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# Exploration of Earthworms of India through Online Digital Library

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Additional information is available at the end of the chapter

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## Abstract

Online digital library (<http://earthwormsofindia.com>) for identification of earthworms of India has been developed for the first time. The database comprises digital keys for identification of earthworms of India, diagnostics, and mathematical parameters to provide a useful supplement for traditional morphological taxonomists and nonexperts in this area. This will scientifically broaden the taxonomic coverage of Indian earthworms. The genomic signatures with short sequences from standardized regions of the genome for 1192 specimens of earthworms were generated. Earlier, species identification of adult earthworms was possible only by dissection of the anterior end. However, this method is labor intensive, time-consuming, and very difficult for nonspecialists, particularly when dealing with field collections consisting of several different earthworm species. Furthermore, identification is limited to adult worms, as most life stages are unidentifiable and many morphological and anatomical characteristics of earthworms are variable, consequently, and the degree of variability can differ and features can overlap the taxa. The present work appears pioneer endeavor in this direction, as there appears no work available on the digitization of earthworms of India.

**Keywords:** identification key, earthworms of India, diagnostics of earthworms of India, computational key to identify earthworms, genomic signature, *coi-1*

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## 1. Introduction

The scientific exploration of earthworm's diversity in India dates back to the nineteenth century. The credit for naming the first earthworm species in the Indian subcontinent goes to Templeton [1], when he discovered *Megascolex coeruleus* from Sri Lanka. However, Perrier [2] was the first to describe earthworm species from the Indian mainland. The significant

contributions on the taxonomy of Indian earthworm are of Bourne [3], Beddard [4], Michaelsen [5, 6], Stephenson [7–10], Aiyer [11], Gates [12–20], Jamieson [21], Julka [22–27] and Julka and Paliwal [28–30] Paliwal and Julka [31], Verma et al., [32] have provided comprehensive checklists for earthworms of different regions of India. The earthworm fauna of India is well reported as compared to other Asian Countries (excluding Myanmar).

2. Database of earthworms of India

Presently, 451 valid species/subspecies of earthworms under 71 genera are known from the Indian territory, including the islands of Andaman, Nicobar and Lakshadweep which have reported 9 families described in **Table 1** (as per Brinkhurst and Jamieson’s classification of Oligochaeta, and Gates [33] classification of Megascolecidae), Endemism, both at genera and species level, is very high; about 71% of genera and 89% of species are endemic. Some exotic peregrine species of earthworms are also found, and these are now widespread in disturbed habitats following deforestation and intensive cultivation practices.

Sl No.	Family	Genus (No)	Species (No)*
1.	Acanthodrilidae	03	43
2.	Almidae	02	5
3.	Eudrilidae	01	1
4.	Lumbricidae	09	16
5.	Megascolecidae	14	149
6.	Moniligastridae	03	85
7.	Ocnerodrilidae	08	17
8.	Octochaetidae	30	134
9.	Rhinodrilidae	01	1
	Total families: 9	71	451
*Species incertae sedis: 8.			

**Table 1.** Families of earthworms of India with genera and number of species.

3. Earthworm diversity in India

India is located 8.4–37.6°N latitude with covered area 3,287,797 km<sup>2</sup> and is rich country as far as its biodiversity is concerned. Considering the past geological history of the Indian subcontinent excluding (Burma, Nepal, and Pakistan) has been divided into six well-defined physiographic regions depending upon topography, climate, and vegetation viz. Western Himalayas, Eastern Himalayas, and Northeast ranges, Indo-Gangetic Plains, Central high lands, Peninsular plateaus, and Western Ghats including Sahyadri and Nilgiri hills (**Table 2**).

Family	Genus	Number of valid species
Acanthodrilidae	<i>Microscolex</i>	1
	<i>Plutellus</i>	41
	<i>Pontodrilus</i>	1
	Total	43
Almidae	<i>Progizzardus</i>	1
	<i>Glyphidrilus</i>	4
	Total	5
Eudrilidae	<i>Eudrilus</i>	1
	Total	1
Lumbricidae	<i>Allolobophoridella</i>	1
	<i>Aporrectodea</i>	3
	<i>Bimastos</i>	1
	<i>Dendrobaena</i>	2
	<i>Dendrodrilus</i>	1
	<i>Eisenia</i>	2
	<i>Eiseniella</i>	1
	<i>Lumbricus</i>	3
	<i>Octolasion</i>	2
	Total	16
Megascolecidae	<i>Amyntas</i>	13
	<i>Comarodrilus</i>	1
	<i>Kanchuria</i>	4
	<i>Lampito</i>	8
	<i>Megascolex</i>	33
	<i>Metaphire</i>	10
	<i>Nellosolex</i>	2
	<i>Notoscolex</i>	10
	<i>Perionyx</i>	56
	<i>Pheretima</i>	1
	<i>Pithemera</i>	1
	<i>Polypheretima</i>	2
	<i>Tonoscolex</i>	7
	<i>Troyia</i>	1
	Total	149
Moniligastridae	<i>Desmogaster</i>	1
	<i>Drawida</i>	73
	<i>Moniligaster</i>	11
	Total	85

