FIELD GUIDE

EARTHWORMS IN HEIRLOOM RICE FIELDS OF THE PHILIPPINE CORDILLERA AND THEIR INTEGRATED MANAGEMENT

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INTRODUCTION

Earthworms are beneficial to the soil ecosystem as they help modify the physical, chemical, and biological properties of the soil (Science Learning Hub 2012). These organisms recycle and decompose organic materials, turning them into compost fertilizers. Their continuous burrowing into the soil improves the soil structure. Earthworm castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium, thereby increasing the availability of nutrients (in the soil) to the plant compared to undigested soil. They contain 5 times more than the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than what is found in good topsoil. Several researchers have demonstrated that earthworm castings contribute to the excellent aeration, porosity, structure, drainage, and moisture-holding capacity of the soil. The content of the castings, along with natural tillage (the result of the worms' burrowing action), enhances the permeability of water in the soil, thus bringing soluble nutrients down to the plant roots and boosting root penetration. Earthworms also serve as food resources for small mammals and birds. However, not all earthworms have beneficial effects on plants and the environment.

This guide discusses the pest and non-pest species of earthworms as well as their integrated management. Different species of earthworms were collected in the Cordillera Administrative Region (CAR) of the Philippines, particularly in the provinces of Ifugao, Kalinga, and Mountain Province, and were studied.

General Description and Characteristics of Earthworms

What are Earthworms?

Earthworms (*vermis* in Latin) are soil-dwelling animals without backbones. They have the following characteristics:

- Have a segmented body resembling a cylindrical tube; the first segment at the head end which protrudes has the mouth while the last segment at the tail end has the anus.
- Have a ring-like fleshy structure around their body known as *"clitellum"* or the saddle/reproductive ring (Figure 1).
- Do not have legs; they have numerous bristly hairs called *"setae"* in each segment which provide them some grip to move through the soil.
- Breathe through their skin which is covered by a moist mucous layer that serves the main purpose of respiration (gaseous exchange).
- Stay in burrows or in soil or leaf litter during daytime and surface out at night.
- Reproduce by mating of two individuals despite most earthworms being hermaphrodites, meaning having both male and female sexual organs; some species also reproduce parthenogenetically (reproduce on their own with the egg not fertilized by the sperm).
    - During mating, sperms (male sex cells) are exchanged and stored in one of the segments of the body. The cocoon casing is then produced by the *clitellum* (the band seen on mature worms) and the worm "backs out" of the casing, depositing the sperms and eggs into the casing as it passes over the appropriate segments.
    - The cocoon (2-4 mm in diameter) then incubates in the soil for several months, depending on soil conditions, before one young worm (or two for

some species) emerges. New worms will generally only emerge when soil moisture and temperature conditions are suitable.

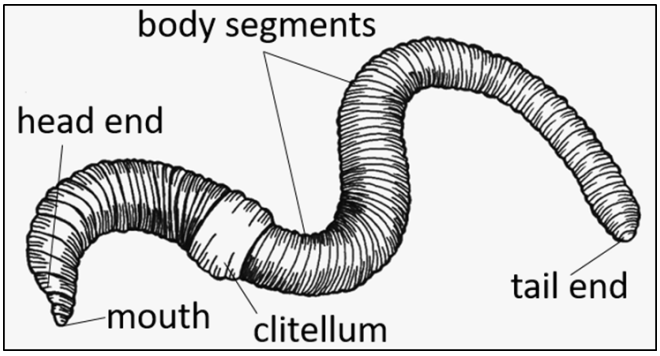


Figure 1. Diagram of an earthworm.
(Source: https://www.kindpng.com/imgv/iRTbmJb_collection-of-free-worm-drawing-download-on-ui/)

What do earthworms eat?

- They feed on decaying organic matter such as leaf litter or crop residues. Their digestive system runs through the length of their bodies. They have no teeth and they digest their food through a thick-walled muscular gizzard (gastric mill) that grinds the food.

Why are earthworms slimy?

- They may feel smooth and slimy to the touch but they actually have tiny, hair-like bristles or setae. Each of the body segments, called annuli (ring-like segments), use their setae to make the earthworm move through the dirt. Without the setae, earthworms would find it much more difficult to burrow underground.

How are adults and juvenile earthworms identified?

- Adult earthworms have a clearly developed clitellum (may form a ring around the body or saddle, that is only on the back side of the earthworm) while juveniles do not.
- Size is not a good indicator of maturity as adult earthworms typically range in size from 2 cm to 15 cm depending on species.
- Identification of earthworms is usually achieved through morphological comparison (external and internal morphology) although DNA-based methods are being developed which are proving to be useful in identifying juveniles.

How many kinds of earthworms are there?

- There are more than 4,000 different species of earthworms in the world, many of them not even named or studied. In the Philippines, there are more than 200 native and introduced species.

