophagus behind gizzard rather thick. Typhlosole simply lamelliform, ending in seventieth segment, continuous with a ridge that becomes smaller through xxvi-xxii and then enlarges again until into xvi.

Dorsal blood vessel complete, bifurcating in region of brain. Ventral blood vessel complete, bifurcating over subpharyngeal ganglion. Subneural trunk, adherent to parietes, complete. Hearts of x-xiii (latero?)-esophageal, filaments passing to dorsal trunk white. Heart on right side of ix large, lateral, heart on left side of ix, possibly functionless, represented by a slender strand that can be traced from dorsal to ventral trunk. Dorsal portions of loops of viii large, blood-filled, passing to gizzard, ventral portions aborted. Lymph glands, recognizable only in posterior segments, U-shaped, horizontally placed.

Pseudovesicles of xiii represented by very small rudiments? Pseudovesicles of xiv, if present, too small to be identified with certainty. Male gonoducts pass into ental ends of prostatic ducts. Spermathecae are in vii-viii. Ovaries fan-shaped, each with several short egg strings.

REPRODUCTION: Spermatozoal iridescence in spermathecal seminal chambers shows that the worm had copulated, and a similar iridescence on the male funnels shows that sperm had been matured. Reproduction presumably is sexual and biparental.

INGESTA: Earth back to the seventieth segment. Remainder of gut filled with shreds and bits of plant material amongst which there is but little earth.

*Pheretima diffringens* (Baird, 1869)

*Pheretima diffringens*, GATES, 1937, Bull. Mus. Comp. Zool. Harvard College, vol. 80, p. 350.

SPECIMENS EXAMINED: Taipei, May 9, 1956, 0-0-1; Taipei, at Green Mountain, July 20, 1956, 0-0-6; D. E. Beck. (A.M.N.H. Nos. 3574, 3575.)

REMARKS: Lymph glands, in one specimen, are recognizable from xix.

The male terminalia, except for the external porophores, is normally developed in none of these specimens. One prostate has a muscular duct of near normal length and the texture of a mature gland though small enough to be confined to xviii. On the opposite side and on both sides of other worms a small and flat patch of tissue on parietes

over male porophore is all that at first is visible. Some probing, under high magnification, usually reveals a thickening of the male gonoduct that can be a rudimentary prostatic duct as well as an associated patch of shapeless tissue that presumably is a gland rudiment. Male gonoducts, in one specimen, cannot be traced into xviii. The bipartite soft mass on the parietes over the male porophore appears to be composed of two GM glands.

Genital markings, present only in spermathecal segments, are located as usual.

These specimens, as are all of those that have been available during the last dozen or more years, are parthenogenetic.

Sexual specimens of a form that is close to *diffringens* (as hitherto known) are described below.

**SPECIMENS EXAMINED:** Chao-Chow, Ping Tung, November 1956, 0-0-1; June 17, 1957, 0-0-1; D. E. Beck. (A.M.N.H. No. 3575.)

**EXTERNAL CHARACTERISTICS:** Length, 77, 160 mm. (contracted). Diameter, 6, 9 mm. (only 5 mm. in clitellar region of larger specimen, No. 2). Segments, 94, 121. Color brownish in dorsum behind clitellum, anteriorly much darker, bluish gray in dorsum and in ventrum of first few segments. Prostomium epilobous, tongue open. Setae present from ii, 32/ii, 42/iii, 64/viii, 60/xii, 64/xx, 81/lxxiv, vii/22, viii/20, xviii/12 (No. 1), 32(+?)/iii, 66/viii, 78/xii, 75/xx, 72/cx, vi/17, vii/20, viii/20, xviii/14 (No. 2). First dorsal pore at 11/12. Clitellum red (formalin preservation), annular, narrowed, intersegmental furrows obliterated, dorsal pores functional, setae apparently lacking except possibly in ventrum of xvi (No. 1), dorsal pores, intersegmental furrows, and setae unrecognizable (No. 2), on xiv-xvi.

Octothecal, pores minute and superficial, well towards mL, at 5/6-8/9. Female pore median. Male pores minute, superficial, each in a small glistening area distinctly demarcated anteriorly and posteriorly but seemingly only a more protuberant part of the equatorial ridge that bears the setae of xviii.

