

Morphological characters of the pheretimoid earthworms in North America north of Mexico

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As of 2016, sixteen species of pheretimoid earthworms have been recorded in North America north of Mexico. They belong to four genera, *Amynthas*, *Metaphire*, *Pithemera* and *Polypheretima*, with only one species for each of the last two genera. All morphological descriptions in this document apply only to the 16 species, and should not be regarded as a general description for the pheretimoid earthworms as a whole. The descriptions are not exhaustive. Only characters used for diagnosis in the study are included (Figure 1).

Body size

The body length of these species range from around 30 cm in *Amynthas carnosus* to only 2 cm in *Amynthas minimus*. Many of the species, such as *Amynthas agrestis* and *Amynthas corticis*, have large intraspecific variations in their size. Altogether, body size in most cases is a useful but not reliable character in species identification. In addition, an earthworm specimen may be relaxed and stretched, or contracted and shortened, making it even harder to use the measurement of body length for species identification. The same goes for body width, which is frequently measured at the clitellum.

Body shape

Some species are relatively slender, such as *Amyntas corticis* and *Polypheretima elongata*; some species are relatively robust, such as *Metaphire hilgendorfi*. However, just as body size, shapes of earthworms change dramatically in an individual and the measurement is influenced by specimen anesthetization and/or fixation. The cross section is generally circular.

Color

Colorations and the associated patterns can come from pigments in the body wall, as well as colors of internal organs, tissue, coelomic fluid, and gut contents. The latter is due to semi-transparency of the body wall in many species. The general overall colorations are brown, dark red, pink, green, and greenish brown. Some species have very consistent colors; for instance, *Amyntas hupeiensis* is almost always green or dark green. Others can be more variable. For instance, *Amyntas gracilis* can be dark red, red, or light red; *Amyntas corticis* can be brown or green. Similarly to body size, coloration is a useful but not very reliable character for species identification. Moreover, colors change dramatically in formalin and ethanol, the two most common chemicals for fixation and preservation. For preserved specimens, colors also change through time, as pigments are gradually degraded in the preservatives, especially ethanol. There is no good way to preserve the color except taking photos.

Clitellum

The most apparent structure on a mature pheretimoid earthworm is its clitellum. Clitellum is always in XIV-XVI, annular, unsegmented, and usually without setae (*A. gracilis* and *A. morrisoni* are two exceptions; they have setae on XVI). However, segments may still be visible on young adults. Compared to common European non-native species, which have a saddle-shaped clitellum composed of more than three segments, pheretimoid earthworms have an annular (ring-like), shorter clitellum that is also closer to the anterior end of their bodies. In the US, where most common earthworms are non-native, these differences are one of the primary diagnostic characters for pheretimoids.

Segment numbers

Numbers of segments can vary greatly even within a species. Conventionally segments are indicated using Roman numerals (e.g., VII-IX); intersegmental furrows (the visible external boundary between adjacent segments) are indicated using slashes between Arabic numerals (e.g., 6/7/8/9). The first segment with setae is segment II, and clitellum is on XIV-XVI. One can count the position of organs or pores by using the mouth or clitellum as the reference starting points.

Setae

The pheretimoid earthworms have numerous setae (as many as 150) per segment (perichaetine). These setae arrange in a ring around all segments (around the equator of all segments), except the first and last ones. The numbers of setae vary slightly from one segment to another and from one specimen to another. Within-specimen variations are usually largest in the pre-clitellar region. This type of setal arrangement is quite different from that in the earthworm family Lumbricidae, which has only eight setae per segment in four pairs (lumbricine), and from native North American species which also have a lumbricine setal arrangement.

Dorsal pores

Dorsal pores are situated in the intersegmental furrows along the mid-dorsal line. The first dorsal pore may occur in any furrow between 9/10 and 12/13, depending on the species.

Male pores

Male pores are always widely paired, ventral in XVIII in amphimictic specimens and are still present in some parthenogenetic specimens. They could be superficial (the pore is located at the exterior of the body) or inside a copulatory pouch. There are usually genital markings associated with male pores on XVIII and/or the surrounding segments.

Copulatory pouches

Copulatory pouches are invaginations of the ventral body wall surrounding the male pores. A copulatory pouch contains the primary male pore and its opening is the

secondary male pore (frequently referred to as the “male pore”). A copulatory pouch can be quite shallow and confined within the body wall or large and penetrating into the coelom. Sometimes, recognition of a copulatory pouch may be more difficult than expected. A superficial male pore may look like it is within an invagination due to contraction of muscles around the male pore during specimen preservation. In contrast, strong muscle contraction may cause a copulatory pouch to be fully everted and look like a cone-shaped superficial male pore. These deformations of the male pore area make the recognition of copulatory pouches sometimes challenging.

Female pores

Female pores are usually single but occasionally closely paired, mid-ventral in XIV (the first segment of clitellum). They are generally easy to find, as the color surrounding the pores is usually lighter than that of the clitellum.

Spermathecal pores

There are one to five pairs in amphimictic individuals, usually at or close to the intersegmental furrows (the visible external boundary between adjacent segments). During copulation, sperm is passed from one individual’s male pores into the spermathecal pores of a second individual. These are eventually stored in the latter’s spermathecae. The numbers and positions of the pores are important species identification characters. The pores are usually ventral, 0.2-0.4 body circumferences apart, but can be lateral or dorsal in some species. They are sometimes miniature or could be buried deep in the intersegmental furrows in contracted specimens and may not be visible externally.