Family	Genus	Number of valid species
Ocnerodrilidae	<i>Curgiona</i>	1
	<i>Deccania</i>	1
	<i>Eukerria</i>	1
	<i>Gordiodrilus</i>	2
	<i>Malabaria</i>	5
	<i>Nematogenia</i>	1
	<i>Ocnerodrilus</i>	1
	<i>Thatonia</i>	5
	Total	17
Octochaetidae	<i>Bahlia</i>	1
	<i>Barogaster</i>	3
	<i>Calebiella</i>	1
	<i>Celeriella</i>	7
	<i>Chaetocotoides</i>	1
	<i>Dashiella</i>	1
	<i>Dichogaster</i>	5
	<i>Eudichogaster</i>	6
	<i>Eutyphoeus</i>	23
	<i>Herbettodrilus</i>	1
	<i>Hoplochaetella</i>	19
	<i>Karmiella</i>	2
	<i>Konkadrilus</i>	6
	<i>Kotegeharia</i>	1
	<i>Lennogaster</i>	7
	<i>Mallehulla</i>	1
	<i>Octochaetoides</i>	1
	<i>Octochaetona</i>	15
	<i>Octonochaeta</i>	1
	<i>Parryodrilus</i>	1
	<i>Pellogaster</i>	3
	<i>Priodochaeta</i>	1
	<i>Priodoscolex</i>	1
	<i>Ramiella</i>	5
	<i>Rillogaster</i>	2
	<i>Scolioscolides</i>	1
	<i>Senapatiella</i>	3
	<i>Shimodrilus</i>	2
	<i>Travoscolides</i>	3
	<i>Wahoscolex</i>	10

Family	Genus	Number of valid species
	Total	134
Rhinodrilidae	<i>Pontoscolex</i>	1
	Total	1

**Table 2.** Earthworms of India with valid number of species.

## 4. Diagnostics of families of earthworms of India

Earthworms of India belong to 9 families that may be identified with the following key:

1 Inconspicuous male pores	2
Conspicuous male pores	3
2 Clitellum flared into wings; zygotoboc prostomium; setae in regular rows body	<b>Almidae</b>
Clitellum not flared; irregular arrangement of setae in caudal segments	<b>Rhinodrilidae</b>
3 Male pores in front of segment 15	4
Male pores behind segment 15	5
4 Male pores at segment 13 or 15	<b>Lumbricidae</b>
Male pores at intersegment groove 10/11	<b>Moniligasteridae</b>
5 Without dorsal pores	6
With dorsal pores	7
6 Thin whitish worms, female pore tiny close to mid-ventral lines or at <i>b</i> lines on segment 14	<b>Ocnerodrilidae</b>
Robust, dark-colored, female pore large slits close to lateral margins of segment 14, Male Pore on 17	<b>Eudrilidae</b>
7 Prostate tubular, holonephric	<b>Acanthodrilidae</b>
Prostate tubular, meronephric	<b>Octochaetidae</b>
Prostate racemose, meronephric	<b>Megascolecidae</b>

## 5. Databases and genus characteristics of earthworms of India

The characteristic features of each genus with available known species and their type locality are described in the library.

### 5.1. Family: Acanthodrilidae

#### 5.1.1. *Microscolex phosphorus* (Duges, 1837)

- Male pores minute between apertures of *a* and *b* follicles at eq/xvii.
- Female pore at or slightly median to *a*, about halfway between xiii and xiv.

- Lumbricine, widely paired setae.
- Spermathecae one pair, diverticulate.
- Size 10–35 mm.
- Single species recorded in India.
- Type locality is Montpellier, France.

#### 5.1.2. *Plutellus* Perrier, 1873

- Male pores in xviii, xix, or xx.
- Three pairs of kidney-shaped extramural calciferous glands.
- Dorsal pores present behind clitellum.
- Intestinal origin xiv, xv, xvi, xvii, or xviii.
- Spermathecae 1, 2, 3, 4, 5, 6, or 7 pairs in some or all of vi–xii.
- 41 species recorded from India.

#### 5.1.3. *Pontodrilus litoralis* (Grube, 1855)

- Male pores in xviii, biprostatic
- Female pores in xiv.
- Spermathecal pores at vii/viii/ix.
- Genital markings oval unpaired, median usually in xi/xx, and sometimes in xii/xiii/xiv.
- Prostate tubular.
- Spermathecae paired in vii and ix with club-shaped diverticulum.
- Without typhlosome, calciferous, and supra-intestinal gland.
- Known to occur in mud with large content of organic matter and salt on seashores and margins of estuaries and brackish water lakes.
- Single species recorded in India.
- Type locality is French Riviera.

