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EARTHWORM BIODIVERSITY OF JHARKHAND : TAXONOMIC DESCRIPTION

M. P. SINHA*, ROHIT SRIVASTAVA[1], D. K. GUPTA[2]
Department of Zoology, Ranchi University, Ranchi - 834 008
[1]Department of Zoology, J. N. College, Dhurwa, Ranchi - 834 004
[2]Department of Zoology, K. C. B. College, Bero - 835 202, Ranchi
e-mail: dr.mp.sinha@gmail.com

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***Corresponding author**

ABSTRACT
Earthworms were collected from different habitats viz. agroecosystems, grassland, pasture, forest and garbage sites form different parts of Jharkhand. A total of 15 species of earthworm were identified namely *Glyphidrilus tuberosus* (Stephenson), *Eisenia foetida* (Savingny)*Pontoscolex corethrurus* (Michaelsen), *Dichogaster affinis* (Michaelsen), *Dichogaster bolaui* (Michaelsen), *Lennogaster pusillus* (Stephenson), *Pellogaster bengalensis* (Michaelsen), *Ocnerodrilus occidentalis* (Eisen), *Lampito mauritii* (Kinberg), *Pheretima planata* (Gates), *Pheretima posthuma* (Vaillant), *Perionyx sansibaricus* (Michaelsen), *Perionyx excavatus* (Michaelsen)*Drawida calebi* (Gates) and *Drawida willsi* (Michaelsen) have been identified belonging to 6 families and 9 genera.

INTRODUCTION

Earthworms are widely distributed throughout the world and there population contributes about 8% of the total biomass of the soil organism. There is a great paucity of information on the biology of tropical earthworms (Dash, 1978; Lavelle, 1978).Earthworms from Idian sub-continent have been studied but earthworms from Jharkhand and adjoining area are little known.

Earthworms are invertebrates belonging to the phylum Annelida and class Oligochaeta. The ecology and the biology of the earthworms have been studied since Darwin's contribution to the study of earthworms in 1881. Distribution of earthworms is usually irregular (Guild, 1952; Satchell, 1955; Svendsen, 1957), the numbers vary in relation to the type of soil (Evans and Guild, 1947) and ecological factors especially edaphic factors (moisture and temperature).

The first records of earthworms from the Indian subcontinent have been provided by Templeton (1844). Subsequently, several species were added by various workers notably Michaelsen (1907), Stephenson (1923, 1924, 1925, 1926, 1931), Gates (1940, 1945a, 1945b, 1972), Julka (1976, 1978, 1981), Julka and Senapati (1987), Bano and Kale (1991) and Singh and Rai (1997). At present the Indian earthworm fauna comprises about 408 species placed in 10 families and 69 genera (Dash, 2012). Thirty-eight genera are endemic on main land and 20 are peregrine that have been introduced to this region presumably in soil around the roots of exotic plants.

Earthworms of Jharkhand and Bihar had not been studied till 2001. There was no report on the occurrence distribution and diversity of earthworms of Jharkhand, Bihar and also the adjoining area of Chhattisgarh till 2001. The first attempt was made by Sinha *et al. (*2001)to study the earthworm diversity and since then considerable contribution has been madein this field (Sinha *et al.,* 2001a; 2001b; 2002a; 2002b; 2002c; 2002d; 2003a; 2003b; 2003c ; 2003d; 2003e; 2003f). Similarly some more worth mentioning contributions are made by Srivastava *et al*. (2003; 2012) and Srivastava and Sinha (2004) on earthworms of Jharkhand. The present paper is first exhaustive account of taxonomic diversity of earthworms from Jharkhand.

Table 1: Earthworm genera and species known from Jharkhand

Family/Genera	No. of sp. from Jharkhand	No. of sp. from India
ALMIDAE		
Glyphidrilus	1	
LUMBRICIDAE		
Eisenia	1	4
GLOSSOSCOLECIDAE		
Pontoscolex	1	1
OCTOCHAETIDAE		
Dichogaster	2	7
Pellogaster	1	2
Lennogaster	1	6
OCNERODRILIDAE		
Ocnerodrilus	1	1
MEGASCOLECIDAE		
Lampito	1	7
Pheretima	2	9
Perionyx	2	47
MONILIGASTRIDAE		
Drawida	2	62

Despite the fact that there are about 509 species in India, this field of earthworm study has not achieved any attention in the state of Jharkhand and Bihar. For the first time 15 earthworm species belonging to 7 families and 10 genera have been identified (Table 1) while a sizeable number of species are still under observation for identification.

MATERIALS AND METHODS

Earthworms were collected from different habitats viz. agroecosystems, grassland, pasture, forest and garbage sites form different parts of Jharkhand following the monolith method as described by Dash and Patra (1977). Sampling was confined upto 40cm depth of soil. Earthworms were hand sorted and preserved in 5% formaldehyde solution with some amount of glycerine. The specimens have been preserved in Department of Zoology, Ranchi University, Ranchi.

RESULTS

Earthworms are of particular biogeographical interest since the means of dispersal available to them are restricted; their mobility is limited to small areas at all stages of their life cycle, they are unable to survive prolonged desiccation or exposure to sunlight and many species are killed by even brief immersion in sea water. However, some species that are capable of adaptation to a wide range of habitats have been spread over large areas of the world with plants and soil transported by man and it seems most likely that, not all but some earthworms of Jharkhand may have been introduced in this way.

Thus from the point of view of earthworm biogeography, species richness of a given site is constituted by two groups of earthworms: native and exotic species. The first category comprises species that evolved in the site or region under study. Although some of these species have been able to survive in disturbed ecosystems, mainly restricted to natural ecosystems (forests, natural savannas). The majority of the presently known species belong to this group. If in future the present rates of deforestation are maintained, massive extinction of native species can be anticipated, especially since endemism appears to be common for many native earthworm species (Fragoso *et al.*, 1995).

The group of exotic species includes earthworms introduced by human activities. They have also been called peregrine (Lee, 1985; 1987) and anthropochorous (Gates, 1970) species. This group of species can tolerate a wide range of soil and environmental conditions; they have been often considered as the predominant earthworm fauna in anthropic tropical ecosystems and also to be important in maintaining the fertility of agricultural and pastoral lands (Lee, 1987). Less than 1% of the total number of earthworms described is tropical exotic species.

In the present investigation peregrine genera are distributed among 3 families namely Megascolecidae, Ocnerodrilidae and Octochaetidae as shown in Table 2. The peregrine species being *Pheretima posthuma, Pheretima planata, Ocnerodrilus occidentalis, Dichogaster bolaui* and *Dichogaster affinis*. Table 3 lists endemic genera in Jharkhand of which 2 have exclusively Indian and 6 have extra Indian distribution

Classification based on Ecology

Table 2: Peregrine earthworm genera and species of Jharkhand

Family/Genera	Species
LUMBRICIDAE	*Eisenia foetida*
OCTOCHAETIDAE	
Dichogaster	*Dichogaster affinis*
	Dichogaster bolaui
OCNERODRILIDAE	
Ocnerodrilus	*Ocnerodrilus occidentalis*
MEGASCOLECIDAE	
Pheretima	*Pheretima planata*
	Pheretima posthuma

Table 3: Endemic earthworm genera and species of Jharkhand

Restricted to India	Family	Extra Indian distribution
	ALMIDAE	
		Glyphidrilus
		Glyphidrilus tuberosus
	GLOSSOSCOLECIDAE	
		Pontoscolex
		Pontoscolex corethrurus
	OCTOCHAETIDAE	
Pellogaster		*Lennogaster*
Pellogaster bengalensis		*Lennogaster pusillus*
	MEGASCOLECIDAE	
Lampito		*Perionyx*
Lampito mauritii		*Perionyx sansibaricus*
		Perionyx excavatus
	MONILIGASTRIDAE	
		Drawida
		Drawida calebi
		Drawida willsi

Evans and Guild (1947) distinguished earthworms into surface dwelling and deep dwelling forms. Byzova (1965) was the first to distinguish surface living smaller worms with high metabolic rate from deep dwelling larger worms with less metabolic rate. Bouche (1977) proposed an ecological classification of earthworms into 3 generalised life forms.