Genital markings are in two sizes. Transversely elliptical protuberances, rather indistinct, four pairs, postsetal on v-viii, in front of the spermathecal pores (No. 1). One marking just in front of and one just behind each spermathecal pore of the last three pairs (No. 2). Smaller tubercles, in xviii, one just in front of and one just behind each male porophore (two specimens).

**INTERNAL ANATOMY:** Septa 5/6-7/8 slightly muscular, 8/9-9/10 aborted, 10/11-12/13 slightly muscular. Pigment brownish, in circular muscle layer and in longitudinal muscle band at mD which is distinct

from 10/11, lacking (or very sparse?) immediately underneath inter-segmental furrows.

Intestinal origin in xvi (two specimens). Intestinal caeca simple, dorsal and ventral faces smooth except for septal constrictions, in xxvii-xxiv. Typhlosole simply lamelliform from xxvii, becoming smaller posteriorly, unrecognizable behind lxxi.

Dorsal blood vessel, traceable forward to pharyngeal bulb, probably complete. Ventral blood vessel complete, bifurcating at anterior end of subpharyngeal ganglion. Subneural trunk, adherent to parietes, probably complete. Hearts of x lacking (two specimens) but on right side (one specimen) a large branch from the supra-esophageal passes down on the gut for a short distance. Hearts of xi-xiii (latero?)-esophageal, no blood in filaments passing to dorsal trunk. Heart of ix, lateral, on right side (one specimen) or left side (one specimen). Dorsal portions of segmental loops of viii pass to gizzard, ventral portions aborted. Loops of vii-v, slender, "joints" unrecognizable, have been traced to ventral trunk. Lymph glands, present from xxviii, seemingly paired but probably V- or U-shaped and then with median connective very slender.

Holandric. Testis sacs unpaired and subesophageal. Male funnels plicate. Male gonoducts, without epididymis, pass to ental ends of prostatic ducts. Seminal vesicles medium-sized, filling coelomic cavities of xi-xii, soft, each with a distinct dorsal lobe. Pseudovesicles of xiii rudimentary, vertically placed, slightly widened at dorsal end. Pseudovesicles of xiv shorter and slenderer but also slightly widened dorsally. Prostates in xvi-xix or xvii-xx. Ducts 4+ mm. long, each in a hairpin loop, the ectal limb thicker and with muscular sheen.

Spermathecae rather small and subesophageal. Ampullae distended but fluid filled. Duct short and rather spindle-shaped, narrowed entally and within the parietes. Diverticulum, from anterior face of duct at parietes, comprising a long stalk with muscular sheen and a short, thicker, ellipsoidal seminal chamber. Ovaries fan-shaped, no long egg strings.

GM glands not recognizable in xviii, if present concealed within longitudinal musculature. Small, fragile, and shortly stalked glands are visible in the spermathecal region.

REPRODUCTION: Spermatozoal iridescence is recognizable in the coagulum within each spermathecal seminal chamber of both specimens, on all male funnels of one specimen, and on one male funnel of the second specimen (further dissection of this worm avoided). As sperm



had been matured and exchanged in copulation, reproduction is assumed to be sexual and biparental.

The clitellum of No. 1 appears not to be at maximal tumescence, but the clitellum of the other specimen is.

INGESTA: Earth.

ABNORMALITY: Right seminal vesicle in xii of No. 2 is small.

REMARKS: These Formosan worms may be close to, if not identical with, the ancestral hermaphroditic morph from which the parthenogenetic previously known strains of *diffringens* diverged since acquisition of ability to reproduce asexually.

*Pheretima elongata* (Perrier, 1872)

*Pheretima elongata*, GATES, 1937, Bull. Mus. Comp. Zool. Harvard College, vol. 80, p. 352.

SPECIMENS EXAMINED: Tsing-chao Maa, central Formosa, 8-1-10 (all macerated). Received from United States Department of Agriculture.

The label with these worms bears the following statements: "Earthworms which cause serious damage to rice plants near a small village at central Formosa. They live in soil of rice field and make numerous tunnels therein, and thus the proper irrigation of the field cannot be made. At present, their occurrence seems to be restricted to about 20 ha. but the range is gradually enlarging. In the area infested, the farmers complained that 50 percent of their rice yield was lost during the last ten years simply because of the indirect damage of this worm."