### 5.2. Family: Almididae

#### 5.2.1. *Glyphidrilus* Horst, 1889

- Male pore Inconspicuous (not clearly visible), difficult to recognize and intracitellar behind segment xvi.
- Lumbricine

- Clitellum annular and laterally flared into wings.
- Seminal vesicles in ix–xii.
- Four species recorded in India.

#### 5.2.2. *Progizzardus varadiamensis* (Nair, 2010)

- Male pore in xiii segment.
- Lumbricine
- Four pair seminal vesicle.
- Multiple Spermathecae (4-5) and adiverticulate.
- Presence of genital markings in xxi–xxvi.
- Single species recorded in India.
- Type locality is Varadium, Thrissur dist., Kerala, India.

### 5.3. Family: Eudrilidae

#### 5.3.1. *Eudrilus eugeniae* (Kinberg, 1867)

- Male pores minute paired on segment xvii, penes retractable copulatory chamber.
- Female pores paired, large transverse slits, close to sides of the body on segment xiv.
- Lumbricine closely paired.
- Color reddish to purple or dark purplish.
- Y-shaped gland present that opens through own porophore into the copulatory chamber.
- Dorsal pores absent.
- Only one species found in India.
- Type locality is St. Helena Island, South Atlantic.

### 5.4. Family: Lumbricidae

#### 5.4.1. *Allolobophoridella eiseni* (Levinsen, 1884)

- Male pores in xv.
- Male tumescences confined to median half of *bc*.
- Female pores in xiv, slightly lateral to *b*.
- Holandric, seminal vesicles in xi, xii.

- Tubercula pubertatis and TP glands absent.
- Single species recorded in India.
- Type locality is Deer Garden, Copenhagen.

#### 5.4.2. *Aporrectodea* (Orley, 1885)

- Male pore inconspicuous and transverse slits on usually much elevated glandular area, which occupy xiv–xvi.
- Prostomium epilobic.
- Spermathecal pore at most three pairs or pairs of groups in *cd*.
- Seminal vesicles four pairs in ix–xii.
- Tubercula pubertatis absent.
- Three species recorded in India.

#### 5.4.3. *Bimastos parvus* (Eisen, 1874)

- Color reddish.
- Length 23–46 mm.
- Lumbricine.
- Clitellum saddle-shaped segments xxiv–xxx.
- Tubercula pubertatis absent.
- Male pores on segment xv.
- Single species recorded in India.
- Type locality is Mount Lebanon, New York-New England, USA.

#### 5.4.4. *Dendrobaena* Eisen, 1874

- Male pores at the bottom of equatorial clefts at or bear *mbc*. Male tumescences (swellings) large protuberant confined to xv and *bc* but often slightly dislocating xiv/xv and xv/xvi.
- Female pores at xiv just lateral to *b*.
- Tubercula pubertatis longitudinal bands of translucence slightly depressed just lateral to *b* in xxxi–xxxiii.
- Spermathecal pores in *cd*.
- Color dark red to slate.
- Size 20–60 mm.
- Two species recorded in India.

5.4.5. *Dendrodrilus rubidus* (Savigny, 1826)

- Male pores in xv between *bc*.
- Spermathecal pores ix/x/xi.
- Clitellum covers six segments in xxvii–xxx.
- Tubercula pubertatis xxviii–xxx or only xxix–xxx.
- Genital tumescence surrounds setae *ab* in xvi, ix, xvii, xxii–xxv, and xxx.
- Dark red, pale ventrally.
- Size 20–100 mm.
- Single species recorded in India.
- Type locality is Paris, France.

5.4.6. *Eisenia* Gates, 1968

- Distinctive striped appearance because of alternating segmental bands of red and yellow color along the entire length of the body.
- Male pore on segment xv.
- Clitellum covering from segment xxvi to segment xxxii.
- Tubercula pubertatis on segment xxviii–xxx.
- Spermathecal pore two pairs, close to together on the upper side, in intersegment furrow ix/x, and x/xi.
- Two species recorded in India.

5.4.7. *Eiseniella tetraedra* (Savigny, 1826)

- Male pores in xv at or somewhat below *c*, each at the lateral end of *a* deep transverse cleft.
- Tubercula pubertatis longitudinally band like, uninterrupted by intersegment furrows.
- Color reddish brown with golden tinge.
- Single species recorded in India.
- Type locality is Paris, France.

5.4.8. *Lumbricus* Beddard, 1895

- Dark pigmented.
- Male pore inconspicuous and without glandular area.
- Spermathecal pore of two pairs in ix/x and x/xi in *cd*.

- Seminal vesicles of three pairs in ix, xi, and xii.
- Three species recorded in India.

