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An illustrated key to the earthworms of the Samoan Archipelago (Oligochaeta: Glossoscolecidae, Megascolecidae, Moniligastridae)

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Abstract—In order to facilitate the study of earthworms in the Samoan Archipelago, an identification key has been assembled. The key relies exclusively on external characters so that non-specialists may use it easily. In addition to previously reported species, four more were collected by the author or collaborators during the fieldwork leading to the preparation of the key: *Amynthas rodericensis* Grube 1879, *Pheretima (Pheretima) sangirensis* Michaelsen 1891 species group, *Pithemera pacifica* Beddard 1899, and *Polypheretima elongata* Perrier 1872. A short diagnostic description of each species is included to verify identifications. However, users should be aware that the key can give wrong results if attempting to identify species not included in the key. Although it may be applicable to the earthworms of other SW Pacific islands, misidentifications are possible. These problems arise because many of the species presently known from the Samoan Archipelago belong to very large and diverse genera, many species of which will key to the same point in this simple key based on external characters. The following species are covered in the key: *Pontoscolex corethrurus* Muller 1856, *Drawida barwelli* Beddard 1886, *Dichogaster reinckei* Michaelsen 1898, *D. affinis* Michaelsen 1891, *D. bolaui* Michaelsen 1890, *Amynthas corticis* Kinberg 1867, *A. gracilis* Kinberg 1867, *A. minimus* Horst 1893, *A. rodericensis*, *A taitensis* Grube 1866, *Metaphire californica* Kinberg 1867, *Perionyx excavatus* Perrier 1872, *Pheretima (Pheretima) montana* Kinberg 1867, *Ph. sangirensis* species group, *Pithemera bicincta* Perrier 1872, *P. pacifica, P. godeffroyi* Michaelsen 1899, and *Polypheretima elongata.*

Introduction

Until recently, rather little was known about earthworms from the Samoan islands. A few collections had been made (see Easton 1984) and some species were described based on material collected in American Samoa (Beddard 1899, Michaelsen 1900). In 1996 I visited Western Samoa for the purpose of collecting earthworms, mainly to locate *Dichogaster* species that might be present in the interior forests of the largest islands Upolu and Savai'i. Later I made contact with Don Vargo, a biologist interested in identifying earthworms collected from

American Samoa. One result of that contact is the present illustrated key to the earthworms of the Samoan Islands, followed by a short description of each species included.

This key will not reliably identify earthworms from any other South Pacific location, nor is it guaranteed to produce good results on earthworms collected from Samoa. This is because I cannot be sure that all earthworms actually present on the islands have been found, identified and included in the key. Many of the species represented belong to very large Asian genera for which there are no comprehensive, up-to-date keys. Therefore the key could give an incorrect identification of a worm not known to occur on the Samoan Islands, but which has the same outer features used in this key. In constructing the key I have tried to use the most easily located external characteristics. With practice, it will become possible to dispense with the key in some cases, for many of the species are quite distinctive and are easily recognized in the field. The best sources of information on the more difficult groups are Michaelsen (1900), Gates (1972) and Sims & Easton (1972). Easton (1984) provides most of the species records used to assemble this list of the earthworms known from Samoa. He includes distributional data, a key to the species mentioned in his paper, and morphological data on some of the species. It is also a good reference for Samoa and the region, since earthworms not yet known from Samoa may be among those in Easton (1984). A detailed introduction to the study of earthworms can be found in Jamieson (2000).

Basic equipment and techniques

The minimum equipment required for identification is a 10X hand lens. Better is a low power dissecting microscope capable of magnifications up to 30X. All observations will be easier if the worms can be pinned to a solid surface and viewed under water. For this I use a 10cm diameter dish with walls no more than 3 cm high, the bottom of which has been coated to a depth of 1 cm with a smooth layer of silicone rubber caulking compound or candle wax. Pins are easily inserted and withdrawn, and the rubber lasts for many years. The best pins are stainless steel insect pins, but any pins will do if one does not allow them to rust.

When collecting earthworm specimens it is important to look for individuals with a clitellum, a band-like structure which completely or almost completely encircles several segments of the body near the head end (in the Samoan worms, beginning anywhere from the 10th to the 20th segment). Such worms are sexually mature and will have all of the features necessary for identification using this key.