This species never was found in paddy fields in Burma and India but almost only in "black earth."

*Pheretima formosae* Michaelsen, 1922

*Pheretima formosae* MICHAELSEN, 1922, Cap. Zool., vol. 1, pt. 3, p. 39, fig. 12. (Type locality, Dorf Koseypo. Type in Leiden Museum.)

SPECIMENS EXAMINED: Chao-Chow, Ping-tung, November, 1956, 0-0-3 (Nos. 1-3). June 17, 1957, 0-0-1 (No. 4). Taipei, at Green Mountain, July 20, 1956, 0-1-0 (No. 5); D. E. Beck. (A.M.N.H. No. 3576.)

EXTERNAL CHARACTERISTICS: Length, 210 (No. 1), 407 (No. 4), 230 mm. (No. 5). Diameter, 14 (gizzard region, No. 1), 12 (in clitellum probably at maximal tumescence, No. 4), 12 mm. (gizzard region, No. 5), 10 mm. shortly in front of anus. Segments, 115 (No. 1, posterior portion lacking), 175 (No. 4, probably a posterior amputee), 194 (No. 5). (The terminal segment of No. 4 has a large number of setae, and the longitudinally grooved anal portion is not demarcated by an intersegmental furrow from the setigerous portion. The longitudinally grooved anal

region of No. 5 is demarcated by an intersegmental furrow from the last setigerous segment which is much shorter than in No. 4.) Body shortly elliptical in cross section, the dorsoventral diameter slightly shorter. Color of dorsum dark, seemingly brownish in one specimen, bluish in another, of about the same appearance in ventrum of first eight or nine segments. Numerous brown flecks, in postclitellar portion of body, recognizable (No. 1) under the binocular in the ventrum. Prostomium epilobous, tongue closed (No. 4) or open, with a deep groove at mD that is continued anteriorly. Peristomium with numerous deep longitudinal grooves. Postsetal secondary furrows deep in v-xiii, presetal secondary furrows deep in vi-xiii, a more or less distinct tertiary furrow present in the anteriormost secondary annulus and the posteriormost secondary annulus of ix-xiii. Setae, present in a complete circle in ii, 115/ix, 100+/xii, 113/xx, vii/40, xviii/19 (No. 1), 110/xx, xviii/27 (No. 4), 125/xii, xviii/27 (No. 5). First dorsal pore at 12/13. Clitellum annular, red (formalin preservation), not quite reaching 16/17 and in dorsum still farther from 13/14, as indicated by functional dorsal pores of those levels (No. 1), intersegmental furrows obliterated, dorsal pores occluded, setae unrecognizable, between 13/14 and 15/16 (No. 4).

Octothecal, pores minute, superficial, well towards mL, at 5/6-8/9. Female pore median. Male pores minute, invaginate, each on a smooth-surfaced glistening ridge on median face of a slight invagination with thin lateral wall.

Genital markings lacking.

INTERNAL ANATOMY: Septa 5/6-7/8 thickly muscular, 8/9 complete but membranous (five specimens), 9/10 aborted, 10/11-12/13 very thick, 13/14 thickly muscular, 14/15 slightly muscular, 15/16 and some of the following septa slightly strengthened. Pigment reddish brown, in circular muscle layer, dense except just under intersegmental furrows and in immediate vicinity of each setal follicle, in dense deposits on ventral side of pharynx, flecks also recognizable in tissues around prostatic and spermathecal ducts, on hearts and in various mesenteries as well as in dorsal portions of seminal vesicles.

Intestinal origin posteriorly in xv, though the insertion of 15/16 sometimes at first appears to be on very anterior edge of intestine. Typhlosole about 1 mm. high from xxvii, almost triangular in cross section, gradually becoming smaller anteriorly as well as posteriorly. In the irregularities on roof of gut, after typhlosole has become unrecognizable, there is recognizable at mD a series of segmental pits. Intestinal caeca simple, long, dorsal and ventral faces constricted by septa

and with an occasional small lobe, in xxvii–xviii or long enough to reach into xviii.