#### 5.4.9. *Octolasion* (Oerley, 1885)

- Male pores with large glandular area which encroach xiv and xvi.
- Female pore just lateral to *b* at eq/xiv.
- Tubercula pubertatis fused to form wall.
- Spermathecal pore two pairs in ix/x or x/xi in the region of *cd*.
- Four pairs of seminal vesicles in ix–xii.
- Two species recorded in India.

### 5.5. Family: Megascolecidae

#### 5.5.1. *Amyntas* Kinberg, 1867

- Male pore paired in xviii (rarely xix) discharging directly onto the surface.
- Female pore single rarely paired on xiv.
- Spermathecal pores paired (bithecal), occasionally numerous, or single between iv/v and viii/ix.
- Prostate racemose.
- Copulatory pouches absent.
- Spermathecae usually paired, rarely multiple or single.
- Thirteen species recorded in India.

#### 5.5.2. *Comarodrilus gravely* Stephenson, 1915

- Male pores on small conical papillae, which touch each other in the middle line.
- Spermathecal pores unpaired and at the median in vii/viii and viii/ix.
- Clitellum xiv–xvii (four segments).
- Gizzard in v.
- Prostate a compact glandular mass (racemose).
- Penial setae absent.
- Length 92 mm.
- Color gray.
- Single species recorded in India.
- Type locality is Thrissur, Kerala, India.

5.5.3. *Kanchuria* Julka, 1988

- Male pores paired in xviii.
- Megameronephridia absent.
- Four species recorded in India.

5.5.4. *Lampito* Michaelsen, 1909

- Male pores in xviii (combined with prostatic pores).
- Female pore in xiv.
- Spermathecae bidiverticulate with two small digitiform diverticula arising from lateral and median faces of the duct.
- Intestinal caeca and supra-intestinal glands absent.
- Meronephric: one pair enteronephric meganephridia with preseptal funnels from the region of xx.
- Eight species recorded in India.

5.5.5. *Megascolex* Beddard, 1895

- Male pores in xviii.
- Female pore in xiv.
- Spermathecal pores 1–5 pairs between segments iv and ix, lateral to mid-ventral.
- Penial setae present.
- Thirty-three species recorded in India.

5.5.6. *Metaphire* Sims and Easton, 1972

- Male pores (combined with prostatic pores paired) within copulatory pouches on xviii rarely on xix or xx.
- Female pore single rarely paired in xiv.
- Clitellum annular xiv–xvi.
- Spermathecal pores usually large transverse slits, rarely small paired, occasionally single or multiple between iv/v and ix/x.
- Meronephric, nephridia absent from the spermathecal ducts.
- Prostate gland racemose.
- *Metaphire* is different from *Amyntas* by the presence of copulatory pouches and differs from *Pheretima* by the absence of nephridia from the spermathecal ducts.
- Ten species recorded in India.

5.5.7. *Nellosocolex Gates, 1939*

- Male pores in seminal grooves confined to xvii.
- Female pores anteromedian to *a* in xiii.
- Calciferous glands unstalked and not constricted off from the esophagus.
- Calciferous lamellae within lateral swellings of esophagus in viii–xii.
- Dorsal pores present from region viii/ix–ix/x.
- Pigment lacking.
- Prostate strap-shaped.
- Spermathecal pores paired lateral to mid-ventral.
- Two species recorded in India.

5.5.8. *Notoscolex Michaelsen, 1907*

- Male pores in xviii.
- Spermathecal pores 1, 2, or 3 pairs, the last in viii/ix, lateral to mid-ventral.
- Very close to *Megascolex* only difference is arrangement of setae.
- Ten species recorded in India.

5.5.9. *Perionyx Perrier, 1872*

- Male pores (combined with prostatic pores) paired on xviii.
- Female pore intraclitellar and median.
- Spermathecal pores paired, lateral to mid-ventral.
- Dorsally pigmented reddish to blackish, ventrally nonpigmented.
- Holonephric: nephridia with preseptal funnels and postseptal loops that open in their own segments to the exterior through epidermal apertures.
- Typhlosole, intestinal and supra-intestinal glands absent.
- Ovaries are fan-shaped with several egg strings.
- Fifty-six species recorded in India.

5.5.10. *Pheretima darnleiensis (Fletcher, 1886)*

- Male pores paired within copulatory pouches in xviii.
- Gizzard present between vii/viii and ix/x.

- Copulatory pouches present often with secretory diverticulate.
- Meronephric, nephridia always present on spermathecal ducts.
- Single species recorded in India.
- Type locality is Darnley Island, Torres Strait, Australia

5.5.11. *Pithemera bicincta* (Perrier, 1875)

- Male pores paired in xviii small on a porophore.
- Preclitellar genital markings absent.
- Postclitellar genital markings present or absent when present paired on xviii or xviii/xix.
- Spermathecal pore five pairs in iv/v/vi/vii/viii/ix.
- Spermathecae present or absent when present five pairs in vi–x with a duct as long as the ampulla, diverticulum usually shorter than duct, and ampulla combined.
- Single species recorded in India.