It is always easiest to work on preserved earthworms. The simplest method of preservation is to first kill the worms in alcohol (isopropyl alcohol and ethyl alcohol work well and are easily obtained). If relaxed, extended specimens are desired, anaesthetize the worms in 5% alcohol for 10 minutes or more then transfer them to 50% alcohol for one minute. Otherwise go directly to 50% alcohol. Next place them in 5% formaldehyde, with a least three volumes of fluid to every

one volume of earthworm body. After 24 to 48 hours, the worms can be rinsed with water and placed in 80% alcohol. If DNA sequencing is envisaged, worms should be preserved directly in 90% or stronger alcohol and no aldehydes should be used. Notes should be taken on the natural color of the worms when alive and when in the formaldehyde solution, because in some species colors change dramatically during preservation. For the purposes of scientific studies, voucher specimens should be preserved, labeled and identified, and then stored in airtight bottles in a safe place within an established institution of education and research. For the Samoan earthworm collections used in this paper, voucher specimens are in the author's collection.

Terminology is explained as the key proceeds. Each couplet contains an explanation and illustration of the parts referred to, unless a previous couplet has provided this explanation.

Key to the earthworms of the Samoan Archipelago

1.A. Setae 8 per segment and arranged in 8 regular rows, at least in the anterior portion of the body. (Setae are the small hair-like bristles on each segment, and can usually be felt by rubbing the worm body from tail to head.) (Fig. 1) 2

1.B. Setae more than 8 per segment throughout the body, possibly except in the first 2 or 3 segments, and arranged in a continuous ring around each segment. (Fig. 2). 6

2.A. Setae in posterior half of the body arranged in offset pattern to make 16 rows encircling the body; clitellum begins in segment 15 (Fig. 3) . . . . . *Pontoscolex corethrurus*

2.B. Setae not as above: grouped in 4 pairs in regular rows, clitellum (Fig. 4) begins before segment 15. 3

3.A. Clitellum covering segments 10–13 or 14, often very thin; conspicuous male pores on intersegmental furrows 10/11 (the actual pores are on small finger-like structures sometimes protruding from the openings always visible). (Fig. 5) . . . . . *Drawida barwelli*

3.B. Clitellum covering most of segments 13–20; no paired intersegmental pores at 10/11 and 11/12; pair of grooves (the acanthodriline male field) in segs. 17–19 (Fig. 6). 4

4.A. Dorsal pores commence near intersegment 5/6 or 6/7 . . . . . 5 (Dorsal pores are small openings in the intersegmental furrows on the dorsal side).

4.B. Dorsal pores commence much later, near 11/12 or 12/13, or farther back. . . . . *Dichogaster reinckei*

5.A. A single female pore on the ventral side of segment 14. . . . . *Dichogaster bolaui*
(Female pores are always on segment 14, except in *Drawida* and related species.)

5.B. Paired female pores in 14; midventral genital markings in some or all of furrows 7/8/9/10/11 . . . . . *Dichogaster affinis*

6.A. Clitellum covering 2 or 2.5 segments only, 14, 15 and part of segment 16 7

6.B. Clitellum covering 3 or 4 segments, 14–16 or 14–17 8

7.A. Spermathecal pores in intersegments 4/5–8/9. . . . *Pithemera bicincta* (Fig. 7)

7.B. Spermathecal pores in intersegments 5/6–8/9. . . . *Pithemera pacifica*

7.C. Spermathecal pores in intersegments 7/8, 8/9 . . *Pithemera godeffroyi*

8.A. Clitellum covering 14–17; ventral side of segments 17–21 (male field area) as in Fig. 8; worm with strong red-brown color and blue iridescence . . . . . *Perionyx excavatus* (Fig. 8)

8.B. Clitellum on 14–16 only 9

9.A. Pores on segment 18 (male pores) large, sphincter-like (Fig. 9). . . 10

9.B. Pores on segment 18 very small though they may be on an obvious bump 11

10.A. Spermathecal pores in 7/8, 8/9 (as in Fig. 7) . . . . . *Metaphire californica*