They are mainly divided into two distinct groups based on their feeding strategies:

1. Detritivores - which feed on plant litter and mammalian dung (surface feeders).
2. Geophages - which feed in the deeper layers of the soil or plant material.

These two groups can be further subdivided into three groups based on where earthworms live within the soil and feed in (diet) (Figure 2):

1. Surface-dwelling or litter dwellers or non-burrowing earthworms, also called the composting worms *(Epigeic earthworms),* do not make burrows but live on the soil surface or just below it – in the leaf litter and in compost. These species do not ingest large amounts of soil. They rapidly consume the organic matter that is partially decomposed. They reproduce very quickly and are not common in most

agricultural soils. They are usually bright red or reddish-brown, small and usually less than 3 inches long when mature. Example: Compost/Manure or Red Earthworm, *Eisenia foetida* and *Amynthas diffringens.*

2. Shallow-burrowing or topsoil dwelling or topsoil earthworms, also called redworms, grayworms, or fishworms *(Endogeic earthworms),* live primarily in the upper 2 to 3 inches of the soil (top soil layer) and range in size from 1 to 5 inches. They eat soil which is high in organic matter. They do not build permanent burrows, but instead they randomly burrow throughout the topsoil, ingesting residues and mineral soil as they go. They are pale colored — pink, grey, green or blue — and make horizontal burrows through the soil to move around and to feed in. They secrete mucus from their skin which lines up the horizontal burrows to enable them to crawl underground easier with their setae. Some can burrow deep into the soil up to 12 inches. For example: *Pontoscolex corethrurus* and *Polypheretima elongata.*

3. Deep-burrowing earthworms or subsoil dwellers *(Anecic earthworms)* include the common garden worm or common nightcrawler, *Lumbricus terrestris* (grey/pink color which is about 15 cm long), and they make permanent vertical burrows/tunnels in the soil. They pull decaying plant matter into their burrows. The deep burrowers create long tunnels/burrows that go down at least 3 m, allowing deep penetration of water and oxygen. At the same time, they bring up minerals from the soil into the surface. They construct middens over the mouth of their burrows. Middens are a mixture of plant residues and castings (worm feces) and could serve as protection as well as a food reserve. Because nightcrawlers require crop residues at the surface to pull down into their burrows, they were not expected to be seen in the experiment fields which

routinely leave no surface residue cover (i.e. moldboard-plowed). The burrows serve to increase aeration, drainage, and root penetration. These make them important in soil development and agricultural production as they enhance soil fertility and productivity through increasing the availability of mineral nutrients to plants and integrating undecomposed surface residues into the soil, thereby reducing loss of nutrients, increasing the organic matter content, and improving soil structure. The negative ecological changes in the ecosystem of the terraces like overlogging of watersheds have led the anecic worms to burrow into the bunds of the terraces for lack of water (Rafael D. Guerrero III, Personal Communication).

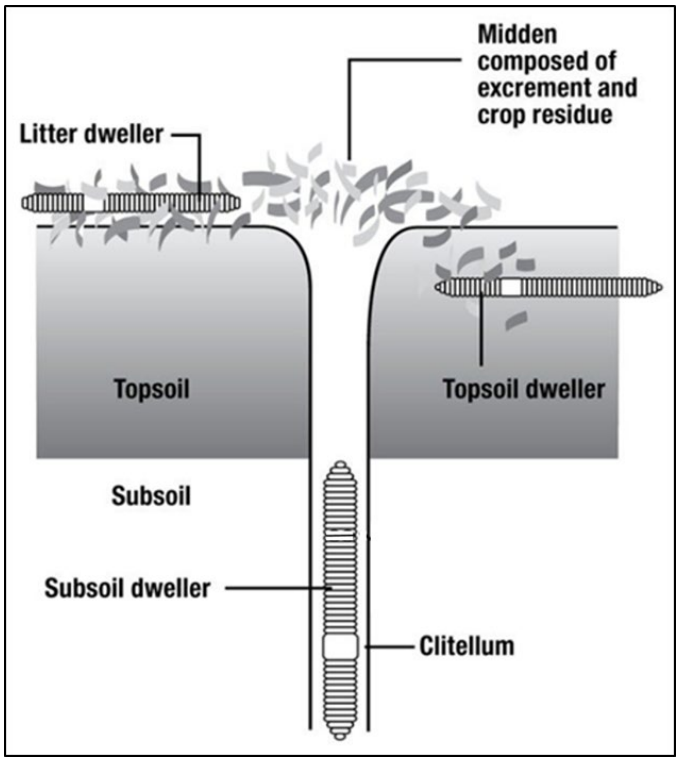


Figure 2. Three major groups of earthworms.
(Source: https://extension.psu.edu/earthworms)