5.5.12. *Polypheretima* Michaelsen, 1934

- Male pores on circular porophores in xviii.
- Perichaetine, setae never excessively crowded ventrally, creeping sole absent.
- Crescentric genital markings absent.
- First dorsal pore between iv/v and xii/xiii.
- Two species recorded in India.

5.5.13. *Tonoscolex* Gates, 1933

- Male pores in xvii and in seminal grooves that extend into another segment.
- Quadrithecal pores at vi/vii–vii/viii.
- Gizzard in vi.
- Discrete calciferous glands stalked in viii–xii, ix–xii, x–xii.
- Intestinal caeca and supra-intestinal glands absent.
- Meroic, V-shaped, exoic micronephridia on parietes from iv and especially numerous in clitella segments.
- Prostate strap-shaped extending through several segments, duct short, soft, and joined ventally by the sperm duct.
- Spermathecae each with a diverticulum shorter than the main axis.
- Seven species recorded in India.

#### 5.5.14. *Troyia gundarshola* Jamieson, 1977

- Male pores in *ab* near *a* of xviii relative to adjacent segments each with wide tumid lips, which constitute papillae.
- Single pair of the tubular racemose prostate in xviii.
- Three pairs extramural calciferous glands in xiii, xiv, and xv.
- Intestine begins in xvi.
- Meronephric, enteronephric tufts in v, caudally with numerous preseptal nephrostomal funnels on each side in each segment corresponding with post septal exonephric avesiculate micromeronephridia.
- Megameronephridia absent.
- Spermathecae one pair in viii with single elevate diverticulum.
- Single species recorded in India.
- Type locality is Gundar Shola, Palni Hills, Tamil Nadu, India.

### 5.6. Family: Moniligastridae

#### 5.6.1. *Desmogaster farina* Gates, 1943

- Two pairs of male pores xi/xii and xii/xiii.
- Female pores at or just lateral to *b* and at or slightly behind xiii/xiv.
- Spermathecae adiverticulate.
- Single species recorded in India.
- Type locality in Tingpai, Myitkyina district, Myanmar.

#### 5.6.2. *Drawida* Michaelsen, 1900

- Male pores at or near x/xi.
- Female pores at or just behind xi/xii.
- Spermathecal pores at vii/viii.
- Spermathecae without a stalked glandular mass in the association.
- Seventy-one species recorded in India.

#### 5.6.3. *Moniligaster* Perrier, 1872

- Male pores in x/xi.
- Spermathecae with a bifid muscular atrial chamber, each horn of which bears a lobulated glandular mass.
- 11 species recorded in India.

## 5.7. Family: Ocnerodrilidae

### 5.7.1. *Curgiona narayani* (Michaelsen, 1921)

- Male pores in papillae just behind eq/xvii.
- Copulatory chambers in xvii into which sperm duct open.
- Gizzard in vii and ventromedian calciferous gland in ix and x.
- Single species recorded in India.
- Type locality is River Hatti at Madapur, Coorg, S. India, and is endemic.

### 5.7.2. *Deccania alba* Gates, 1949

- Male pores paired minute in seminal grooves on xviii near *a*.
- Prostatic pores paired, minute at the ends of seminal grooves on xvii and xix in
- Spermathecal pores paired inconspicuous in vii/viii/ix at *b*.
- Genital markings paired usually presetal on xx–xxi at *ab* sometimes on ix, x, xiv, and xv at *bc* or *ab*.
- Clitellum saddle-shaped.
- Length 47–66 mm.
- Single species recorded in India.
- Type locality is Baraila (near Jabalpur), MP, India, and is endemic.

### 5.7.3. *Eukerria kukenthali* (Michaelsen, 1908)

- Male pores in xvii.
- Quadrithelial pores at mAB, at vii/viii–viii/ix.
- Calciferous glands one pair in ix with a small central lumen a triangular in section.
- A solid “clear gland” with short stalk protrusible from each prostate-pore invagination.
- Single species recoded in India.
- Type locality is Thomas Isl., West Indies.

### 5.7.4. *Gordiodrilus Beddard*, 1895

- Male pores and prostatic pores approximated xvii/xviii.
- Spermathecae without diverticulate on the duct, often with evaginations at the ectal end of the ampulla.
- Two species recorded in India.

#### 5.7.5. *Malabaria Gates, 1942*

- Male and prostatic pores in xvii.
- Holonephric, large nephridia.
- Dorsal pores and pigment lacking.
- Five species recorded in India.