10.B. Spermathecal pores one pair in 7/8, pigmentation lighter or lacking within setal zones, giving striped appearance, male pores about 0.25 circumference apart . . *Pheretima sangirensis*

10.C. Spermathecal pores one pair in 7/8, pigmentation not striped, male pores about 0.5 circumference apart . . . . . *Pheretima montana*

11.A. Male pores on 18, usually on prominent bumps, distinct markings on ventral sides of segments 19–21 or more; ventralmost setae on either side of midventral line larger than their neighbors (Fig. 10) . . . . . *Polypheretima elongata*

11.B. Male pores on 18 but not necessarily on bumps; ventralmost two rows of setae not enlarged 12

12.A. First pair of spermathecal pores in 7/8 . . . . *Amynthas taitensis*

12.B. First pair of spermathecal pores in 5/6 . . . . . 13 (as in Fig. 4)

13.A. Four pairs of spermathecal pores (in some species these may be towards the dorsal side 14

13.B. Less than four pairs of spermathecal pores 15

14.A. Spermathecal pores towards the dorsal side (Fig. 11) . . . . . *Amynthas rodericensis*

14.B. Spermathecal pores on the ventral side . . . . *Amynthas corticis*

15.A. Three pairs of spermathecal pores . . . . . *Amynthas gracilis*

15.B. One pair of spermathecal pores . . . . . *Amynthas minimus*

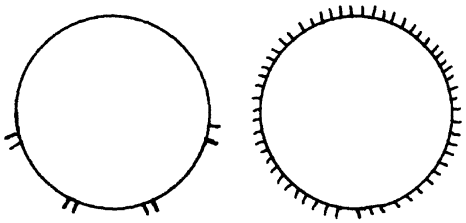

Figure 1. Lumbricine setal arrangement, cross sectional view. Figure 2. Perichaetine setal arrangement, cross sectional view.

Diagnosis of the species included in the key

All species included are listed alphabetically by genus. The information given will help to verify the identification obtained from the key. A full diagnosis of the characters needed to absolutely confirm the identity is not possible without providing details of internal organs. Since this key is based on readily observable external characters, I do not include the internal anatomy here. Users should bear in mind that this is a major limitation because two species could be very similar in the external characters but differ internally. To date no such matches are known in the earthworms from Samoa. More collecting of earthworm specimens might reveal species not presently known to occur in the Samoan Archipelago, and which could not be distinguished by this key.

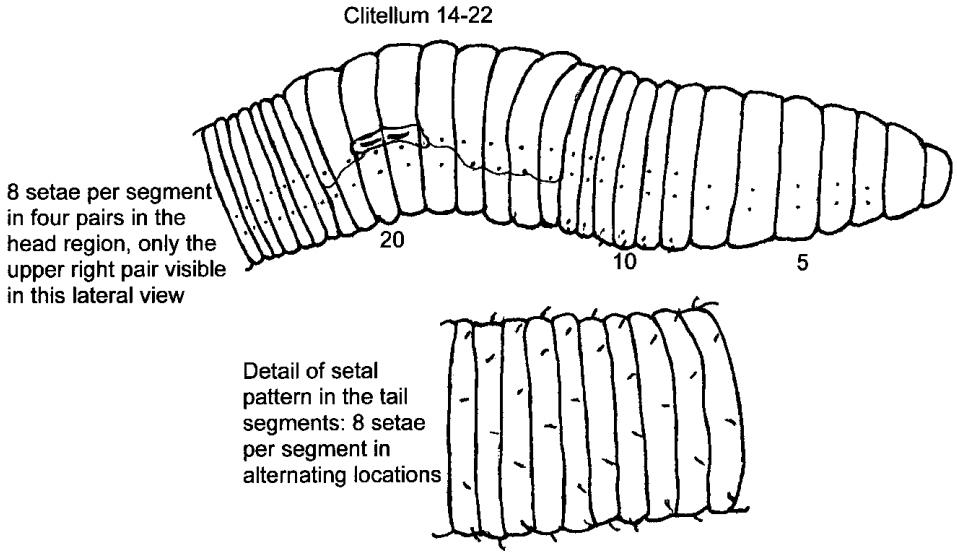

Figure 3. *Pontoscolex corethrurus*, lateral view of head end and portion of tail showing distinctive setal arrangement. The several broad segments about 15 segments back from the head are the clitellum, and within it are some longitudinal markings at the edge of the clitellum. These are the tubercula pubertatis. The portion of tail shown has 8 setae per segment with setae offset between segments.