Genital markings

Genital markings could be pre-clitellar (anterior to the clitellum) or post-clitellar (posterior to the clitellum). Pre-clitellar genital markings are usually associated with spermathecal pores; post-clitellar genital markings are usually associated with male pores. Depending on the size and shape, genital markings are sometimes referred to as

tubercles, papillae or pads. Some genital markings are connected internally with accessory glands.

Spermathecae

Spermathecae are the organs that store sperms received from the “donor” individual during copulation. There are one to five pairs in amphimictic individuals. Spermathecae open to the body wall through spermathecal pores near the intersegmental furrows anterior to each segment. For instance, a spermatheca in IX usually has its spermathecal pore in 8/9.

Prostate glands

Amphimictic individuals have one pair of large, racemose prostate glands in XVIII, usually extending anteriorly and posteriorly for several segments. The ducts of prostate glands are always in XVIII, where they meet with sperm ducts (vas deferens) and connect to the male pores. The shape of the glands and the size of the glands relative to the body are important species identification characters. The relative size is usually indicated using the numbers of segments the prostate gland covers (e.g. XVII-XIX). This range, as well as the shape, varies to some degree within a species.

Caeca (Intestinal caeca)

Caeca, or intestinal caeca, are a pair of pouches protruded from the gut. They originate from either XXVII or XXII and extend anteriorly for several segments. The extents to which they extend are usually reported in taxonomic literatures, but they vary even within species. Caeca may be simple (finger-like), with shallow incisions, or manicate (hand-shaped, i.e., complex with several finger-like, deep incisions). These shape differences are important for species identification.

Accessory glands

Some species or individuals have accessory glands, extending from the body wall into the coelom. When present, these glands are usually connected to the corresponding genital markings externally.

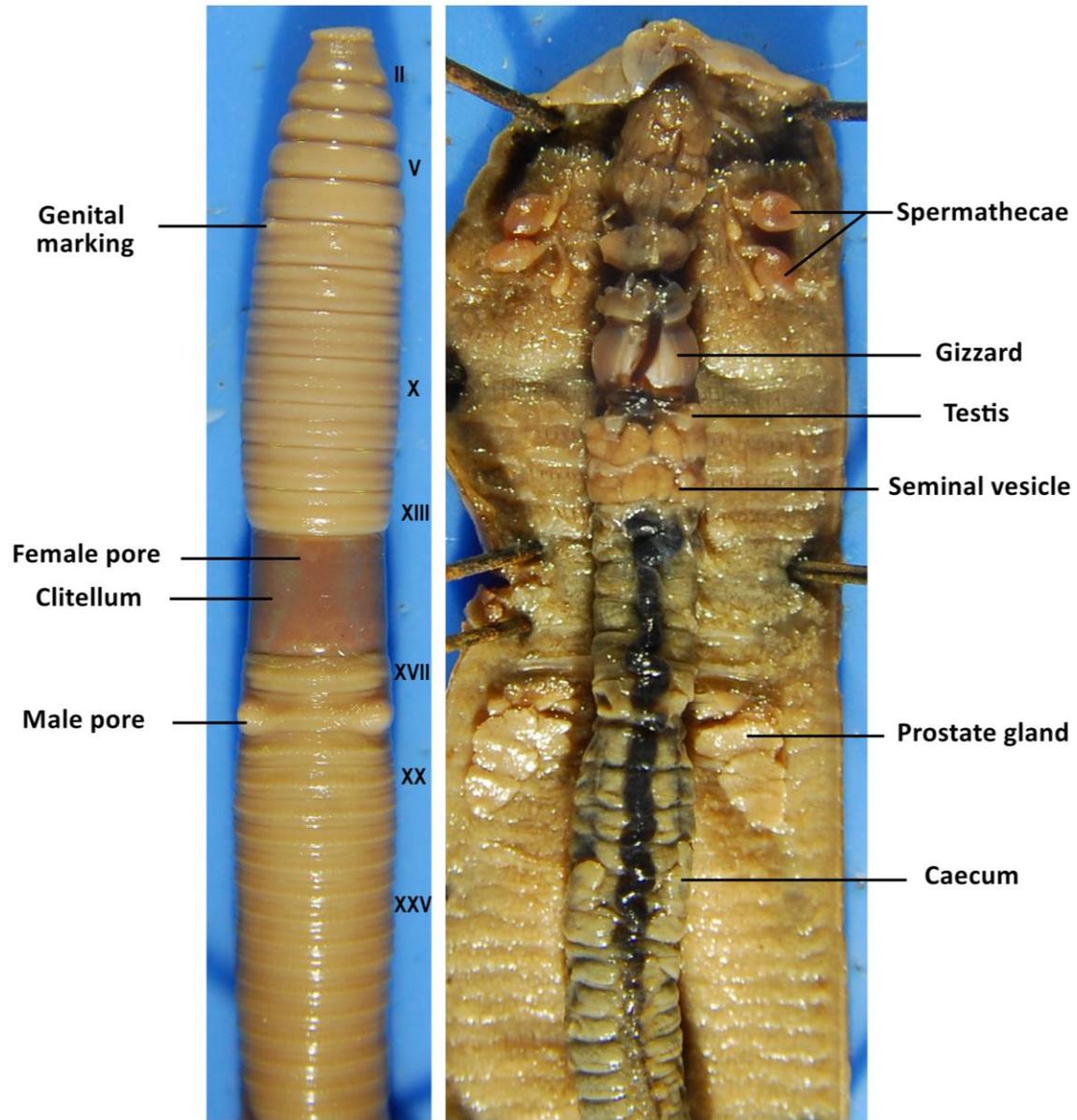


FIGURE 1. External (left, ventral view) and internal (right, dorsal view) morphology of the pheretimoid earthworms.