(i) Epiges - litter or dung dweller, tolerant to disturbances, high rate of cocoon production and short life cycle, body size small and deeply pigmented.

(ii) Endoges – Dwellers of top soil rich in organic matter, tolerant to some disturbances moderate to high rate of cocoon production light pigmented and

(iii) Aneciques – Deep soil dwellers, intolerant to disturbances, low rate of cocoon production, long life cycle, body size large and unpigmented or light pigmented.

The details of characteristics of ecology-based classification have been presented in Table 4. Earthworms may also be clearly divided into detritivores, that feed at or near the soil surface mainly on plant litter or dead roots and other plant debris in the organic matter rich surface soil horizons or on mammalian dung, and geophages, that feed in deeper layer beneath the surface ingesting large quantities of soil, usually selecting portion with higher than normal organic matter content. The group that comprises detrivorous earthworms are more or less equivalent to the humus formers and geophagous species to humus feeders, the two principal morpho-ecological categories of earthworms recognized by Perel (1977).

Table 4: Summary of characteristics used by Bouche (1977) to distinguish ecological type of earthworms (After Dash and Senapati, 1986)

Character	Ecological type		
	Epigeics	Endogeics	Anecics
Body size	Small	Moderate	Large
Burrowing muscles	Reduced	Strongly developed	Developed
Longitudinal contraction	Nil	Developed	Least developed
Hooked chetae	Absent	Present	Absent
Sensitivity to light	Feeble	Moderate	Strong
Mobility	Rapid	Moderate	Feeble
Skin moistening	Developed	Developed	Feeble
Pigmentation	Homochromic	Dorsal and anterior	Absent
Fecundity	High	Moderate	Limited
Maturation	Rapid	Moderate	Slow
Respiration	High	Modest	Feeble
Survival of adverse conditions	As cocoons	True diapause	By quiescence

Table 5: Three proposed reclassifications of family Megascolecidae (Stephenson's 1930)

Gates(1959) 1	Omodeo(1958) 2	Lee(1959) 3
Family Megascolecidae Prostates lobular(racemose)	Family Megascolecidae Prostates lobular(racemose)	Family Megascolecidae as Stephenson (1930)
Family ACANTHODRILIDAE Prostates tubular Calciferous glands not in segment 9 or 9 and 10 Excretory system holonephridial	Family ACANTHODRILIDAE Prostates tubular	Subfamily Megascolecinae One pair of prostatic pores combined with or in addition to one pair of male pores on segment 18
	Subfamily Ocnerodrilinae Calciferous glands in segment 9 or segments 9 and 10	
Family OCTOCHAETIDAE Prostates tubular Calciferous glands not in segment 9 or 9 and 10 Excretory system meronephridial	Subfamily proposed Caliciferous glands absent	Subfamily Acanthodrilinae One pair of prostatic pores on segments 16, 17 or 19 or two pairs on segments 17 and 19
Family OCNERODRILIDAE Prostates tubular Calciferous glands in segments 9 or 9 and 10	Subfamily proposed Simple calciferous glands in segments 10-13 Nephridiopores in two series alternating in position in successive segments	Tribe Neodrilacae Excretory system holonephridial
	Subfamily proposed Simple calciferous glands in segments 14-17	Tribe Acanthodrilacae Excretory system holonephridial with nephridiopores in a single series on each side of the body; or excretory system meronephridial
	Subfamily Benhaminae Calciferous glands stalked and laminate	

Systematics

A systematic account and ecological as well as biological observations on the earthworms of Jharkhand has been presented along with a key for the identification of the earthworms of Jharkhand. For a detailed synonymy of the species, the works of Gates (1972) and Julka (1976, 1978) may be referred. In this work the classification of Oligochaeta into orders and suborders as proposed by Brinkhurst and Jamieson (1971) and the division of the suborder Lumbricina into superfamilies and families as given by Sims (1980) have been followed.

Earthworms of family Megascolecidae are most widely distributed. This family has 30 genera, of which *Perionyx* is the largest with 47 species. The classification of the megascolecid earthworms has always been more controversial than that of other oligochaete families. In recent years three new systems of classification have been proposed, those are by Omodeo (1958), Gates (1959) and Lee (1959). These classificatory schemes given in Table 5 replace that of Stephenson (1930).

The photographs of specimens are presented as Plate 1 to 8 while various specific identifying characters are presented as Fig. 1 to 21. Some of the specific features as SEM have been presented in Fig. 22 to 25.

Key to the Identification of earthworms of Jharkhand

1. Testes and male funnels intraseptal, male pores in 10/11, clitellum in *x-xiii*.....2 (Fam. Moniligastridae)

   Testes and male funnels interseptal, male pores posterior to 10/11, clitellum in *xiii* and posteriad segments 4

2. Genital markings with central pores, genital marking glands digitiform, prostate-like, distinctly protuberant into body cavity 3

   Genital markings without central pores, genital marking


Plate 1a: ***Glyphidrilus tuberosus;*** **b:** ***Pontoscolex corethrurus***


Plate 2a: ***Dichogaster affinis;*** **b: Casts of** ***Dichogaster affinis***


Plate 3a: Cocoon of ***Dichogaster affinis;*** **b:** ***Dichogaster bolaui***


Plate 4a: ***Lennogaster pusillus;*** **b:** ***Pellogaster bengalensis***


Plate 5a: ***Ocnerodrilus occidentalis;*** **b: Cast of** ***Ocnerodrilus occidentalis***


Plate 6a: ***Lampito mauritii;*** **b:** ***Pheretina planate***


Plate 7a: ***Pheretina posthuma;*** **b:** ***Perionyx sansibaricus***


Plate 8a: ***Drawida calebi;*** **b:** ***Drawida willsi***

glands spheroidal to oval between epidermis and longitudinal muscle layer... *Drawida calebi*

3. Genital markings in 9/10, genital marking glands shorter than prostates..... *Drawida willsi*
4. Male and spermathecal pores inconspicuous, prostates absent, body wall protuberant at maturity as a longitudinal lamellar ridge ("Wing") through several clitellar segments..... *Glyphidrilus tuberosus* (Fam. Almidae)

   Male and spermathecal pores distinct, prostates present, body wall not so modified..... 5
5. Spermathical pores two pairs in 9/10 & 10/11 near the middorsal line.....Eisenia foetida
6. Prostates tubular 6

   Prostates racemose..... 15

   (Fam. Megascolecidae)
7. Last pair of hearts in *ix*, dorsal pores usually absent..... 8

   (Fam. Ocnerodrilidae) Last pair of hearts behind *ix*, dorsal

pores usually present..... 8

8. Extramural calciferous glands paired in *ix*, gizzard absent .....*Ocnerodrilus occidentalis*

9. Meronephric, nephridia present in preclitellar segments..... 9 (Fam- Octochaetidae)

9. One gizzard present..... 15 Two gizzards present..... 11

11. Calciferous glands one pair, each gland trilobed with one vertical lobe in each of segments *xv*, *xvi* and *xvii*... 12 Calciferous glands more than one pair, anterior to segment *xiv*..... 13

12. Female pore single, median; genital marking absent,... *Dichogaster bolaui* Female pores paired 13

13. Median genital markings present ..... *Dichogaster affinis*

14. Calciferous glands 4 pairs in *x-xiii*, holandric, spermathecal pores on *viii* and *ix*... *Pellogaster bengalensis* Calciferous glands 3 pairs in *x-xiii*, proandric, spermathecal pores on *viii*... *Lennogaster pusillus*