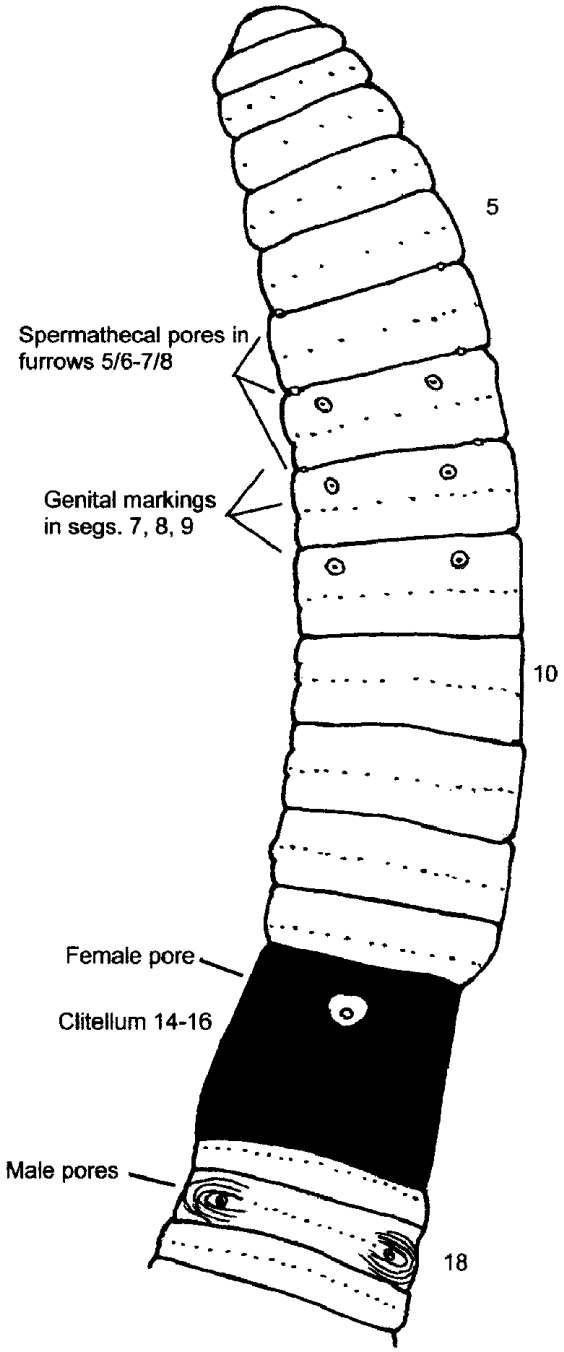

Figure 4. *Amynthas gracilis*, illustrating the spermathecal pores, male and female pores, and clitellum.

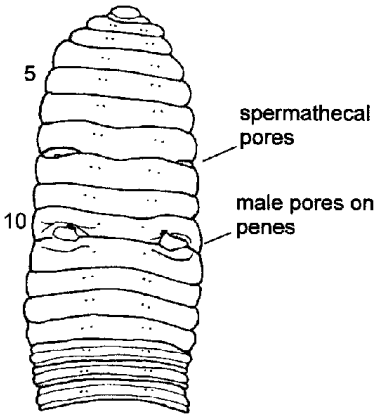

Figure 5. *Drawida barwelli*, ventral view.

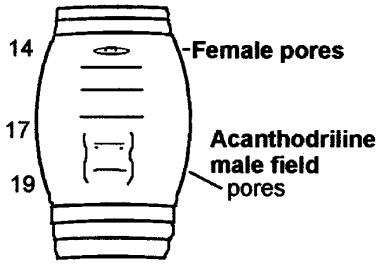

Figure 6. Schematic representation of the acanthodriline male field, showing paired longitudinal grooves over ventral surface of segments xvii–xix.