Dorsal blood vessel, having been traced forward to brain, probably complete. Ventral blood vessel complete, bifurcating over subpharyngeal ganglion. Subneural trunk present and adhering to parietes. Hearts of xi–xiii (latero?)–esophageal, filaments passing to dorsal trunk without blood. Hearts of x short, bound to gut and anterior face of 10/11 by tissue sometimes so opaque as completely to conceal them from view, possibly esophageal, as filaments to the dorsal trunk were not found (if colorless unlikely to have been recognizable in the connective tissues). Heart of ix, lateral, on right side (three specimens), on left side (two specimens). Dorsal portions of large loops of viii pass to gizzard, ventral portions aborted. Loops of vii–v appear to pass eventually to ventral trunk. Lymph glands, present from xv, U-shaped but transverse limb (just in front of septum) often so thin as to be almost unrecognizable. Length of other limbs often greater than that of the segment, accumulations of brown debris frequently present terminally. One limb of several glands, in one of the specimens, is more or less deeply bifid. Very little brown debris is present in anterior glands of the acitellate worm.

Proandric. Testis sac subesophageal. Male funnels fairly large, plicate. Male gonoducts, without epididymis but possibly with muscularized walls, pass into prostatic ducts near the ental ends. A strengthened cylindrical membrane between 10/11 and 11/12 encloses gut, seminal vesicles, ventral blood vessel, and hearts. Seminal vesicles of xi antero-posteriorly flattened, tough, each fairly deeply constricted into two nearly equal-sized portions, brown spots especially obvious in ventral portions. A very small vesicle (?) vertically placed on left side of posterior face of septum 11/12 is slightly widened dorsally where there is a small ball of brown debris. Pseudovesicles unrecognized in xiii as well as xiv. Prostates, in xvii–xix. Ducts about 6 mm. long, straight, gradually narrowing ectally.

Spermathecae medium-sized. Duct much shorter than ampulla, narrowed in parietes, with annular ridges on inner wall. Diverticulum, from anterior face of duct at parietes, much shorter than main axis and just reaching up onto ampulla, the slender stalk (muscular?) closely and shortly looped in a more or less regular zigzag. Seminal chamber small, shortly ellipsoidal. Considerable strong tissue passes up from parietes onto ampulla and seminal chamber, sometimes concealing loops of diverticular stalk and disguising relationships of duct and ampulla as well as shape of former. Additionally, the ampulla may be

bound down around the duct almost to diverticular junction. Ovaries fan-shaped and with numerous long strings, some with many ova. Other strings have no ova but transparent spaces or aggregations of brown debris all of which are of about the same size as mature ova (No. 1).

**REPRODUCTION:** Spermatozoal iridescence is unrecognizable on male funnels, just as in case of male sterility, in the first three specimens. Male funnels are, however, normally plicate. Absence of iridescence, then, could mean that the worms had been preserved near the end of the reproductive period or even later. Absence of coagulum in spermathecal ampullae which contain only a watery fluid, tough texture of seminal vesicles and the brown debris in the ventral portions, absence of coagulum in testis sac of x, the slimy consistency of content of spermathecal seminal chambers (instead of a solid coagulum), length of egg strings and absence of ova in some of them, all are compatible with a postsexual stage, though some of those conditions may exist in male sterile individuals. Some iridescence is recognizable in spermathecal seminal chambers of Nos. 1-3, but none was noted in those of the clitellate June specimen (No. 4). Sperm definitely are present in the seminal chambers of the aclitellate July specimen (No. 5). Copulation obviously had taken place in Nos. 1-3 and 5. Lack of brilliance of iridescence in Nos. 1-3 may be due to resorption of some of the sperm. Reproduction is assumed to be sexual and biparental.

No indications of postreproductive regression were recognized in the aclitellate worm. Copulation may then take place before appearance of the clitellum.

**INGESTA:** Earth.

**ABNORMALITY:** The testis sac of x, of one worm, has only one male funnel, on the right side. A male funnel is present in the testis sac of xi, on the left side but is on 10/11 and faces posteriorly. This funnel presumably belongs in x.

**PARASITES:** Nematodes are present in coelomic cavities of xi-xiii (three specimens). A large brown disc in the coelomic cavity of xi contains a huge number of nematode ova.

**REMARKS:** Two specimens (Nos. 2-3) had been more or less dehydrated at some time, perhaps just prior to preservation or immediately afterward. Sand and earth could not be removed even after soaking in detergents. Determination of external characters had to be omitted.