#### 5.7.6. *Nematogenia panamaensis (Eisen, 1900)*

- Male pores in xvii.
- Seminal vesicles in xii, large.
- Paired calciferous glands in ix, each with the fairly thick wall (n large canal) and a central, vertically slit like lumen, a long and slender stalk bound in a U-loop against the esophagus.
- Single species recorded in India.
- Type locality is Panama.

#### 5.7.7. *Ocnerodrilus occidentalis Eisen, 1878*

- Male pores in xvii.
- Prostomium epilobic, tongue usually open but may be closed, or even unrecognizable.
- Single species recorded in India.
- Type locality is Fresno, California, USA.

#### 5.7.8. *Thatonia Gates, 1942*

- Male pores in xviii.
- Gizzard in vii, a dendritically branched system of spaces (opening into gut lumen) in the thickened ventral wall of esophagus in ix–x.
- Holonephric, avesiculate, and ducts passing parietes to *b*.
- Five species recorded in India.

### 5.8. Family: Octochaetidae

#### 5.8.1. *Bahlia albida Gates, 1945*

- Male and prostatic pores paired in seminal grooves on xvii.
- Two pairs of discrete intramural calciferous glands in xi–xiii.
- Genital markings unpaired and median with two central translucent areas, post setal on xviii–xix, sometimes on xvi, xx, and xxi at *aa* or *bb*.
- Type locality is found in Allahabad, UP, India, and is endemic.

5.8.2. *Barogaster Gates, 1939*

- Combined male and prostatic pores paired with xviii, seminal grooves absent.
- Typhlosole lamelliform simple and “grid-like” thickening present at the posterior end of typhlosole.
- Genital markings present.
- Three species recorded in India.

5.8.3. *Calebiella parva Gates, 1945*

- Male pores paired in seminal grooves on xviii.
- Prostatic pores paired at the end of seminal grooves on xvii and xix.
- Typhlosole lamelliform, bifid ventrally at the anterior portion.
- Single species recorded from Partapgarh, UP, India, and is endemic.

5.8.4. *Celeriella Gates, 1958*

- Combined male and prostatic pores paired, on xviii.
- Intestinal caecae, supra-intestinal glands, and typhlosole absent.
- Prostates paired in xviii, extending posteriorly through several segments, and vasa deferential on each side join the prostatic duct entally.
- Seven species recorded from India.

5.8.5. *Chaetocotoides montanus (Stephenson, 1920)*

- Male pores paired in seminal grooves on xviii, prostatic pores paired at the ends of seminal grooves on xvii, and xix.
- One pair of discrete extramural calciferous gland present. Each gland bilobed, one lobe in xv and other in xvi, opening into gut in xv slightly anterior to septum xv/xvi.
- Single species found in India.
- Type locality is Panchgani, W. Ghats and Maharashtra, India, and is endemic.

5.8.6. *Dashiella khandalaensis Julka, 1988*

- Combined male and prostatic pores paired on xvii; seminal grooves absent.
- Genital markings are circular to oval, paired, and presetal on xvi and xvii at *ab*.
- Spermathecal pores in paired batteries of 1-4 (polythecal) on vi/vii/viii
- Single species found in India.
- Type locality is Khandala, W Ghats, Maharashtra, India, and is endemic.

#### 5.8.7. *Dichogaster Beddard, 1888*

- Male pores paired in seminal grooves on xviii or xvii/xviii; prostatic pores two pairs at the ends of seminal grooves.
- esophagus with two gizzards anterior to septum viii/ix.
- Each calciferous gland trilobed, a vertically reniform lobe in each of segments xv–xvii with a common duct opening into gut in xvi.
- Five species recorded in India.

#### 5.8.8. *Eudichogaster Michaelsen, 1902*

- Male pores paired in seminal grooves on xviii; prostatic pores paired at the end of seminal grooves on xvii and xix.
- Two pairs of discrete extramural calciferous glands in xi–xii.
- Six species recorded in India.

#### 5.8.9. *Eutyphoeus Michaelsen, 1900*

- Male pore paired just posterior to prostatic pores on xvii; seminal grooves absent.
- Prostatic and male pore paired near the setal arc of xvii, discharging within vestibula or directly into the body surface.
- Typhlosole lamelliform, ending posteriorly with a short series of supra-intestinal glands.
- 23 species recorded in India.

#### 5.8.10. *Herbettodrilus bahli Julka, 2004*

- Male pores paired in seminal grooves on xviii.
- Prostatic pores paired at ends of seminal grooves on xvii and xix.
- One pair of discrete, extramural calciferous glands, each gland bilobed, one lobe in xv and the other in xvi, both discharging into gut through a common duct in xv close to attachment of septum xiv/xv.
- Micromeronephridia astomate, enteronephric paired tufts in iii, few scattered on body wall in xiv and posteriad segments; paired, stomate, enteronephric megameronephridia in xv and posteriad segments, discharging into rectum through paired excretory canals.
- Single species recorded in India.
- Type locality is Herbetu, Shimoga dist., Karnataka, India, and is endemic.