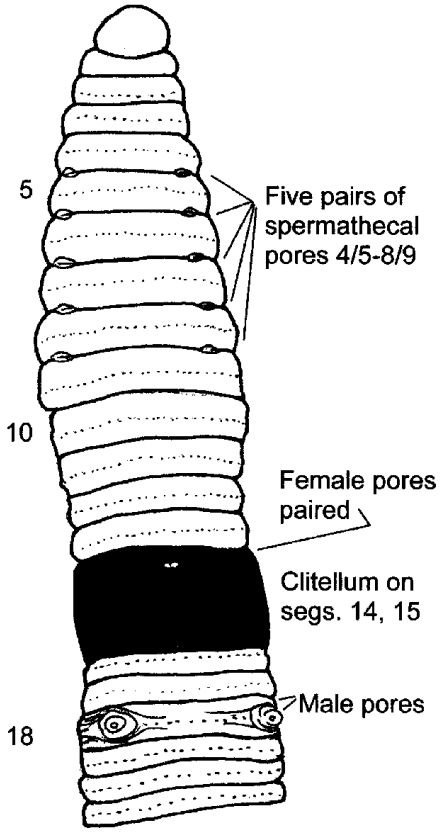

Figure 7. *Pithemera bicincta*, ventral view.

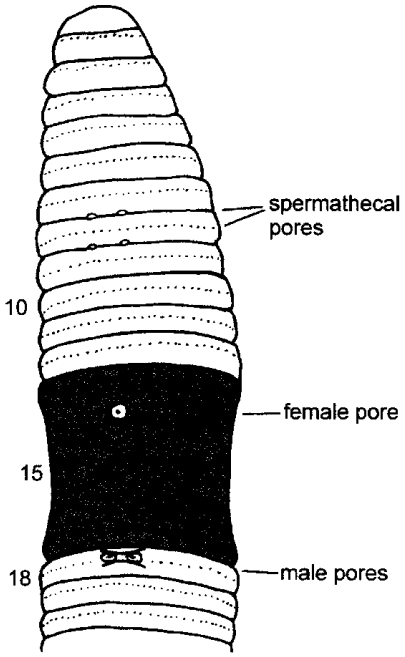

Figure 8. *Perionyx excavatus,* ventral view.

Amynthas corticis

Many setae per segment, male pores on body surface of segment 18, rather than deep in a pocket within the body, male pores sometimes associated with small circular markings, other small markings in some or all of segments 5–9, often near spermathecal pores; paired spermathecal pores in furrows 5/6/7/8/9; 50–170 mm. Family Megascolecidae, origin Asia.

Amynthas gracilis

Many setae per segment, male pores on body surface of segment 18, rather than deep in a pocket within the body, associated with clusters of small genital markings on segment 18, other genital markings paired in some or all of 6–9; paired spermathecal pores in furrows 5/6/7/8; 60–160 mm. Family Megascolecidae, origin Asia.

Amynthas minimus

Many setae per segment, male pores on body surface of segment 18, rather than deep in a pocket within the body, male pores surrounded by circular pad; genital markings paired and near level of spermathecal pores in 5–8; genital markings also midventral in some of 17, 19, 20 or 21; paired spermathecal pores in furrow 5/6; worms small at adulthood, only 30–60 mm. Family Megascolecidae, origin Asia.

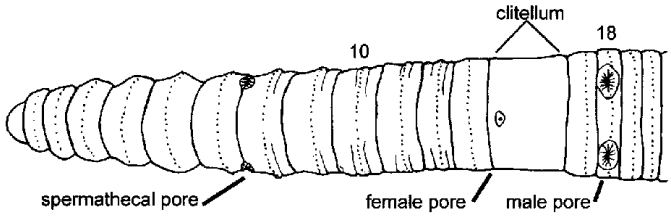

Figure 9. *Pheretima sangirensis* species group, ventral view.