Earthworm Species Diversity in Heirloom Terraced Rice Fields of the Philippine Cordilleras

To understand earthworm species diversity, earthworm collections were done by the DA-RFO-CAR-IRRI-LGU Heirloom Rice Project team members at the terraced rice fields of selected municipalities and barangays cultivating heirloom rice in three Cordillera Provinces: Mountain Province (88 samples), Kalinga (62 samples), and Ifugao (83 samples). The following habitats were sampled for earthworms: the terraced wall, the terraced rice fields, and the adjacent areas to the terraced rice fields. Samples were examined in collaboration with earthworm taxonomists Dr. Samuel W. James of Maharishi University of Management, USA and Dr. Nonillon M. Aspe of the Mindanao State University at Naawan, Naawan, Misamis Oriental, Philippines. Furthermore, these earthworm species were grouped according to dominant and less dominant species based on their abundance.

There were three dominant species recorded which are also of most concern to rice farmers:

1. *Sparganophilus* cf. *tamesis* Benham, 1892 (Family: Sparganophilidae)

Species diagnosis. Length, 80-175 mm. Width, 1-2.5 mm. Calciferous gland and gizzard, absent. Hearts, lateral and moniliform in segments 7-11. Nephridia, holoic, absent in cephalic region (segments 1-12). Nephropores, inconspicuous, in AB. Setae, paired. Lateral lines, absent. Seminal vesicles, two pairs, in segments 11 and 12. Holandric epididymis, present. Longitudinal musculature, fasiculate. Color, unpigmented. Anus, terminal slit-like.

Remarks. This species is thread-like, semi-aquatic to aquatic, living at the margins of water or less commonly under water in the sediment. It exhibits oxygenation behavior by placing its tail at the water surface. Typically, it eats dead organic matter. It was recorded in England, France, and in the eastern states of the USA and is, thus, an introduced species to the Philippines. It is of biggest concern to rice farmers in the rice terraces as it is seen in high numbers and is considered destructive to rice plants. This species was most frequently encountered in the municipalities/barangays of Ifugao and Kalinga Provinces (Figures 3-4 and Figure 9). It was not encountered in the earlier surveys done by Joshi et al. (1999 & 2000). However, some *Sparganophilus* in Balbalasang, a barangay in Balbalan, Kalinga, were found back in 2001 (Samuel W. James, Personal Communication) but were first identified in Nueva Ecjia in 2017 as *Sparganophilus* (Nonillon M. Aspe, Personal Communication). This is the first time the thread or wire-like worm habituating the Cordilleras was described and identified up to species level.

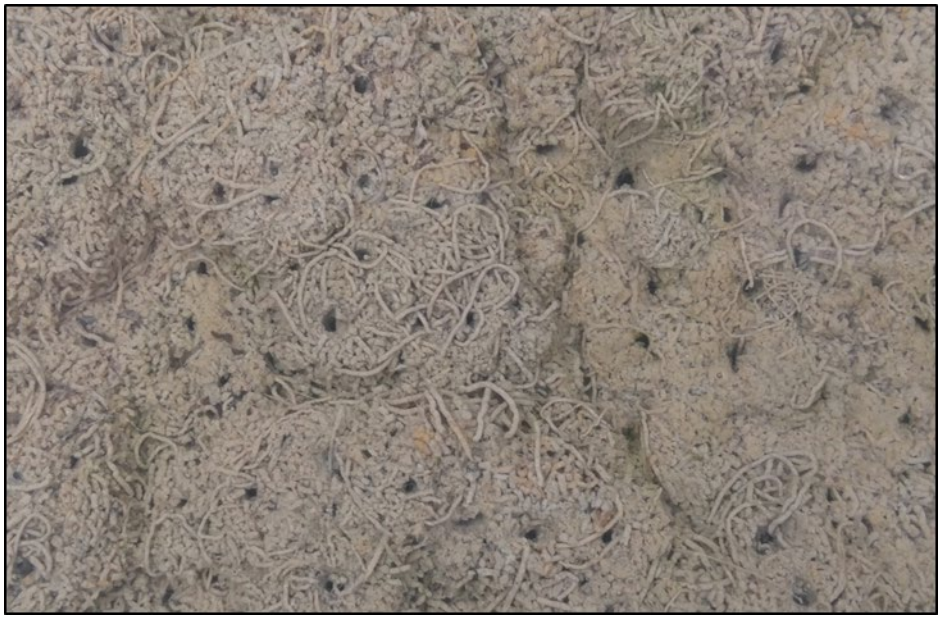


Figure 3. Thread-like earthworm (*Sparganophilus* cf. *tamesis*) on the soil surface of terraced fields with water, Barlig, Mountain Province, Philippines.