The proandric species of *Pheretima* are seven: *densipapillata* (Michaelsen, 1896) from Batjan and with spermathecal pores at 7/8, *formosae*, *pataniensis* (Michaelsen, 1896) from Halmahera and Batjan

and with pores at 7/8–8/9 or 8/9, *queribunda* Gates, 1958, from Guadalcanal and with pores at 4/5–8/9, *saonekana* Cognetti, 1913, from Saonek and with pores at 7/8–8/9, *stephensoni* Michaelsen, 1934, from Annam and with pores at 5/6–8/9, and *weberi* Cognetti, 1913, from Batjan and with pores at 7/8. The Guadalcanal species now appears to be of a more ancient lineage than the others. The Indonesian species (*densipapillata*, *pataniensis*, *saonekana*, and *weberi*) may well have had a common and more recent origin. The Annam and Formosa species are not closely related.

The proandry now seems to have arisen independently in four sections of the *Pheretima* domain. Accordingly, this reduction is not available to define a subgenus as was proposed for the other meroandric reduction, metandry.

*Pheretima incongrua* Chen, 1933

*Pheretima incongrua* CHEN, 1933, Contrib. Biol. Lab. Sci. Soc. China, Nanking, Zool., vol. 9, p. 270. (Type locality, Lin-hai-hsien, Chekiang, China. Depository of types, if still extant, unknown.)

*Pheretima incongrua*, GATES, 1935, Lingnan Sci. Jour., vol. 14, p. 452. (After examination of one of the original specimens.)

SPECIMEN EXAMINED: Taipei, May 9, 1956, 0–0–1; D. E. Beck. (A.M.N.H. No. 3577.)

EXTERNAL CHARACTERISTICS: Length, 54 (+?) mm. Diameter, 3 mm. Segments, 55 (+? a posterior portion lacking). Color brownish, dark in dorsum of i–ix, much lighter behind clitellum. Prostomium small, epilobous, tongue open and with a median groove that is continued anteriorly. Setae, in a complete circle on ii, 53/iii, 60/viii, 56/xii, 48/xx, vi/26, xviii/4(+?). First dorsal pore at 11/12. Clitellum annular, red (formalin preservation), dorsal pores occluded, intersegmental furrows obliterated, setae unrecognizable, on xiv–xvi.

Quadrithecal, pores minute, superficial, well towards  $\frac{1}{2}$ C apart, just median to lateral genital markings, at 5/6–6/7. (Female pore median? Paired pores?) Male pores minute, superficial, each on a tubercle that appears to be a trifle larger than the adjacent genital markings, along with the latter surrounded by several concentric grooves.

Genital markings small tubercles; seven anteriorly, one just lateral to spermathecal pore levels, one farther mesially by a distance equal to two to three intersetal intervals, on the posterior margins of v and vi, the more lateral marking of the right side in vi lacking. Four tubercles in the vicinity of each male porophore, one just in front, one just behind, two just mesially so that one is presetal and the other is postsetal.

The center of each tubercle is slightly depressed and has the appearance of a single pore.

**INTERNAL ANATOMY:** Septum 5/6 muscular, 6/7–7/8 thickly muscular, 8/9–9/10 aborted, 10/11–11/12 muscular, 12/13–14/15 slightly strengthened with a few muscular fibers. Pigment, in circular muscle layer, reddish brown, sparse immediately under intersegmental furrows. Longitudinal muscle band at mD distinguishable only from 11/12.

Glandular (?) collar on esophagus behind gizzard low and rather thick. Intestinal origin in xv. Caeca simple, with smooth margins, arising in xxvii, turned upward or downward in xxvi but long enough to reach through xxv or well into xxiv. Typhlosole simply lamelliform from xxvii, becoming smaller posteriorly but still recognizable in the last segment.

Dorsal blood vessel, traced forward to brain, probably complete. Ventral blood vessel complete, bifurcating over subpharyngeal ganglion. Subneural, adherent to parietes, probably complete but not recognized in some of the anterior segments. Heart of ix lateral, on right side. Hearts of x–xiii esophageal (?), no filaments to dorsal trunk recognized. Segmental loops of viii apparently completely aborted. Lymph glands small, recognizable in several segments near posterior end. Brain in iii.