5.8.11. *Hoplochaetella* Michaelsen, 1900

- Combined male and prostatic pores two pairs on xvii or xvii/xviii and xix or xviii/xix, seminal grooves absent.
- Genital markings present or absent when present with or without central apertures.
- 19 species recorded in India.

5.8.12. *Karmiella* Julka, 1983

- Male pores paired, in seminal grooves, on xviii; prostatic pores paired at the end of seminal grooves, on xvii and xix.
- Stomate megameronephridia present at least in caudal segments; micromeronephridia astomate throughout the body.
- Calciferous gland one pair, each gland bilobed one lobe in xv and the other in xvi.
- Two species recorded in India.

5.8.13. *Konkadrilus* Julka, 1988

- Male pores paired in seminal grooves on xviii; prostatic pores paired at the end of seminal grooves on xvii and xix.
- Discrete calciferous glands, intestinal caeca, and supra-intestinal glands absent.
- Spermathecae paired in viii and ix.
- Six species recorded in India.

5.8.14. *Kotegeharia gatesi* Julka, 1988

- Male pores paired, in seminal grooves on xviii; prostatic pores paired at the end of seminal grooves on xvii and xix.
- Single species recorded in India.
- Type locality is Kotegehar, Karnataka, India, and is endemic.

5.8.15. *Lennogaster* Gates, 1939

- Male pores paired in seminal grooves on xviii or xvii/xviii; prostatic pores two pairs at the end of seminal grooves on xvii and xix or one pair in xvii.
- Three pairs discrete extramural calciferous glands in x–xii.
- Paired stomata mega-meronephridia in caudal segments.
- Seven species recorded in India.

5.8.16. *Mallehulla indica* Julka and Rao, 1982

- Male pores paired in seminal grooves on xviii; prostatic pores paired at the end of seminal grooves on xvii and xix.
- Prostate paired in xvii and xix extending posteriorly to two segments.
- Single species recorded in India.
- Type locality is Moodabidri, Karnataka, India, and is endemic.

5.8.17. *Octochaetoides aitkeni* (Fedarb, 1898)

- Male pores paired on xviii in seminal grooves, prostatic pores paired at the end of seminal grooves, on xvii and xix.
- Spermathecal pores paired in viii and ix, each with a tubular diverticulum arising from about the middle of the duct.
- Single species recorded in India.
- Type locality is Travancore, Kerala, India, and is endemic.

5.8.18. *Octochaetona Michaelsen*, 1922

- Male pores paired on xviii in seminal grooves, prostatic pores paired at the ends of seminal grooves on xvii and xix.
- Esophagus with a single gizzard in vi or in a space between septa iv/v and vii/viii or viii/ix or ix/x.
- One pair discrete extramural asymmetrical calciferous glands opening into gut close to the attachment of septum v/vi.
- Prostate paired in xvii and xix extending posteriorly to a few segments.
- Fifteen species recorded in India.

5.8.19. *Octonochaeta rosea* (Stephenson, 1926)

- Male pores paired in seminal grooves on xviii, prostatic pores paired at the end of seminal grooves on xvii and xix.
- Esophagus with a single gizzard in a space between septa iv/v and vii/viii and one pair of discrete extramural calciferous glands.
- Single species recorded in India.
- Type locality is Secunderabad, AP, India, and is endemic.

5.8.20. *Octonochaeta rosea* (Stephenson, 1926)

- Male pores paired in seminal grooves on xviii, prostatic pores paired at the end of seminal grooves on xvii and xix.
- Single species recorded in India.
- Type locality is Secunderabad, AP, India, and is endemic.

5.8.21. *Parryodrilus lavellei* Julka, 1997

- Male pores (combined male and prostatic pores) paired, large slits in line with *b* discharging directly on the body surface of xviii, at lateral ends of transverse furrow across a tumescent male field extending laterally to mid *bc*.
- Single species recorded in India.
- Type locality in Nilambur, Malappuram dist., Kerala, India, and endemic.

5.8.22. *Pellogaster* Gates, 1939

- Male pores paired in seminal grooves on xviii, prostatic pores paired at the end of seminal grooves on xvii and xix.
- Prostate two pairs in xvii and xix.
- Three species recorded in India.

5.8.23. *Priodochaeta pellucida* (Bourne, 1894)

- Combined male and prostatic pores on xviii.
- Esophagus with single large gizzard in v.
- Single species recorded in India.
- Type locality is Coonoor, Nilgiri Hills, South India, and is endemic.

5.8.24. *Priodoscolex montanus* Gates, 1940

- Combined male and prostatic pores on xviii.
- Three pairs extramural calciferous glands in xiv–xvi.
- Single species recorded in India.
- Type locality is Coonoor, Nilgiri Hills, South India, and is endemic.