Figure 4. Thread-like earthworm (*Sparganophilus* cf. *tamesis*) with part of their body in the soil-water surface, and presence of numerous pin-sized holes on the soil surface of terraced fields, Barlig, Mountain Province, Philippines.

The rest of the earthworm species listed below have been previously reported by Joshi *et al.* (1999), including the giant earthworm (*Pheretima* spp.).

2. *Polypheretima elongata* (Perrier, 1872) (Family: Megascolicidae) is of Asian origin but is a widespread invader around the world. It can damage young rice plants in the paddy field when the population becomes very large. It is abundant in terraced rice fields.

Species diagnosis. It has a clitellum covering segments 14-16, encircling the body completely. It has no pigmentation but has more than eight setae per segment and a pair of conspicuous bumps on the ventral (lower) side of segment 18 (which bear the male pores). Associated with these bumps may be several paired smaller pads on segments 19-21 or more. The ventral most setae on each segment are typically larger than the more dorsally placed ones. Adult sizes range from 10 to 20 cm.

Remarks. As early as 1972, Gates had cited this species as a pest, stating that it causes severe seepage losses from the mountain terraces of Ifugao.

3. *Pheretima* spp. Kinberg, 1867 (Family: Megascolecidae)

Species diagnosis. It is dark, 200-300 mm long, and has approximately the diameter of an index finger. Its distinguishing feature is the presence of nephridia (small excretory organs) on the spermathecal ducts. Body is circular in cross section, with numerous setae regularly arranged equatorially around each segment; setae absent on first and last segments. Male pores paired within copulatory bursae opening on segment 18; one or more pairs of spermathecal pores in intersegmental furrows between segments 4/5 and 8/9. Clitellum annular, covering three segments (14-16) and completely encircling the body. Single female pore midventrally on segment 14. Genital markings, usually absent. Internally, esophageal gizzard usually originating in segment 8; a pair of caeca originating in segment 27, extending forward; septa in segments 4/5-7/8, 10/11-12/13, thickened or slightly thickened, lacking in segments 8/9 or 9/10 in some species. Ovaries and funnels free in segment 13. Male sexual system holandric, with paired testes and funnels enclosed in sacs in segments 10 and 11 and seminal vesicles in segments 11 and 12. Spermathecae a single pair, multiple pairs, or sometimes single and located midventrally. Nephridia on spermathecal duct, present. One pair of prostate glands, racemose. Copulatory bursae, present; secretory diverticula on coelomic surface of copulatory bursae, lacking.

Remarks. This species is abundant in pigpens, coops, forest areas, and along the terrace walls. It is a native species and is considered destructive along the terrace walls. This is the largest earthworm species, also referred to as Giant Earthworm.

Simple Diagnostic Features to Identify the Three Dominant Earthworm Species in the Heirloom Rice Fields of the Cordilleras

The three earthworm species can be easily diagnosed whether they are destructive or not in terraced fields based on the following characteristics: appearance, size, color, habits, habitats, and castings.

Species: *Sparganophilus* cf. *tamesis*

- Thread-like appearance (Pancit size - thinnest) (Figures 5).
- Length 80-175 mm. Width 1-2.5 mm.
- Half of their distal body is seen at the water surface.
- On slight disturbance of the paddy water surface, they quickly bury inside the soil.
- Present in both semi-aquatic to aquatic environments.
- No castings seen in rice paddies if there is water; if no standing water on soil surface, castings are very fine and small.
- Not destructive in terraced rice fields.

Figure 5. Dense population of *Sparganophilus* cf. *tamesis* in mudded terraced fields of Cordillera (A); closer view of the thinnest and thread-like earthworm (B); and collection of *S.* cf. *tamesis* in large amounts for microplot field experiment (C). Photo credits: RC Joshi (A), SP Balloyan (B), and JT Alfonso (C).

Species: *Polypheretima elongata*

- String-like appearance (Spaghetti/noodle size) (Figures 6 and 8).
- Length 100-355 mm. Width 5 mm.
- Not found in soil surface that has standing water.
- Shallow-dwellers, live primarily on the top 12 inches of the soil.
- Present in moist soil environments.
- Move gently when disturbed.
- Castings seen in rice paddies on moist soil and are the size of a mungbean seed.
- Destructive in terraced rice fields as they cause water loss with their burying habits.

Figure 6. *Polypheretima elongata* in its natural habitat. Photo credits: RC Joshi.

Species: *Pheretima* sp.

- Snake-like-appearance (Rope size - largest species) (Figures 7 and 8).
- Length 200-300 mm. Width: diameter of a man's index finger.
- Slimy skin, red-brown or purplish-red with a sheen that does not change color in bright light.
- Not found in soil surface that has standing water.
- Deep burrowers; present along the sides of the terrace walls.
- Move swiftly when disturbed.
- Castings seen along the terraced walls and are the size of a Chickpea seed.
- Destructive to the terrace walls as they cause water loss with their burying habits.