15. Holonephric..... ... 16

Meronephric..... 17

16. Spermathecal pores 3 pairs in 6/7/8/9, nephridia vesiculate, nephridiopores alternating in position in successive segments on each side ..... *Perionyx sansibaricus*

17. No spines on the falt end of the penial setae...*Perionyx excavatus*

18. Gizzard in *v*, spermathecae bidiverticulate, male pores discharging directly on to the body surface, penial setae present, intestinal caeca absent ... *Lampito mauritii* Gizzard posterior to septum 7/8, spermathecae unidiverticulate, male pores discharging within copulatory pouches, penial setae absent, intes-tinal caeca present, originating in or near *xxvii*... 19

19. Septum 8/9 present and muscularized, spermathecal pores 4 pairs opening slightly anterior to 5/6-8/9, genital markings paired usually on *xvii* and *xix*, slightly median to male pore lines ..... *Pheretima posthuma*

Septum 8/9 absent, spermathecal pores 2 pairs opening on *vii* and *viii* close to 6/7/8, genital markings 1-4 slightly median to each spermathecal pore on *vii-viii*, 8-13 on roof and walls of each copulatory pouch... *Pheretima planata*

20. Calciferous glands present, extramural in *xvv-ix*, typhlosole present, gizzard present oesophageal ...*Pontoscolex corethrurus* (Family– Glossoscolecidae) A sizable number of specimens are still under examination for their systematics and bionomics.

Systematic Account

Order Haplotaxida belongs to class Oligochaeta of Phylum Annelida.

Order **HAPLOTAXIDA**

Diagnosis. Testes and male funnels interseptal; male funnels at least one segment anterior to that bearing the male pores.

Suborder **LUMBRICINA**

Diagnosis. Male pores at least 2 segments posterior to testes. Clitellum formed from multiple layers of cells.

Superfamily **GLOSSOSCOLECOIDEA**

Diagnosis. Ovaries large, elongate, band or ribbon-shaped, tending to become lobate, oocytes not forming egg-strings.

Family **ALMIDAE**

Diagnosis. Body quadrangular in cross-section at least posterior to clitellum. Dorsal pores absent. Male pores inconspicuous, one pair between *xv-xxx*; spermathecal pores inconspicuous, multiple, usually posterior to testes. Prostates usually absent. Oesophageal gizzard(s) anterior to the testicular segment; extra-mural calciferous glands absent. Holonephric.

Distribution. Tropical America, Africa, India, Burma, Malaysia and Indochina eastward to Sulawesi.

Genus ***Glyphidrilus*** Horst

Diagnosis. Setae lumbricine. Male pores inconspicuous, ventral to the laterally protuberant ridges or "wings" in clitellar segments. Oesophagus with a single gizzard in *vii* or *viii,* sometimes extending into an adjacent segment; calciferous

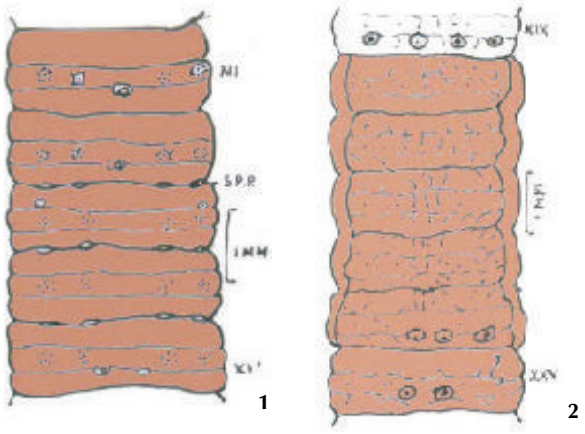


Figure 1 to 2: *Glyphidrilus tuberosus* (Stephenson); 1. Spermathecal pore area; 2.Clitellar region

glands, intestinal caeca and supra-intestinal glands absent; typhlosole simple lamelliform. Prostates absent. Nephridiopores at *b* lines, nephridia absent anterior to *xii*.

Distribution. India, Sri Lanka, Burma, Hainan, Malaya, Sumatra, Java, Borneo, Celebes, Tanzania.

Glyphidrilus tuberosus Stephenson

(Fig. – 1, 2; Plate – 1a)

1916. *Glyphidrilus tuberosus* Stephenson, *Rec. Indian Mus.,* **12**: 349 (Type locality: Cuttack, Orissa, India); Stephenson, 1923, *Fauna Br. India, Oligochaeta*: 494-495; Jamieson, 1971, In *Aquatic Oligochaete of the world*, Ed. Brinkhurst, R.O. and Jamieson, B.G.M., Oliver& Boyd, Edinburgh: 766.

Diagnosis. Length 60-118 mm, diameter 3 mm, 221 segments. Prostomium prolobic. Clitellum annular, *xiv*, *xv*, *xvi-xxviii*, *xxix*, with lateral, longitudinal protuberant ridges (ala or 'wings') on *xx - xxiv*, extending forwards as slight ridges to *xiv* and sometimes back to *xxviii*. Setae *aa* =2 *ab* = 0.9 *bc* = 2 *cd* = 0.72 *dd* on *xii*, *aa* = 2 *ab* = *bc* = 2.25 *cd* = 0.78 *dd* on *xxii*. Male pores inconspicuous. Female pores paired, minute, presetal, on *xiv*, slightly lateral to *b* lines. Spermathecal pores 2-4 on each side, in 13/14/15, at *a, b* and *bc*, sometimes at *c*. Genital markings

small, rounded papillae, postsetal, usually arranged in a set of 6 in a transverse row on a segment; 2 in *aa*, 1 in *ab* and 1 slightly lateral to *b* on *x-xii*, *xiii*; 1 median to *a*, 1 in *ab* and 1 lateral to *b* on *xvi*, *xvii, xviii-xix, xxiv-xxviii, xxx*.

Gizzard in *vii*, sometimes slightly extending in *vi*, size variable. Intestine begins in *xv*. Last pair of hearts in *xi*. Holandric, testes and male funnels free in *x* and *xi*; seminal vesicles in *ix-xii*. Spermathecae small spherical sacs without diverticula, 2-4 on each side in *xiv* and *xv*. Nephridia avesiculate.

Distribution. India : Jharkhand : Morhabadi, Dhurwa; Orissa; West Bengal; Tamil Nadu.

Material examined. Five aclitellate and two clitellate specimens from Morhabadi, Bero in Ranchi district.

Habitat. Submerged soil with high organic matter (>10g%) particularly mulched materials, muddy soil, with about neutral pH, in lowland crop field soil and sewage system.

Biology. The maximum population density was 300 m^{-2} in a lowland crop field. Activity ceases at a lower soil moisture (<15-18g %). Reproduction is biparental; cocoons are flat, beetle leaf shaped; usually a single young hatches from each cocoon; incubation period is about 15-30 days. Reproduction is restricted to the rainy season in August-September, but it may continue throughout the year in permanent moist habitats. Two reproductive peaks, one during rainy and the other during early summer, were observed in irrigated crop fields. This species deposits casts on the soil surface in the form of elongated threads arranged in small tower-like structures. Cast production was estimated as 26g g^{-1} dry weight of body tissue/ day.

Genus ***Eisenia*** Malam.

Diagnosis Prostomium epi to tany lobous. Spermathical pores two or three pairs, in 8/9-10/11, above *d,* in or near the middorsal line. Gizzard taking up more than one segment. Three or four pairs of seminal vesicles in ix, xi and xii, or in ix - xii.

The indian species are distinguished by their colour and their transverse pigmented bands over the dorsum in Indian *E. foetida* are very distinctive.