5.8.25. *Ramiella Stepheson, 1921*

- Male pores paired in seminal grooves on xviii; prostatic pores paired at the end of seminal grooves on xvii and xix.
- Esophagus with a single gizzard in v or vi and calciferous lamellae in viii–xi.
- Discrete calciferous glands and supra-intestinal glands absent.
- Genital markings usually present.
- Five species recorded in India.

5.8.26. *Rillogaster Gates, 1939*

- Combined male and prostatic pores paired on xix; Seminal grooves absent.
- Esophagus with two gizzards in vi and vii.
- Typhlosome in the form of low ridge.
- Spermathecal pores paired in vii/viii.
- Genital markings present.
- Spermathecae paired diverticulate.
- Two species recorded in India.

5.8.27. *Scolioscolides bergtheili (Michaelsen, 1907)*

- Combined male and prostatic pores paired on xviii.
- Esophagus with a single gizzard between septa v/vi and viii/ix.
- One pair discrete intramural calciferous glands in xii.
- Holandric, testes, and male funnels in x enclosed in U-shaped sacs.
- Spermathecae one pair in viii, each with a median and a lateral bi or trilobed ental diverticula, duct shorter than ampulla.
- Exonephric megameronephridia in each segment posterior to the supra-intestinal glands.
- Single species recorded in India
- Type locality is Sandakphu, Darjeeling dist., W Bengal, India, and is endemic.

5.8.28. *Senapatiella Julka, 2004*

- Male pores paired in seminal grooves on xviii.
- Prostatic pores paired at ends of seminal grooves on xvii and xix.
- Single gizzard in vi.

- One pair bilobed extramural calciferous gland is present. One lobe in xiv and other in xv.
- Micromeronephridia astomate, exonephric.
- Megameronephridia in caudal segments.
- Prostomium tanylobic.
- Three species recorded in India.

#### 5.8.29. *Shimodrilus Julka, 2004*

- Male pores paired in seminal grooves on xviii.
- Prostatic pores paired at ends of seminal grooves on xvii and xix.
- Prostomium prolobic to proepliobic.
- Single gizzard in v.
- Large extramural calciferous glands in xvi with calciferous ridges extending to xviii.
- Intestinal caeca and supra-intestinal glands absent.
- Typhlosole simple lamellicorn.
- Penial setae present.
- Micromeronephridia astomate, exonephric, small paired tufts on body wall in ii–iv on septa in v–xii, in clusters of iv–v in xiii, and posteriad segments.
- Paired stomata exonephric megameronephridia lateral to micromeronephridia in xvii and posteriad segments.
- Two species recorded in India.

#### 5.8.30. *Travoscolides Gates, 1940*

- Combined male and prostatic pores on xviii.
- Esophagus with a single gizzard in v and four pairs of discrete calciferous glands in x–xiii.
- Supra-intestinal glands absent.
- Typhlosole simple lamelliform.
- Megameronephridia absent.
- Spermathecal pores paired in or close to vii/viii/ix.
- Genital markings absent.
- Holandric, seminal vesicles in xi and xii.
- Prostate paired in xviii.

- Penial setae present.
- Spermathecae paired in viii and ix.
- Three species recorded in India.

#### 5.8.31. *Wahoscolex* (Julka, 1988)

- Male pores paired in seminal grooves on xviii or xvii/xviii or on porophores on xvii; prostatic pores two pairs at the end of seminal grooves on xvii and xix or xvii and xviii or one pair on xvii.
- Esophagus with a single gizzard in v and with calciferous lamellae in in xvi.
- Discrete calciferous glands, caeca, and supra-intestinal gland absent.
- Typhlosole simple lamelliform.
- One or two pair stomate enteronephric megameronephridia in each segment from about middle of the body to posterior end.
- Testes holandric.
- Spermathecae paired or unpaired.
- Ten species recorded in India.

### 5.9. Family: **Rhinodrilidae**

#### 5.9.1. *Pontoscolex corethrurus* (Muller, 1856)

- Male and spermathecal pores minute and inconspicuous.
- Female pore small transverse slit at left side of mid-ventral line just in front of intersegment furrow xiv/xv.
- Lumbricine in regular furrow, but enlarged and located in alternate positions on adjacent segments in tail region.
- Clitellum saddle-shaped generally covering segments xv–xxii/xxiii.
- Dorsal pores absent.
- Calciferous glands visible through the body wall in live specimen.
- Digestive system with paired “Panicked tubular” calciferous glands in vii–ix.
- First Segment and snout (prostomium) often elongated as a long thin proboscis when the worm is exploring the area.
- Body pale, light pink in head.
- Single species found in India and is exotic in origin.
- Type locality is found in Itajai, Brazil.

## 6. Conclusions

First systematic comprehensive earthworm database of India developed for identification of earthworms to provide a useful supplement for traditional morphological taxonomists and nonexperts in this area.

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