Figure 7. Giant earthworm, *Pheretima* spp. with snake-like appearance measures 200-300 mm. This species is destructive to the terraced walls. Photo credits: JM Capuno (A), RC Joshi (B) and SP Balloyan (C).

Six less dominant species were also recorded as follows:

1. *Pontoscolex corethrurus* (Fr. Müller, 1856) (Family Rhinodrilidae)

Species diagnosis. Length, 50-95 mm. Width, 3-4 mm. Body unpigmented, no dorsal pores. Clitellum, bright yellow to light orange from segment 14 or 15-22, with thickened ridge on the ventral clitellum margin. Genital pores, very small or absent. Setae, single-pointed, lumbricine in arrangement, with eight setae per segment, setal arrangement in

the anterior part arranged in eight regular rows; setae after the clitellum to the posterior part arranged in offset pattern. Internally, a large gizzard is found in segment 6. Intestine is enlarged in segment 15. Intestinal caecum, absent. Three pairs of calciferous glands, positioned dorsolaterally, found in segments 7, 8, and 9. Hearts greatly enlarged in segments 10 and 11. Nephridial batteries are paired in segments 4 and 5. Pair of testis sacs located in segment 12 extending to segment 11 and a pair of seminal vesicles located in segment 13. Three small pairs of spermathecae with slender ducts, small ampulla, with no diverticulum, are found in segments 7-9. Prostate glands and ovaries, absent. Nephridia on spermathecal ducts, absent.

Remarks. This species is originally from Brazil but is now extremely abundant in tropical soils worldwide. It dwells both in terraces and non-terraces and reproduces parthenogenetically, faster than any species that reproduces sexually.

2. *Pithemera bicincta* (Perrier, 1875) (Family Megascolecidae) is widespread but mainly in Asia and the Pacific. It is dark-colored and small. Adult size is 6-8 cm.

Species diagnosis. Its clitellum covers segments 14, 15, and half of 16, leaving the ring of setae in segment 16 clearly visible; no other earthworm in the Cordilleras has this feature at adulthood. It has five pairs of small pores in the intersegmental furrows in segments 4/5-8/9 and two small but easily seen male pore bumps on the ventral side of segment 18.

3. *Amynthas diffringes* (Baird, 1869) (Family: Megascolecidae) is another common and widely transported earthworm of Asian origin. It has dark pigmentation.

Species diagnosis. It has more than eight setae per segment. It also has a clitellum covering segments 14-16 and a pair of small pores on segment 18.

4. *Dichogaster* cf. *curgensis* Michaelsen, 1921 (Family: Octochaetidae)

Species diagnosis. Color, greenish blue. Length, 27-67 mm. Diameter, 1-2.5 mm. Segment number, 70-103. Clitellum annular, covering segments 13-20. Setae lumbricine, eight pairs in each segment throughout the body. Prostomium epilobic, tongue closed. Male pores conspicuous, lies within clitellum on segment 18. Genital marking, absent. First dorsal pore at 5/6th intersegmental furrow. Male pores paired, minute, in seminal grooves on setal arc of segment 18. Spermathecal pores, 2 pairs, minute and superficial, closed together in segments 7/8 and 8/9. Female pore presetal, paired on segment 14. Prostatic pores, two pairs, minute, at both ends of seminal grooves on setal arc of segments 17 and 19. Seminal grooves almost straight between the setal arc of segments 17 and 19. Two esophageal gizzards are in between segments 4/5 and 6/7. Presence of one pair of trilobed extramural calciferous glands in segments 15-17. Last pair of heart in segment 12. Intestine originates in segment 19 which does not have intestinal caecae and supra intestinal glands but with lamelliform typhlosole. Seminal vesicles holandric but vestigial in segments 11-12, testes and male funnels free in segments 10 and 11. Prostates, two pairs in segments 17 and 19. Penial setae irregularly sinuous ectally. Each spermatheca with a ventrally directed ental diverticulum, duct sinuous, much longer than ampulla. Micromeronephridia exonephric on body wall.