Eisenia foetida Savigny

Diagnosis *Allolobophora* (*Eisenia*) *foetida*(Setv.); *1891. Allolobophora foetida,* Rosa, Ann. Hofmus. Wien. vi, p. 381; 1895. *Allolobophora foetida,* Beddard, Monog. p. 702; 1900. *Eisenia foetida,* Michaelsen, Tier. x, p. 475; *1909. Eisenia foetida,* Michaelsen, Mem. Ind. Mus. i, p. 245; *1910. Helodrilus (Eisenia) foetidus,* .Michaelsen, Abh. Ver. Ham-burg, xix, p. 104; 1913. *Heloldrilus (Eisenia) foetidus,* .Michaelsen, Mt. Muss. Ham-burg, xxx, p. 92; 1914. *Helodrilus (Eisenia) foetidus,* Stephenson, Rec. Ind. Mus. x, p.363; 1916. *Helodrilus (Eisenila) fooetida,* Stephenson, Rec. Ind. Mus. xii, p. 352; 1917. *Helodrilus (Eisenia) foetidus,* Stephenson, Rec. Ind. Mus. xiii, p. 414.

Diagnosis: Length 60-90 mm., diameter 3-4mm. in life with red, purple, or brown segmental bands over dorsum, separated by paler intervals; the bands slightly marked in ix-xi, except mid-dorsally; bands sometimes two per segment; ventral surface pale. Prostomiumepilobous ½. Dorsal poers from 4/ 5. Setae slender, ornamented, closely paired; *aa* = *bc; dd* = half the circumference. Clitellum from xxiv, xxv, or xxvi to xxxii (= 7-9). Ridges ("walls") at maturity on 3 – 4 segments, xxvii to xxx or xxxi. Male pores with fairly large raised areas which do not transgress the limits of xv. Spermathecal pores two pairs, in 9/10 and 10/11, near the mid-dorsal line.

Distribution: Simla and neighbourhood; Kodaikanal and neighbourhood, Palni Hills; Coonoor, Nilgiri Hills; Ponmudi, Travancore; Sevok, Darjiling Dist.; Nicobar Islands. In Jharkhand –Ranchi, Ramgarh, Hazaribg, Palamau, Kanke.

Subfamily **GLOSSOSCOLECINAE**

Diagnosis. Genital setae, if present, not grooved longitudinally. Male pores usually intraclitellar, seldom (Opisthodrilus) postclitellar. Spermathecal pores, if not altogether absent, wholly or at any rate partly in front of the testis segments. A single oesophageal gizzard present. Calciferous glands ("chyle sacs") present.

Distribution. The subfamily is endemic only in Central and S. America as far as the Argentina, in the Bermudas and West Indies. The only Indian species is *Pontoscolex corethrurus,* which has been carried all over the Tropics, where it is found on islands or near the coasts.

Genus ***Pontoscolex*** Schmarda.

Diagnosis. Seatae at the hinder end of the body usually arranged in quincunx. Male pores and copulatory papillae in the region of the clitellum. Three pairs of chyle-sacs in *vii-ix*, of complicated structure, originating dorsally. Nephridia with terminal sphincter. Sexual apparatus metandric and metagynous; seminal vesicles very long, piercing the successive septa for a long distance.

Distribution. For the Indian distribution see under the species. The original home of the genus is Central America.

Pontoscolex corethrurus Stephenson (Plate - 1b)

1915. *Pontoscolex corethrurus,* Stephenson, *Mem. Ind. Mus.* **vi**, p. 105; 1916. *Pontoscolex corethrurus,* Stephenson, *Rec. Ind. Mus.* **xii**, p. 349; 1917. *Pontoscolex corethrurus,* Michaelsen, *Zool. Jahrb. Syst.* **xii**, p. 234; 1920. *Pontoscolex corethrurus,* Stephenson, *Mem. Ind. Mus.* **vii**, p. 258; 1921. *Pontoscolex corethrurus,* Michaelsen, *Mt. Mus. Hamburg*, **xxxvii**, p. 68; 1922. *Pontoscolex corethrurus,* Stephenson, Rec. *Ind. Mus.* **xxiv**, p. 440; Stephenson, 1923, *Fauna Br. India, Oligochaeta*: 489-490.

Diagnosis. Length 60-120mm, diameter 4mm, segments 90-212. Unpigmented. Prostomium with segment *i* retractile. Setae slightly ornamented, transversely grooved at the tip (ornamentation often worn away); in the anterior part of the body closely paired and exceptionally so throughout the body; usually from about *x* or *xii* onwards the pairing is wider and in the hinder part of the body the setae are alternately widely and closely paired, with a quincunx arrangement. Setae in the hinder part of the body much enlarged, with straight distal end; in the clitellar region more strongly ornamented. Nephridiopores in *c*. Clitellum *xv* or *xvi-xxii* or *xxiii*; thickened ridges *xix-xxii*, outside the line of *b*. Male pores on 20/22 or immediately behind this. Spermathecal pores three pairs, in 6/ 7-8/9, in *c*.

Septa 5/6, 6/7-10/11 thickened, the first fairly strongly, the last

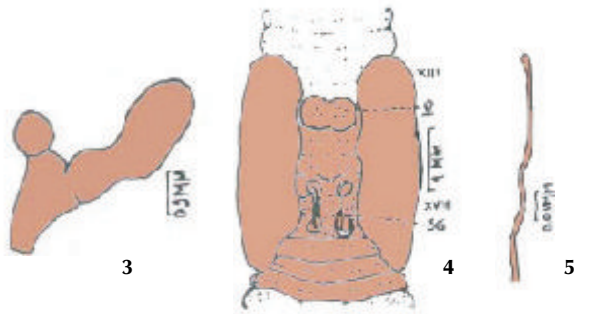


Figure 3 to 5: *Dichogaster affinis* (Michaelsen); 3. Spermatheca; 10.Male genital area; 11.Penial setae

two gradually less. Last pair of hearts in *xi*. Spermathecae very slenderly club-shaped.

Remarks: In a worm probably belonging to this species (there is no other Indian worm which has the quincunx arrangement of the setae) Stephenson found the nephridia of segment *ii* opening into the pharynx, they would therefore be peptonephridia. According to Beddard these nephridia open on the surface of the body on segment *ii*, though owing to the great retractility of the anterior end of the body this orifice may come to lie in a temporary buccal cavity.

Stephenson found the septum 10/11 thin and 9/10 absent; there was also some irregularity in the attachment to the parietes.

Distribution: India: Jharkhand: Pundag, Andhra Pradesh; Maharashtra; Gujarat; Karnataka; Tamilnadu. Adam's peak, Peradeniya, Kandy, Colombo.

Material examined: 3 clitellate specimen from Pundag and Bero in Ranchi district, Nov. – April (2009-2011).

Superfamily **MEGASCOLECOIDEA**

Diagnosis: Ovaries large, fan to rosette-shaped with the oocytes forming several egg strings.

Family **OCTOCHAETIDAE**

Diagnosis: Body cylindrical. Dorsal pores present. Male pores behind *xvi*. Spermathecae in pre-testicular segments; prostates tubular with central canal. Last pair of hearts posterior to *xi*. Meronephric.

Distribution: Australasia, Tropical America and Africa, India, Burma.

Genus ***Dichogaster*** Beddard

Diagnosis: Setae lumbricine. Male pores paired, in seminal grooves on *xviii* or 17/18; prostatic pores one pair on *xvii* or *xix*, or 2 pairs on *xvii* and *xix*. Oesophagus with 2 gizzards anterior to septum 8/9 and one pair of extramural calciferous glands, each gland trilobed, a vertically reniform lobe in each of segments *xv-xvii* with a common duct opening into gut in *xvi*; intestinal caeca and supra-intestinal glands absent; typhlosole simple, lamelliform, micromeronephridia astomate, enteronephric paired tufts in *ii-iv*, several exonephric on the body wall in *v* and posteriad segments, arranged in longitudinal rows posterior to the prostatic region; paired, stomate, exonephric megameronephridia in a few posterior most segments.