Holandric. Testis sac of x apparently horseshoe-shaped, of xi annular, both filled with coagulum, dorsal trunk and hearts included, vesicles as well as ventral trunk included in posterior sac. Testes large. Male funnels perhaps of normal size but thin and with few plications. Male gonoducts, without epididymis, pass into ental ends of prostatic ducts. Seminal vesicles small but not rudimentary. Pseudovesicles unrecognized in xiii and xiv. Prostates, of mature texture, in xvi, xvii–xx, or xxiii. Prostatic duct 2+ mm. long, with muscular sheen, markedly narrowed within parietes.

Spermathecae medium-sized, in vi and vii, adiverticulate. Duct shorter than ampulla, with thick (muscular?) wall, markedly narrowed within parietes. Ovaries fan-shaped, with numerous short egg strings.

GM glands on parietes, in xviii forming a nearly complete circle around each prostatic duct, stalks apparently short and confined to body wall.

**REPRODUCTION:** Spermatozoal iridescence is unrecognizable on male funnels and in spermathecae. Parthenogenesis is suspected, also male sterility.

**INGESTA:** Earth, rather slimy.

**REMARKS:** *Pheretima incongrua* has been known only from the descriptions of the original nine specimens. Two were immature and incomplete. Prostates are lacking in some. Spermathecae are hypertrophied or adiverticulate in some. All probably are more or less aberrant, presumably as a result of the accumulation of mutations permitted by the asexual method of reproduction. Except for GM locations, often highly variable in sexual forms, there are no good contra-indications to identification of the Formosan specimens as *incongrua*.

*Pheretima posthuma* (Vaillant, 1868)

*Pheretima posthuma*, GATES, 1937, Bull. Mus. Comp. Zool. Harvard College, vol. 80, p. 363.

**SPECIMENS EXAMINED:** Chao-Chow, Ping-tung, June 17, 1957, 17-5-14; D. E. Beck. (A.M.N.H. No. 3578.)

**EXTERNAL CHARACTERISTICS:** Segments, 64, 79, 96, 98, (old posterior amputees), 81 (recent posterior amputee), 112 (two specimens), 113 (three specimens), 114 (five specimens), 115 (seven specimens), 116 (eight specimens), 117 (two specimens), 118 (two specimens), 119 (one specimen), 121 (one specimen). Prostomium small, epilobous, tongue short and usually open.

Female pore median (all).

**INTERNAL ANATOMY:** Dorsal and ventral blood vessels complete, bifurcating respectively under brain and above subpharyngeal ganglion. Subneural, adherent to parietes, complete, bifurcating under or in front of subpharyngeal ganglion. Hearts of xii-xiii latero-esophageal, blood present in dorsal bifurcations.

Pseudovesicles rather small, present in xiii. None found in xiv. Spermathecae rather small, subesophageal. Ovaries fan-shaped, with numerous short egg strings.

**VARIATION:** Genital marking of left side of xix lacking (one specimen). Genital marking present on left side of xx (two specimens). Genital marking of left side of xix lacking, a marking present on left side of xvi (one specimen). Genital marking of right side of xix lacking, markings present on right and left sides of xv, left side of xvi, left side of xx (one specimen). The clitellum on the latter specimen is saddle-shaped on xv-xvi, reaching down only to the genital markings.

**ABNORMALITY:** Metamerism in region of i-iv abnormal (one specimen).

**LIFE HISTORY STAGES:** Male pores are recognizable on all juveniles, the smallest of which (contracted) is 30 by 2.5 mm. Prostate and duct in that specimen are represented by a blob of thin tissue (on the

parietes) in which gland and duct are not distinguishable. The male gonoducts, already quite obvious, disappear into anterior margin of the prostatic anlage. Testes and male funnels are recognizable but not testis sacs and seminal vesicles.

In somewhat larger juveniles seminal vesicles are recognizable as are prostatic ducts.

In some of the larger juveniles sites of genital markings are indicated by gaps in setal circles in which follicle apertures no longer are distinguishable. The setae presumably have been dehiscent and the follicles aborted.

The site of the female pore becomes recognizable as such in worms that as yet have no trace of clitellar glandularity.