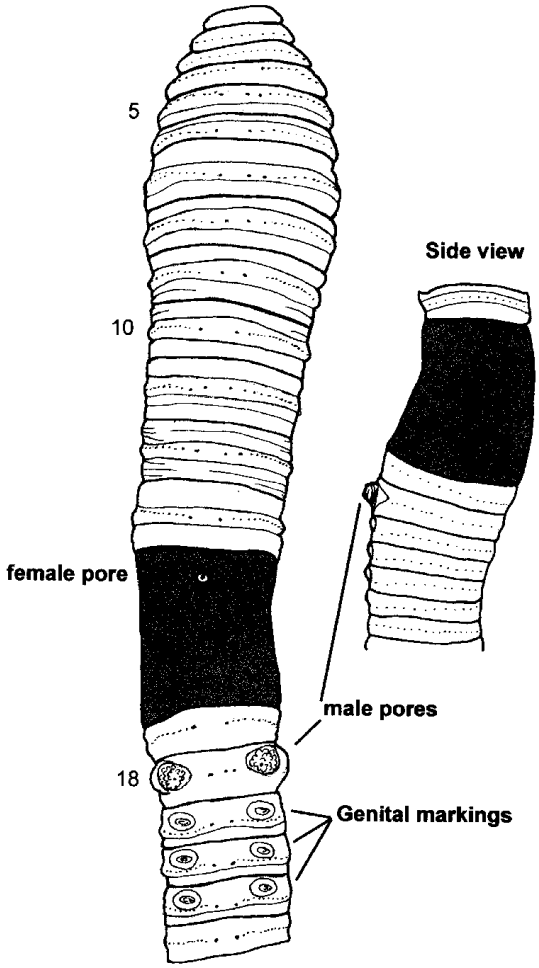

Figure 10. *Polypheretima elongata*, ventral view showing two rows of enlarged setae, genital markings and other features, lateral view showing the protruding male porophores.

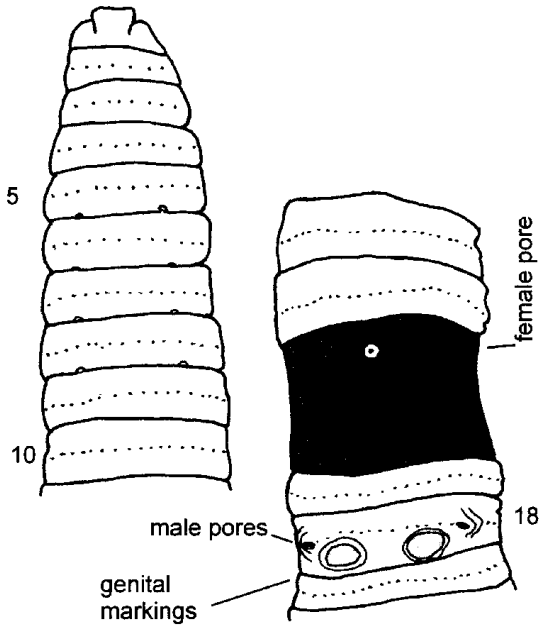

Figure 11. *Amynthas rodericensis*, dorsal view of head segments, showing dorsally-placed spermathecal pores, and ventral view of male field area.

Amynthas rodericensis

Many setae per segment, male pores on body surface of segment 18, rather than deep in a pocket within the body, paired circular or oval markings near male pores in 18; paired spermathecal pores in furrows 5/6/7/8/9 on dorsal side. Family Megascolecidae, origin Asia.

Amynthas taitensis

Many setae per segment, male pores on body surface of segment 18, rather than deep in a pocket within the body, associated with four small post-setal genital markings in 18; paired spermathecal pores in furrows 7/8/9. Family Megascolecidae, origin Asia.

Dichogaster affinis

Eight setae per segment, arranged in pairs; clitellum saddle-shaped over segs. 13–20 or 21, paired parallel grooves on ventral side of segs. 17–19; first dorsal pore in intersegmental furrow 5/6 or 6/7; female pores paired in 14; single genital markings midventral at intersegmental furrows 7/8/9/10. Family Megascolecidae, origin Africa.