Distribution: Tropical Africa and America, India. Species of *bolaui* group widely transported to various parts of the world.

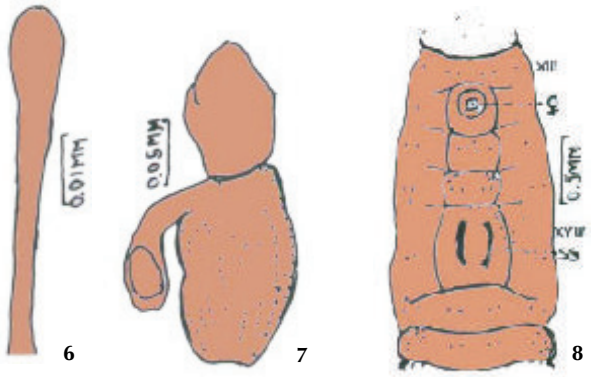


Figure 6 to 8: *Dichogaster bolaui* (Michaelsen); 6. Penial setae; 7. Spermatheca; 8. Male genital region

Dichogaster affinis Michaelsen

(Fig. 3, 4, 5; Plate – 2a, 2b, 3a)

1890. *Benhamia affinis,* Michaelsen, *Jb. hamb. wiss. Anst*., **7**(1):29 (Type locality: Quilimane, Zanzibar); 1910. *Dichogaster affinis,* Michaelsen, *Abh, Ver. Hamuburg,* **xix**: 98; 1913. *Dichogaster affinis,* Stephenson, *Spol Zeyl.* **viii**: 273; 1916. *Dichogaster affinis*, Stephenson, *Rec. Ind. Mus*. **xii**: 338; 1919. *Dichogaster affinis*, Stephenson and Haru Ram, *Tr. Roy, Soc. Edin*. **lii**: 451; 1920. *Dichogaster affinis,* Stephenson, *Mem. Ind. Mus*. **vii** : 258; Stephenson, 1923, *Fauna Br. India, Oligochaeta* : 471-472; 1972. *Dichogaster affinis*, Gates, *Trans. Am. phil. Soc.* **62**(7): 278; Right *et al*., 1978, *Acta Amazonica*, **8** (3), suppl. 1:380.

Diagnosis: Length 27-60 mm, diameter 1-2 mm, 105-140 segments. Prostomium epilobic, tongue closed. First dorsal pore 5/6. Clitellum annular, *xiii, xiv-xxi, xxii*. Setae $aa = 3ab = bc = 3cd = 0.07dd$ on *xii*, $aa = 4.5\text{-}4.7ab = 1.4\text{-}1.5$ $bc = 4.5\text{-}4.7cd = 0.14dd$ on *xxiv*. Male pores paired, minute, in seminal grooves linking prostatic pores on the setal arc of *xviii*, at *a*. Prostatic pores paired, minute, at the ends of almost straight or slightly concave seminal grooves, on *xvii* and *xix*, at *a*. Female pores paired, presetal, minute, at or slightly lateral to *a*. Spermathecal pores paired, minute, in 7/8/9, at or near *a*. Genital markings often present, unpaired and median on 8/9/10, sometimes on 7/8/, 10/11.

Septa 4/5, 7/8-12/13 slightly muscular, 5/6/7 absent. Gizzards between septa 4/5 and 7/8; typhlosole *xxi* to *Ixviii-Ixxvi*, *xc-xci*. Last pair of hearts in *xii*. Holandric, testes and male funnels enclosed in unpaired sacs formed by the peripheral apposition of septa 9/10/11/12, in *x* and *xi*; seminal vesicles in *xi* and *xii*, vestigeal. Penial setae slightly sinuous ectally, ornamented with scale-like markings or teeth in the sinuousities, tip bluntly rounded, knobbed or truncate, 0.29-0.43 mm long, 4-7 m diameter. Spermathecae paired, in *viii* and *ix*, each with a shortly stalked ental diverticulum. Genital marking glands circular to slightly dome-shaped, underneath longitudinal muscle layer.

Distribution: India; Jharkhand, Orissa; Arunachal Pradesh; Meghalaya; Madhya Pradesh; Gujarat; Maharashtra; Karnataka; Kerala. Sri Lanka, Burma, Thailand, Pacific Ocean Islands, Cape Verde Island, Southwest Africa, Madagascar, Zanzibar, Comoro Island, Mexico, El Salvador, French Guiana, Brazil, West Indies.

In Jharkhand specimens were collected from Ranchi,

Morhabadi, Harmu, Bero, Ramgarh, Hazaribagh, Dhanbad, Bokaro, Chaibasa, Chakardharpur and Jamshedpur.

Dichogaster bolaui Michaelsen (Fig. – 6, 7, 8; Plate – 3b) 1891. *Benhamia bolavi,* Michaelsen, *Jb. hamb. wiss. Anst.* **8**:9 (Type locality: Bergedorf, Hamburg, Germany); 1910. *Dichogaster bolaui*,Michaelsen, *Abh. Ver. Hamburg,* **xix**: 98; 1916. *Dichogaster bolaui*, Stephenson, *Rec. Ind. Mus.* **xii**: 348; 1920. *Dichogaster bolaui*, Stephenson, *Mem. Ind. Mus.* **vii**: 257. Stephenson, 1923, *Fauna Br. India, Oligochaeta* : 472-473; 1972. *Dichogaster bolaui*, Gates, *Trans. Am. phil. Soc.,* **62** (7): 279; Righi *et al.*, 1978, *Acta Amazonica*, **8** (3), suppl. 1: 38.

Diagnosis: Length 19-43mm, diameter 1-3 mm, 70-98 segments. Prostomium epilobic, tongue closed. First dorsal pore 5/6, sometimes 6/7. Clitellum annular, *xiii, xiv-xviii, xix, xx, ½ xxi*. Setae *aa* = 2.5-3.3*ab* = 0.8 *bc* = 2.5-3.3 *cd* = 0.08 - 0.09 *dd* on *xii*, *aa* = 2.3-2.8 *ab* = 0.9 *bc* = 2.3-2.8 *cd* = 0.1 *dd* on *xxiv*. Male pores paired, minute, in seminal grooves linking prostatic pores, in *xviii*, at *a*. Prostatic pores paired, minute, at the ends of slightly concave seminal grooves on *xvii* and *xix*, at *a*. Female pore single, median, presetal. Spermathecal pores paired, in 7/8/9, at or near *a*. Genital markings absent.

Septa 4/5, 7/8-12/13 slightly muscular, 5/6/7 absent. Gizzards between septa 4/5 and 7/8; typhlosole *xxi-xxii* to *lxviii-lxxvi*. Last pair of hearts in *xii*. Holandric; male funnels and testes in unpaired sacs formed by the peripheral apposition of septa 9/ 10/11/12, in *x* and *xi*; seminal vesicles acinous, vestigial, in *xi* and *xii*. Penial setae unornamented or ornamented with a few to several triangular teeth, tip hooked or widened and then scalpel, oar, spatula or spoon-shaped, 0.22-0.4 mm long, 3-7.5 m diameter. Spermathecae paired, in *viii* and *ix*, each with a small digitiform to pyriform ventrally directed ental diverticulum, duct rather barrel-shaped.