REMARKS: *Pheretima posthuma*, as do *hupeiensis* (Michaelsen, 1892) and *peguana* (Rosa, 1890), has a definite pattern of GM location. The markings, in *posthuma*, always develop in the setal circles and are symmetrically placed in adults with reference to metameric equators. In *hupeiensis*, which may well have been mistaken for *posthuma* on several occasions, markings never are in the setal circle and usually appear to be intersegmental as they are in *peguana*.

Typically there are two pairs of markings in each of those three species. Individual variation from typical locations appears to be much rarer in *peguana* and *hupeiensis*.

*Pheretima* sp.

I

SPECIMEN EXAMINED: Taipei, May 9, 1956, 1-0-0; D. E. Beck. (A.M.N.H. No. 3579.)

EXTERNAL CHARACTERISTICS: Length, 82 mm. Diameter, 3+ mm. Segments, 124 (posterior amputee?). Color brown, behind first nine or 10 segments in dorsum only. Prostomium epilobous, tongue open and with a median groove that is continued anteriorly. Setae, in a complete circle on ii, 36/viii, viii/13, xviii/12. First dorsal pore at 11/12?

Sexthecal, pores minute, superficial, about  $\frac{1}{3}$ C apart, at 6/7-8/9. Male pores each in an indistinct area that is smaller than the adjacent markings.

Genital markings small tubercles with translucent centers. Six markings on viii, one presetal and one postsetal median, one presetal on each side and median to levels of spermathecal pores by a distance about equal to one intersetal interval, one postsetal on each side and farther mesially by a distance about equal to one intersetal interval. Slightly smaller markings on xviii, one presetal and one postsetal on



each side just median to the male pore area. A postsetal median marking may also be present on xviii.

**INTERNAL ANATOMY:** Septa 8/9-9/10 aborted, none thickly muscular. Pigment reddish, in circular muscle layer. Longitudinal muscle band at mD distinct from 11/12.

Esophageal collar represented by numerous small and discrete lobes with a slight iridescence. Intestinal origin in xvi. Caeca simple, with smooth margins, arising in xxvii and passing forward into xxiv. Typhlosole simply lamelliform from xxvii, becoming smaller posteriorly, unrecognizable behind eighty-eighth segment.

Dorsal and ventral vessel complete. Subneural present and adherent to parietes. Heart of ix, lateral, on left side. Hearts of x-xiii (latero?)-esophageal, filaments to dorsal trunk white. Dorsal portions of loops of viii passing to gizzard, ventral portions aborted. Lymph glands unpaired, small, present from xviii.

Holandric. Testis sacs subesophageal and possibly unpaired. Male gonoducts, without epididymis, pass into prostatic ducts just below ental bifurcation. Seminal vesicles small, each slightly constricted into two equal-sized portions. Pseudovesicles of xiii smaller, of xiv so rudimentary as to be almost unrecognizable. Prostates confined to xviii. Duct bifurcates entally, each branch passing to a discrete lobe of the gland.

Spermathecae protuberant from parietes. Diverticulum distinguishable as a round knob on anterior face.

**INGESTA:** Earth, with a few strands of plant tissue.

**REMARKS:** This specimen is of interest as it seems to indicate presence on Taiwan of a sexthecal species.

## II

**SPECIMEN EXAMINED:** Taipei, at Green Mountain, July 20, 1956, 1-0-0; D. E. Beck. (A.M.N.H. No. 3580.)

**EXTERNAL CHARACTERISTICS:** Diameter, 2+ mm. A considerable posterior portion of the body is lacking. Color dark brown, much lighter or lacking at segmental equators. Setae, present in a complete circle on ii, xviii/10. An area on each side of xviii that probably includes the male pore is very slightly depressed and may contain two or three tubercles, but they are so small and indistinct even after treatment with picric acid solution as to obviate more definite characterization.

**INTERNAL ANATOMY:** Septa 8/9-9/10 aborted. Intestinal origin in xv. Caeca simple, extending from xxvii into xxiii or xxii. Typhlosole, rudimentary anterior to xxvii, a high and simple lamella. Heart of ix,

lateral, on right side. Hearts of x-xiii (latero?)-esophageal. Subneural trunk present.

Holandric. Testis sacs unpaired and subesophageal. Seminal vesicles of xi and xii quite small, each deeply constricted into two halves. Pseudovesicles of xiii much smaller than the vesicles and than the ovaries. Pseudovesicles apparently lacking in xiv. Prostatic anlage confined to xviii.