5. *Eudrilus eugeniae* Kinberg, 1867 (Family: Eudrilidae)

Species diagnosis. Body length, 90-185 mm, posterior tapering, becoming thinly flattened in terminal 'zone of growth'. Width, 4-8 mm. Segments 161-211. Red-brown dorsum fading posteriorly; anterior with bright blue/green iridescent sheen from cuticle diffraction, ventrum beige, clitellum darker (sometimes lighter) than surroundings. Prostosmium small, open epilobous. Dorsal pores, absent. Eight setae per segment from segment 2, closely paired; setae a–b on segment 17, absent. Clitellum covers segments 13, 14, 15-18, usually 13, 14-18, and interrupted ventrally. Male pores in

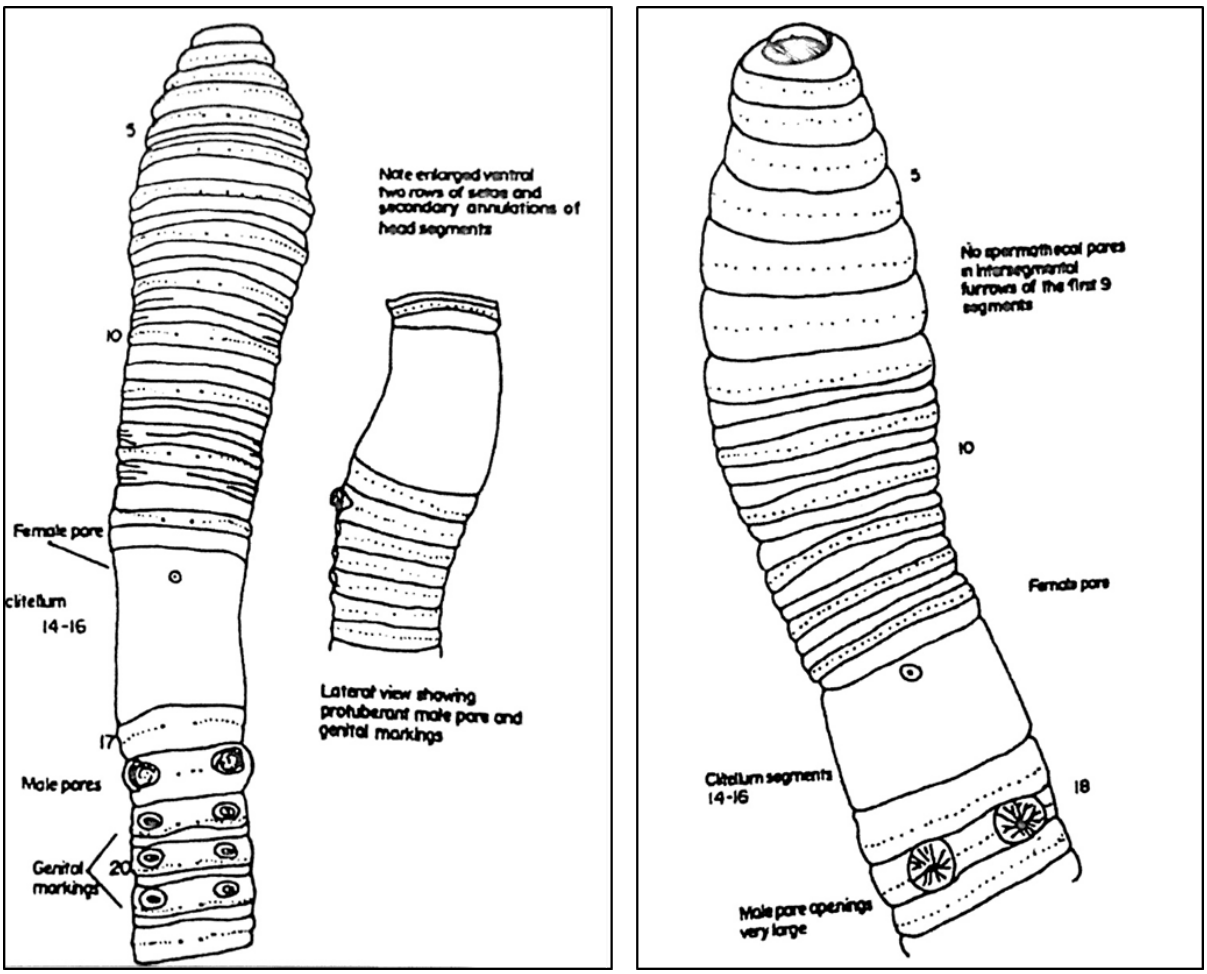
segment 17 on tips of longitudinally grooved, tapering, eversible penis in large ventral chambers, retracted as lateral slits with wrinkled lips just anterior to segment 17/18 in line with b setae. Female pores combined with modified 'spermathecal pores', lateral, presetal in segment 14 as raised intrasegmental openings just anterior to c setae. Central raised pad (gential markings) centered in segment 17 between male pores, faintly repeated in segment 18; sometimes undeveloped or as elliptical, opaque area in segments 16-18. Septa from segment 4/5; (6/)7/8/9 and thickened in 14/15. Weakly muscular gizzard in segment 5 immediately behind pharyngeal mass. Ventral spheroidal sacs (calciferous glands) in segments 10 and 11 (concealed by seminal vesicles): Intestine originates in segments 14 or close to 14/15. Caeca and typhlosole, absent. Paired, large, coiled holonephridia in each segment from segment 4. Male organs holandric with two large, unpaired sacs seen ventrally in segments 10 and 11, each contain a testis anteriorly and funnels posteriorly. Large pair of digitiform euprostates, with white muscular sheen from segment 18 extending to 23; acutely muscular enlargements of loop of paired sperm ducts which attach to apex of copulatory chamber mound centrally.