Dichogaster bolaui

Eight setae per segment, arranged in pairs, clitellum annular covering segs. 13–20, paired parallel grooves on ventral side of segs. 17–19; first dorsal pore in

intersegmental furrow 5/6 or 6/7; a single female pore in 14; no genital markings anterior of clitellum. Family Megascolecidae, origin Africa.

Dichogaster reinckei

Eight setae per segment, arranged in pairs, clitellum covering segs. 13–19; paired parallel grooves on ventral side of segs. 17–19; first dorsal pore in intersegmental furrow 12/13; spermathecal pores 7/8/9, ventral portion of segments 7–9 pale, swollen. Family Megascolecidae, origin Samoa (Pago Pago).

Drawida barwelli

Unpigmented worms of variable length 5–10 cm.; 8 setae per segment in regular rows and paired within segments. Dorsal pores are usually present somewhere in the body, varying from a few intersegmental furrows to almost all of them. The clitellum covers segments 10–13 or 14 but it can be difficult to locate precisely because in this genus (and the rest of the family Moniligastridae) it is only one cell layer thick, unlike all other earthworms. The male pores have large openings at 10/11, and may show penis-like structures protruding from the pores. No other earthworms known from Samoa will have this feature at this location. Family Moniligastridae, origin South Asia.

Metaphire californica

Many setae per segment; male pores on a small protrusion often retracted in a pocket within the body wall segment 18; paired spermathecal pores in furrows 7/8/9; no genital markings. Family Megascolecidae, origin Asia.

Perionyx excavatus

Many setae per segment, spermathecal pores close together in 7/8/9; male spores on segment 18 in small pits in which there may be several setae visible, the pits are close together like the spermathecal pores; dorsal side deeply colored red-brown with a bluish iridescence; length 4–8 cm. Family Megascolecidae, origin South Asia.

Pheretima montana

Many setae per segment, male pores deep within pockets inside body wall, openings of pockets appear like large sphincters in segment 18; similar large spermathecal pores one pair in furrow 7/8. *P. montana* is distinguished from the next species by having widely separated male pores 0.5 of the body circumference apart and relatively solid dorsal pigmentation. Family Megascolecidae, origin Asia.

Pheretima sangirensis species group

Many setae per segment, pigment lacking or fainter around setae; male pores deep within pockets inside body wall about 0.25 circumference apart, openings of pockets appear like large sphincters in segment 18; similar large spermathecal pores one pair in furrow 7/8. Family Megascolecidae, origin Asia.

Pithemera bicincta

Many setae per segment; male pores on body surface in 18; female pores paired and close together; clitellum covering 14 and 15 only; 5 pairs of spermathecal pores (furrows 4/5–8/9). Family Megascolecidae, origin Asia.

Pithemera pacifica

Many setae per segment; male pores on body surface in 18; female pores paired and close together; clitellum covering 14 and 15 only; 4 pairs of spermathecal pores (furrows 5/6–8/9). Family Megascolecidae, origin Asia.

Pithemera godeffroyi

Many setae per segment; male pores on body surface in 18; female pores paired and close together; clitellum covering 14 and 15 only; 2 pairs of spermathecal pores in furrows 7/8/9. Family Megascolecidae, origin Asia.

Polypheretima elongata

Many setae per segment, the setae of ventralmost two rows are significantly larger than the other setae; body unpigmented, long and slender; male pores on turret-like bumps in segment 18; paired genital markings in some or all of segments 19–21 on the ventral side. Family Megascolecidae, origin Southeast Asia.

Pontoscolex corethrurus

8 setae per segment, in regular rows and paired in the anterior portion of the body, but changing to a different regular pattern in which the setae of each segment are evenly spaced around the circumference of the body. In every other segment, the setae are in the same 8 lines, but in two adjacent segments, the lines of setae are offset by about one half the intersetal space. The clitellum is from 15–22 and is interrupted at the ventral side, body is pale and unpigmented, and there may be a slight bulge in the body about one third of the body length from the tail. Under magnification one can see a row of pores on each side of the body. These are the openings of the excretory system. All other pores are minute and inconspicuous and there are no dorsal pores. In life the first segment and snout often are elongated as a long thin proboscis when the worm is exploring the area. Size 50–80mm. Family Glossoscolecidae, origin South America, probably Brazil.

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