Spermathecae slightly protuberant from parietes, four pairs, in vi-ix, well towards mL, probably opening at 5/6-8/9. Diverticular anlage, of the last three pairs, almost as large as the anlage of the main axis, as yet unrecognizable on the anlage in vi.

INGESTA: Earth.

PARASITES: Two large cysts on gut wall between gizzard and collar. Another large cyst on parietes in vii.

REMARKS: This worm is of interest, as it seems to indicate presence on Taiwan of yet another octothecal species.

*Pheretima candida* (Goto and Hatai, 1898)

*Perichaeta candida* GOTO AND HATAI, 1898, Annot. Zool. Japonensis, vol. 2, p. 77. (Type locality, Tapei-fu, northern Formosa. Depository of type, if still extant, unknown.)

*Amyntas tokioensis* (part), BEDDARD, 1900, Proc. Zool. Soc. London, p. 633.

*Pheretima candida*, MICHAELSEN, 1900, Das Tierreich, vol. 10, p. 259.

This species is known only from the original description, apparently of a single specimen. The gizzard, which develops in viii throughout the genus *Pheretima*, was said to be in segments ix-x, as it often does seem to be when septa 8/9-9/10 are aborted. However, septum 8/9 was thought to be thickened, and the aborted septa were supposed to be 9/10-10/11. Septum 10/11 was also said to be thickened!

A quadrithecal battery with pores at 6/7-7/8 and simple intestinal caeca provide but slight support for identity with *tokioensis*. The latter is known only from the brief description of a specimen that is no longer extant. Japanese zoologists appear to have found no worms they could refer to *tokioensis* which also must be regarded as a *sp. inq.*

*Pheretima papulosa* (Rosa, 1896)

*Pheretima papulosa* var. *sauteri* MICHAELSEN, 1922, Cap. Zool., vol. 1, pt. 3, p. 26. (Type locality, Dorf Kosempo. Type and only specimen in the Rijksmus. Nat. Hist. Leiden.)

More is known about *papulosa* than *candida*. The species has been recorded from Balighe in Sumatra, Biserat in the peninsular portion

of Thailand, Kengtung in the Shan Plateau of Burma, and Mong Mong Valley in Yunnan Province of China. Presence in some of those areas presumably is due to transportation, but nothing is known as to relationships with other species or as to the original home. *Pheretima rockefelleri* Chen, 1933, known only from three localities in Chekiang Province, China, is distinguished by characters that now appear to be of little, if any, taxonomic importance.

#### PERIONYX PERRIER, 1872

##### *Perionyx excavatus* Perrier, 1872

*Perionyx excavatus*, GATES, 1933, Rec. Indian Mus., vol. 35, p. 549. KOBAYASHI, 1938, Sci. Rept. Tohoku Univ., Sendai, ser. 4, vol. 13, p. 201 (Shinchiku, North Formosa).

SPECIMENS EXAMINED: Su Ao, Ilan Hsien, May 28, 1956, 6-8-3; D. E. Beck. (A.M.N.H. No. 3581.)

This species, perhaps originally from the vicinity of the Himalayas, undoubtedly is exotic in Formosa to which it probably was brought by man.

#### SUMMARY

The 13 species represented in the collections hitherto available from the island of Formosa are all megascoleids and, with a single exception, of one genus. Two of the 12 pheretimas have been represented only by individuals too young to permit specific identification. Five of the others, as is the perionyx, certainly are exotic (*elongata* from Malaysia, *posthuma* from southeast Asia, *californica* and *diffringens* perhaps from mainland China, *bicincta* from some part of the *Pheretima* domain east of Burma). *Pheretima papulosa* is peregrine, but its original home is unknown. The status of another (*candida*) is dubious. Two (*aspergillum* and *incongrua*) have been reported from the Chinese mainland, but little is known about their relationships and distribution. One species (*formosae*), presumably with biparental reproduction, certainly seems to be endemic in the island.

Reproduction, in three of the exotic pheretimas, is parthenogenetic but in the other two, as well as in the perionyx, is biparental.

Absent in all of the collections are the European, American, and African exotics which have been so widely transported since the days of Henry the Navigator. Most, if not all, of the Formosan exotics may then have been brought to the island prior to arrival of Europeans in the Orient.