Remarks. This species is also called African Nightcrawler, native to tropical West Africa and is now widespread in warm regions and is used in vermicomposting such as in the Philippines and India.

6. *Drawida* spp. Michaelsen, 1900 (Family: Moniligastridae)

Generic diagnosis. Body pale, unpigmented. Prostomium prolobous. Length, 45-60 mm. Segments 121-134. Clitella, absent. Setae, closely paired. Dorsal pores, absent. Spermathecal pores in segment 7/8. Male pores in segment 10/11. Female pores in segment 11/12. Genital markings, absent. Gizzards in segments 15-18. Intestine originates in segment 19. Last hearts are in segment 9.

Distinguishing Characteristics of Damaging Earthworm Species



Left: *Polypheretima elongata*
Right: *Pheretima spp.*

Figure 8. Distinguishing characteristics of two damaging earthworm species (Joshi et al., 1999).

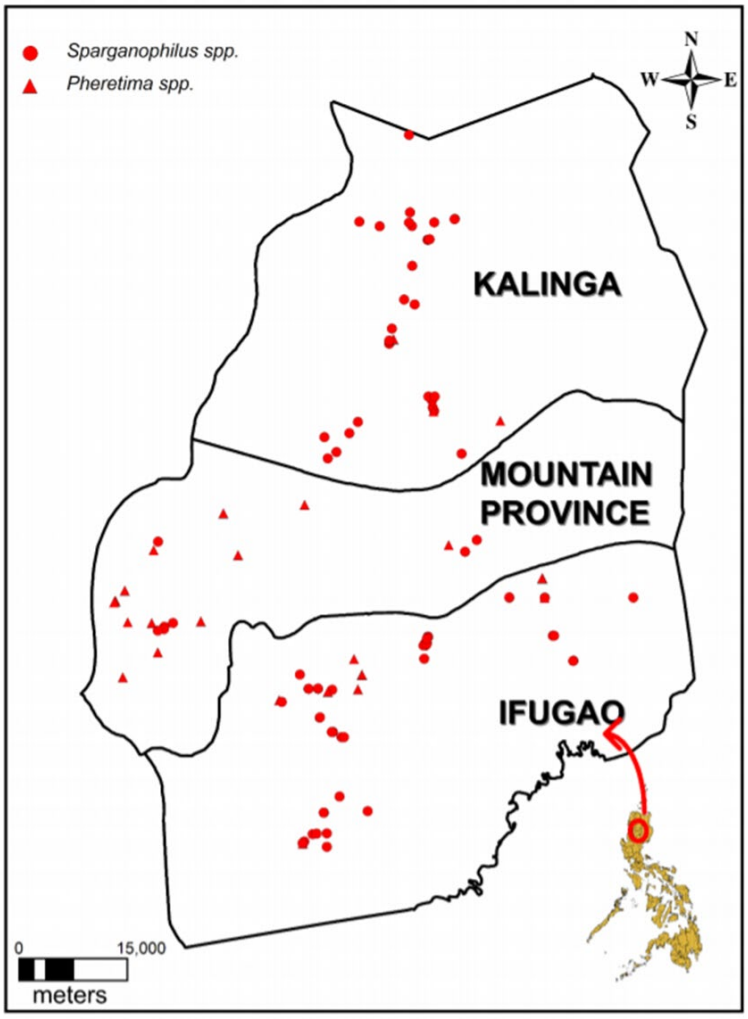


Figure 9. Digitized map showing the distribution of *Sparganophilus* cf. *tamesis* and *Pheretima* spp. in rice fields in the municipalities/barangays of Mountain Province, Kalinga, and Ifugao in the Cordillera Administrative Region.

Damage by Pest Species of Earthworms

A few reports have detailed the damages made by certain earthworm species to rice plants and on the paddy fields in India (Veeresh and Rajagopal, 1981) and the Philippines (Gates, 1972; Conklin, 1980; Barrion and Litsinger, 1997; Joshi et al., 1999; Joshi et al., 2000; Gomez, 2003; Charette-Castonguay, 2014). Among these damages are the following:

- Earthworms bore holes on the terrace walls, resulting in seepage of water, thus causing water stress to the plants and encouraging the growth of weeds. Excessive weeds promote damage to rice by certain pests such as rats, birds, and earhead bugs as well as other plant diseases.
- Young rice seedlings either die owing to water shortage or have uneven plant height, and some wilted plants.
- Earthworms scrape the root tissues of the rice seedlings when the population becomes too dense and interfere with germination by covering the seedlings in the seedbed with their castings.
- The damage is not directly on the plant, but more on the soil.
- Collapse of bunds in rice paddies.