Distribution: India: Jharkhand : Ranchi, (HEC, Sector II), Orissa; Andaman and Nicobar Islands; Arunachal Pradesh; Meghalaya; West Bengal; Sikkim; Himachal Pradesh; Uttar Pradesh; Madhya Pradesh; Rajasthan; Gujarat; Maharashtra; Andhra Pradesh; Karnataka; Tamil Nadu; Kerala. Sri Lanka, Pakistan, Bangladesh, Burma, Malaya Peninsula, Vietnam, China, Indonesia, Philippines, Pacific Islands, Japan, Australia, Africa, Madagascar and adjacent islands, Germany, North, Central and South America, West Indies.

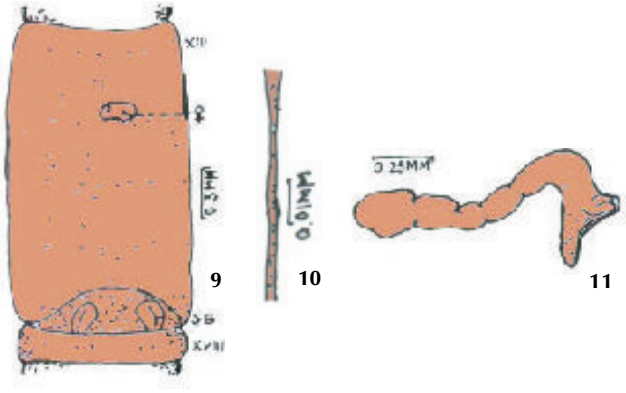


Figure 9 to11: *Lennogaster pusillus* (Stephenson); 9.Male genital area; 10.Penial setae; 11. Spermatheca

Material Examined: 4 clitellate, H.E.C. Sector 2, 2 non clitellate H.E.C. Sector 2. Jharkhand, Sept 2010.

Habitat: It inhabits top 5 cm soil with high organic matter (>10 g%); kitchen waste; soil around compost pits; rotten wood; among roots of lichen growing on stones; in tree holes in soil around palm and coconut leaves; thatched roof of a house.

Biology: Population in a thatched roof of a house was 800 m^{-2}. Activity is restricted to 2-3 months from early rainy to post rainy period from mid-June to September. Reproduction is bi-parental copulation occurring during heavy rains in July. Cocoons are small, thin-walled, light coloured and oval with ornamentations. Clitellar degeneration during post reproductive period and diapause during unfavourable period are distinct. However, reproduction may continue throughout the year in moist places with high humus. Young worms hatch in about 12-18 days. Casts are deposited on the soil surface in small heaps of tiny globular pellets.

Economic importance: Decomposing enzyme like cellulase has been reported in its gut (Mishra and Dash, 1980a) and it might be important in converting organic matter into available nutrients.

Genus ***Lennogaster*** Gates

Diagnosis: Setae lumbricine. Male pores paired, in seminal grooves in *xviii* or 17/18; prostatic pores one pair on *xvii* or 2 pairs on *xvii* and *xix*; female pores paired, in *xiv*. Oesophagus with 2 gizzards, in *v-vi* and 3 pairs of discrete extramural calciferous glands, in *x-xii*; intestinal caeca and supra-intestinal glands absent; typhlosole simple, lamelliform. Microm eronephridia astomate, enteronephric paired tufts in *iii*, few, exonephric on the body wall in *iv* and posteriad segments, arranged in 3-5 longitudinal rows in post clitellate segments; paired, stomate, exonephric megameronephridia in caudal segments.

Distribution: India (From Burma border through the Gangetic plain and into the northern part of the peninsula), Burma, Bangladesh.

Lennogaster pusillus Stephenson

(Fig. – 9, 10, 11; Plate – 4a)

1920. *Eudichogaster pusillus,* Stephenson, *Mem. Indian Mus.*, **7**: 253 (Type locality; Saugor, Madhya Pradesh, India); 1939. *Lennogaster pusillus*, Gates, *Rec. Indian Mus.*, 41: 199, Julka, 1978, *Mitt. Zool. Mus. Berlin.* **54:** 192.

Diagnosis: Length 20-68 mm, diameter 1-2.5 mm, 105-132 segments. Prostomium proepilobic, tongue closed. First dorsal pore 11/12, sometimes 12/13. Clitellum annular, *xiii-xvii*. Setae *aa* = 1.6-1.7 *ab* = 0.9 *bc* = 1-1.1 *cd* = 0.12-0.13 *dd* on *xii, aa* = 2.4-2.5 *ab* = 1.3 *bc* = 1.5-1.7 *cd* = 0.14-0.17 *dd* on *xxiv*, no setae copulatory. Male genital field transversely thickened, on *xvii*; male pores paired, minute, in or near 17/18 at posterior ends of seminal grooves, at *b*. Prostatic pores paired, minute, on the setal arc of *xvii* at anterior ends of seminal grooves at *a*. Seminal grooves crescentric, diagonally placed on oval porophores, extending from the setal arc of *xvii* to 17/18, at *ab*. Spermathecal pores paired, minute, on *viii*, at *a*. Septa 4/5-7/8 delicate, 8/9-12/13 slightly muscular. Typhlosole in *xvii-*

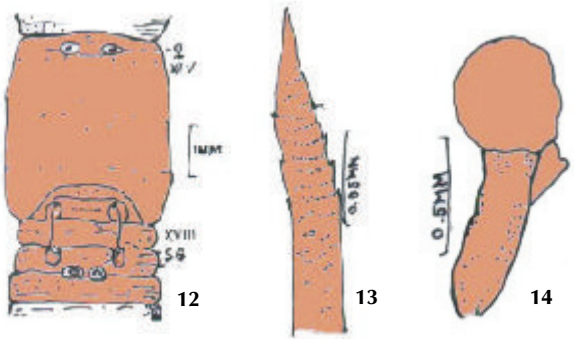


Figure 12 to14: *Pellogaster bengalensis* (Michaelsen); 12. Male genital region; 13. Penial setae; 14. Spermatheca

xviii to *lxx-lxxvi*. Last pair of hearts in *xii*. Proandric but with male funnels in *xi*. Testes and male funnels in *x* enclosed in paired sacs; seminal vesicles absent. Prostates paired, in *xvii*. Penial setae ornamented with scattered small triangular teeth, tip almost membranous, slightly widened with ectal end straight or jagged or concave or deeply indented, 0.53-0.65 mm long, 4-5 m diameter. Spermathecae paired, in *viii*, elongate, each with a sessile spheroidal to tubular ental diverticulum, ampulla at right angle to the duct.

Distribution. India: Jharkhand : Bero, Pundag; Orissa; Uttar Pradesh; Madhya Pradesh; Himachal Pradesh; Karnataka.

Material examined: 4 clitellate specimen from Dhurwa and Pundag in Ranchi District, Aug-Sept, 2010.

Habitat. It is litter dwelling and remains within top 5cm alkaline soil (pH 7-8) with high organic matter (> 10g%). It also inhabits kitchen waste, compost pit near cow shed and in roofs of thatched houses.

Biology: Population density around a compost pit was 600 m^{-2}. Activity is restricted to 2-3 months from late June to September. Diapause during unfavourable period is passed in immature stages. Soil moisture of about 15-20 g% is most favourable. Cocoons are small, round with ornamentations, initially pale lemon gradually changing to greenish-reddish brown. Incubation period is about 12-18 days. Usually a single worm hatches from each cocoon. Clitellum degenerates during post-reproductive period. Activity may continue throughout the year where adequate moisture and organic matter are available (Senapati, 1983). Casts are deposited on the soil surface in the form of small towers with central openings.

Economic importance: This species might be important in the biodegradation of wastes to some extent.