Practical Integrated Management Options

The natural response of farmers to control earthworms is to use any available pesticides, but considering the soil as an open ecosystem, the use of pesticides will not only be likely uneconomical but will also endanger human health and have adverse effects to the environment. Thus, managing the habitat where the earthworms live is most crucial in controlling them. Management practices include limiting their food supply (location, quality, quantity), mulch protection (affects soil water and temperature), and enhancing naturally occurring biological controls which are ecologically sustainable and environment-friendly. By considering how these factors differ across management systems, we can often predict the general effects on earthworm populations. In rice production activities, there are several ways the population of earthworms can be controlled.

Integrated Management Options for Pest Species of Earthworms Based on the Rice Growth Stages.

Rice Plant Stage	Seeding	Vegetative	Reproductive	Maturity
Farmers' Activities	Land Soaking	Land Preparation	Crop Pest Management	Harvesting
Farmers' Practices/Expert Advise	A	B	C	D

A: Flooding, Duck herding, Setting up of screen traps, Compact embankments, Repairing bunds.

B: Setting up screen traps, Transplanting older seedlings, Closer plant spacing, Water management, Using of botanicals.

C: Setting of screen traps, Duck herding, Using of botanicals.

D: Deep Ploughing, Flooding.

During Field Preparation

- Flooding the rice fields at 14 cm depth forces the earthworms to the surface. This exposes them to predators such as chickens, ducks, pigs, and red ants. Herding ducks in terraced rice fields can be done during this period.
- Small mammals especially predators of earthworms could be brought to the rice terraces which are in close proximity to or share/overlap the watersheds and natural forests where these small mammals are usually confined in.
- Screens can be placed at the water inlets, pond inlets, or irrigation sources to prevent the entry of big earthworms into the rice fields.

- Embankments where water seepage is observed on the terrace wall can be compacted.

During and After Transplanting

- Screens can be placed at water inlets, pond inlets, or irrigation sources to prevent the entry of big earthworms into the rice fields.
- Transplanting older seedlings (45-55 days old) provides better tolerance to earthworm root damage.
- Seedlings can be planted closer to compensate for less tillering in the older seedlings.
- Proper water management should be followed. Shallow paddy water level about 2-3 cm deep should be maintained combined with alternate flooding and drying to reduce earthworm multiplication.
- Wild sunflower (*Tithonia diversifolia*) or seeds of neem tree (*Azadirachta indica*) can be ground and mixed with water. When poured on the ground, these may cause earthworms to exit the soil. Such plants are locally available. Wild sunflower has a pungent odor and bitter taste. The fresh sunflower tops can be evenly distributed on the surface of the seedbed with water depth of about 5 cm (2 inches) and left until seedbed is ready for sowing.

After Harvesting

- Deep ploughing is effective when earthworms are at very high population: some are killed during tillage while others are exposed to natural predation and dehydration.
- Flooding the field during fallow periods will reduce the multiplication of earthworms and make them vulnerable to predation.

Other Recommendations:

- Earthworms have limited ability to migrate to any significant distance (by their own means). Thus, farmers should be informed about the dangers of moving soils, plants, and heaps of dead or decaying plant remains because earthworms remain close to their food source. Earthworm cocoons can be quite small, from few millimeters to one or two centimeters in diameter.
- Rice straw or weeds should be fully decomposed before incorporation into the soil to reduce breeding ground for earthworms.
- Sanitation and proper disposal of animal manure, sewage sludge, and other organic wastes should be practiced to reduce the continuous breeding of earthworms.
- Utilization of earthworms in the production of vermimeal as a substitute for imported fishmeal in animal and fish feeds is advised (Guerrero, 2003).

Conclusion

Earthworms are one of the most important soil animals that benefit plant growth and development by improving soil physical and chemical properties and boosting soil biodiversity, thereby, playing a key role in the provision of ecosystem services. However, not all earthworms have beneficial effects on plants and the environment. In the heirloom terraced rice fields of the Philippine Cordilleras, particularly in the provinces of Ifugao, Kalinga, and Mountain Province, both the pest and non-pest species of earthworms are present. There are three dominant earthworm species that are either destructive or considered destructive by farmers in these terraced fields. Simple diagnostic keys help to identify them. Practical integrated management options to control earthworms can be used by the heirloom rice farmers in the Cordilleras.

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FIELD GUIDE

EARTHWORMS IN HEIRLOOM RICE FIELDS OF THE PHILIPPINE CORDILLERA AND THEIR INTEGRATED MANAGEMENT

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