Genus ***Pellogaster*** Gates

Diagnosis: Setae lumbricine. Male pores paired, in seminal grooves, on *xviii*. Prostatic pores paired, at the ends of seminal grooves, on *xvii* and *xix*. Female pores on *xiv*. Oesophagus with 2 gizzards, in *v-vi* and 4 pairs of discrete extramural calciferous glands, in *x-xiii*; intestinal caeca and supra-intestinal glands absent; typhlosole simple, lamelliform. Micromeronephridia astomate, exonephric, paired tufts in *ii-ix*, a few on the body wall in *xii-xix* arranged in 2-3 longitudinal ranks posterior to prostatic region on each side; paired stomate exonephric megameronephridia present in caudal segments.

Distribution: India (northern portion of the peninsula from Jabalpur to Orissa including Bihar, Jharkhand and West Bengal).

***Pellogaster bengalensis*:** Michaelsen

(Fig.–12,13,14; Plate – 4b) 1910. *Eudichogaster bengalensis,* Michaelsen, *Adh. Geb. Naturw. Hamburg.* **19**: 96 (Type locality: Tribeni, W. Bengal, India); 1939. *Pellogaster bengalensis*, Gates, *Rec. Indian Mus.*, **41:** 201; Julka, 1978, *Mitt. Zool. Mus. Berlin.* **54:** 194.

Diagnosis: Length 40-74 mm, diameter 2-5 mm, 94-140 segments. Prostomium tanylobic. First dorsal pore 10/11 or 11/12. Clitellum annular ½ *xiii, xiv-xvi, xvii*. Setae *aa* =2.6 - 3*ab* = 1-1.2 *bc* = 1.6-2.1 *cd* = 0.26-0.27*dd* on *xii*, *aa* = 2.8 *ab* =1.8 *bc* = 1.8 *cd* = 0.27 *dd* on *xxiv*, *a* on *viii* and *ix* absent. Male pores minute slits, at *ab*. Prostatic pores minute, at *ab*; seminal grooves straight. Female pores paired, presetal, within *a* lines. Spermathecal pores paired, tiny, transverse or crescentric slits, at or close to the sites of missing a setae, on *viii* and *ix*. Genital markings tiny, circular to oval, paired, close to the spermathecal pores on *viii-ix*, presetal on *xvii* and postsetal on *xix*, at *ab*, sometimes on the setal annuli of *x* and *xx*, posterior margin of *xix* and in or slightly posterior to 19/20, at *aa*.

Septa 4/5/6 delicate, 6/7-9/10 muscular, 10/11 slightly muscular. Intestine begins in *xvi*; typhlosole *xvii* to *lxxiii*. Last pair of hearts in *xii*. Holandric, testes and male funnels free, in *x* and *xi*; seminal vesicles in *xi* and *xii*. Penial setae ornamented with *c.* 15 irregular broken circles of fine to triangular spines, tip claw-shaped to pointed or bluntly rounded, 0.7-1.3 mm long, 16-20 m diameter. Spermathecae paired, in *viii* and *ix*, each with a sessile ental diverticulum.

Distribution: India: Jharkhand (Ranchi, HEC area, Ormanjhi, Bero, Ramgarh, Hazaribagh, Peterwar, Chaibasa, Chatra, Daltonganj), Orissa; West Bengal; Madhya Pradesh.

Material examined: 10 juvenile, 21 aclitellate, 11 clitellate specimens in September 2010.

Family **OCNERODRILIDAE**

Diagnosis: Body cylindrical. Dorsal pores rarely present. Male pores posterior to *xvi*. Spermathecae in pre-testicular segments; prostates tubular with central canal; last pair of hearts or its homoetic equivalent in *xi*. Holonephric; nephridia avesiculate.

Distribution: Tropical America, Tropical and southern Africa, some Indian Ocean Island, South India and nearby areas.

Genus ***Ocnerodrilus*** Eisen

Diagnosis: Setae lumbricine. Male pores on *xvii*; prostatic pores one pair, combined with male pores, on *xvii*, seldom a second pair on *xviii*; male genitalia degraded due to parthenogenesis in some species. Oesophagus without gizzard, but with a pair of extramural calciferous glands in *ix*; intestinal caeca, supra-intestinal glands and typhlosole absent.

Distribution: Tropical America and Tropical Africa. Peregrine species transported to several parts of the world.

Ocnerodrilus occidentalis Eisen

(Plate – 5a, 5b)

1878. *Ocnerodrilus occidentalis* Eisen, *Nova Acta R.Soc.Sci. Upsaliensis*, 3. **10** (4): 218 (Type locality: California, U.S.A.); Stephenson, 1923, *Fauna Br. India, Oligochaeta*: 484-485; Gates, 1972, *Trans. Am. phil. Soc.,* **62**(7): 273; Gates, 1973, *Bull.Tall Timbers Res. Stat.* **14**(7):14.

Diagnosis. Length 12-69mm, diameter 1-2mm, 70-84 segments. Prostomium epilobic, tongue open, sometimes closed. Clitellum annular, *xiii, xiv-xix, xx*. Setae *aa=bc, dd*=1/2 C. Male pores (combined with prostatic pores) paired, minute, at centres of whitish porophores on *xvii*, each porophore lateral to *b*. Female pores paired, on *xiv*, at or slightly lateral to *b*. Spermathecal pores and genital markings absent.

Septa present from 4/5, 7/8-10/11 slightly muscular. Intestine begins in *xii*. Holandric, testes and male funnels free, in *x* and *xi*; seminal vesicles absent. Prostates paired, in *xvii*, sometimes extending to *xviii-xxx*. Spermathecae absent.

Distribution: India: Jharkhand : Ranchi, Hazaribagh, Bokaro, Khunti, Bundu, Jamshedpur, Orissa; Uttar Pradesh; Rajasthan; Maharashtra; Kerala; Andaman Islands. Burma, Pakistan, Sri Lanka, U.S.A., Mexico, St. Thomas island, Denmark, Italy, Greece, Cape Verde island, Rhodesia, Southwest Africa, Great Comoro island, Palestine, Lebanon, Central Asia, Singapore, China Japan, Philippine islands, New Hebrides, British Solomon island.

Material Examined: Several juvenile, immature and mature worms from Morhabadi, Hatia, Harmu and Kanke in Ranchi district.

Remarks: *Ocnerodrilus occidentalis* is polymorphic. It is known for parthenogenetic morphs without spermathecae and seminal vesicles. Morphs with degraded male terminalia in

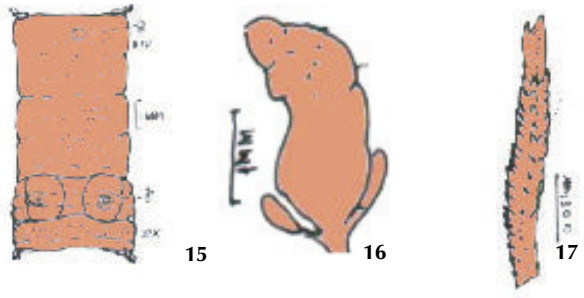


Figure 15 to 17: *Lampito mauritii* (Kinberg); 15. Male genital region; 16. Spermatheca; 17. Penial setae

various forms (absence of testes, male gonoducts, prostates and male pores) have also been recorded.

Habitat: Found in a wide range of moist habitats in alkaline sandy loam and clay loam soils specially in lowland and upland pastures, crop fields, compost pits and sewage.

Biology: A maximum population of about 7600 m^{-2} from a protected upland pasture has been recorded by Srivastava (2002), while Dash and Patra (1977) and Senapati (1980) observed about 550 m^{-2}. Clitellate worms are available during the rainy season and juveniles are abundant during the post-rainy season period. Reproduction by parthenogenesis is suspected, as cocoons were not observed in the field as well as in the laboratory cultures. This species undergoes diapause at low soil moisture (<15g %).

Family **MEGASCOLECIDAE**

Diagnosis: Body cylindrical. Dorsal pores present. Male pores posterior to *xvi*. Spermathecae in pre-testicular segments; prostates racemose without central canals. Last pair of hearts posterior to *xi*. Holo or meronephric.

Distribution: Eastern U.S.S.R., Japan, Korea, Southern China to Australasia.

Genus ***Lampito*** Kinberg

Diagnosis: Setae perichaetine. Male pores (combined with prostatic pores) paired on *xviii*; female pores paired, on *xiv*. Oesophagus with a single gizzard in *v*, calciferous lamellae in *x-xiii*; intestinal caeca and supra-intestinal glands absent; typhlosole present. Meronephric; paired tufts of astomate micromeronephridia on septa *v-xiii*, *xiv*, with ducts from some tufts opening into pharynx; numerous, v-shaped, astomate, exonephric micromeronephridia on the body wall in *xv* and posteriad segments; paired, stomate, enteronephric megameronephridia in *xx* and posteriad segments.

Distribution: India: Jharkhand, Palni and Cardomom Hills in S. India. One species, *Lampito mauritii*, widely distributed upto about 750m altitude throughout India and also to other parts of the world probably due to transportation.

Lampito mauritii Kinberg

(Fig. – 15, 16, 17; Plate – 6a)

1866. *Lampito mauritii* Kinberg, *Ofvers. K. Vetens. – Akad. Forhandl. Stockholm*, **23**:103 (Type locality: Mauritius); Stephenson, 1923, *Fauna Br. India, Oligochaeta* : 259-260; Gates, 1938. *Rec. Indian Mus.*, **40**: 413; Gates, 1960, *Bull. Mus. comp. Zool. Harv.*, **123**(6): 243 Gates, 1972, *Trans. Am phil.* Soc., **62** (7): 133.

Diagnosis: Length 95-155mm, diameter 3-6mm, 157-201 segments. Prostomium epilobic, tongue closed. First dorsal pore in 10/11 or 11/12 or 12/13. Clitellum annular, *xiii*, ½ *xiii-xvii*. Setae 26-39 on *iii*, 40-51 on *viii*, 38-50 on *xii*, 30-43 on *xx*. Male pores on slightly raised porophores, at or lateral to *b*. Female pores presetal, within *aa*. Spermathecal pores paired, in 6/7/8/9. Genital markings absent.

Septa present from 4/5, 7/8-12/13 muscular. Intestine begins in *xv*; typhlosole rudimentary. Last pair of hearts in *xiii*. Holandric; seminal vesicles in *ix* and *xii*. Penial setae ornamented with closely crowded circles of triangular teeth, tip horse shoe-shaped, 1.32-2 mm long, 24-31m diameter. Spermathecae paired in *vii-ix*, each with a median and a lateral digitiform diverticula.

Distribution: India: Jharkhand: Dhurwa, Harmu, Morhabadi, Kanke, Khunti, Ramgarh, Hazaribagh, Orissa; Andaman and Nicobar Islands; Laccadive and Minicoy. Sri Lanka, Maldives, Burma, Bangladesh, Pakistan, Seychelles, Comoro Islands, Madagascar, Mauritius, Zanzibar, Thailand, Malaysia, Sumatra, Christmas Island, Kiss Island, British North Borneo, Philippines, China, Hongkong.

Habitat: Grassland, forest crop field, compost pit, domestic garbage and sewage system. Usually more abundant in soils with high organic matter (>5g %) and neutral to slightly alkaline pH (>7.0).

Material examined: 4 clitellate specimens from Dhurwa and Harmu in Ranchi District. 3 aclitellate specimen from Ramgarh in Hazaribagh district.

Biology: Population is at a low level during summer season (March-mid June). Maximum monthly population in some habitats are : grazed upland pasture 37 m^{-2}; ungrazed upland pasture 42 m^{-2} (Senapati and Dash, 1981); grazed forest 64 m^{-}

^{2} (Mishra and Dash, 1984); ungrazed lowland pasture 240 m^{-2} (Dash and Patra, 1977). Population turnover (maximum/minimum density) is 2 in an upland ungrazed system and 3 in an upland grazed system (Senapati, 1980).

Reproduction in a swampy habitat (soil moisture > 10g %)

occurs throughout the year with two peaks: one around pre-rainy season and another around pre-summer months. In drier habitats, a single peak reproduction is noticed during post-rainy season. Cocoons are oval with a hatching and a non-hatching end; average diameter 3.35mm, length 4.7mm, live weight 25.6mg, ratio of diameter: length 0.70; incubation period around 4 weeks. Usually one, rarely 2 (10%) juveniles hatch from each cocoon. Worms and cocoons are comparatively larger in compost pits during the rainy season (Dash and Senapati, 1980). Cocoon production per adult worm in 3 per year in an ungrazed plot but more than 4 in a grazed (disturbed) plot. Cocoon mortality is higher in a grazed plot (Senapati, 1980). Newly hatched young worms take about

20 months to attain maturity in an upland pasture system. Quiescence during summer delays the maturity around 3-4 months (Senapati, 1980).

L. mauritii deposits casts on the soil surface in the form of small heaps of spheroid or nearly globular pellets. High percentage of fibrous materials might join the pellets to form a string. An average worm of one gram live weight produces 0.7 to 2.8g of dry worm casts/day (Dash *et al.*, 1980). In a lowland ungrazed pasture, it produced about 31 tonnes of dry casts per year per acre.

Economic importance: This species is suitable for utilization as a waste conditioner. In laboratory, inoculation of *L. mauritii* stimulated decomposition of organic waste by 25% (Senapati and Dash, 1982). It has been assessed that an earthworm population mainly dominated by *L. mauritii*, could process about 13% of the net organic matter input from vegetation compartment into soil system. Certain digestive enzymes like protease, amylase, invertase, cellulase and urease have also been reported from the gut of this species (Mishra and Dash, 1980a). Because of high protein content in their body tissue (> 50g %) these worms are quite suitable as fish bait, poultry and fish feed (Dash *et al.,* 1979). Dash *et al.,* (1980) have shown that these worms can also be utilized as biological agents for controlling plant parasitic nematodes.

Genus **Metaphire** Sims and Easton

Diagnosis: Setae perichaetine. Male pores (combined with prostatic pores) paired within copulatory pouches on *xviii,* rarely *xix* or *xx*. Oesophagus with a single gizzard between septa 7/8 and 9/10 and without pouches; intestinal caeca present; originating in or near *xxxii*; supra-intestinal glands absent. Meronephric; paired tufts of astomate, enteronephric micromeronephridia in *iv-vi*; numerous, astomate, exonephric, v-shaped micromeronephridia on the body wall in *iii* and posteriad segments; several stomate, enteronephric, slightly enlarged micromeronephridia on both sides of septa from 16/17 posteriorly; nephridia absent from spermathecal ducts.

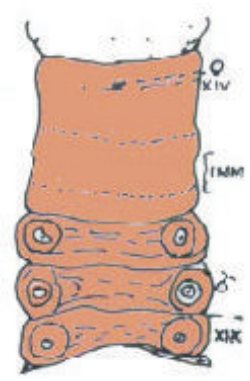


Figure 18 and 19: *Metaphire posthuma* (Vaillant); 18. Male genital region;19. Spermatheca

Distribution: Oriental region from Japan southwards through the Indo-Australasian archipelago to the rain forests of Australasia through Oceania.

Metaphire planata Gates

(Plate – 6b)

1926. *Pheretima planata,* Gates, *Ann. Mag. nat. Hist. (ser. 9)*: **17**:411 (Type locality: Rangoon, Burma); Gates, 1972, *Trans. Am. phil. Soc.,* **62** (7): 211; 1972. *Metaphire planata*, Sims and Easton, *Biol. J. Linn. Soc.* **4**: 239.

Diagnosis: Length 64-176mm, diameter 4-7mm, 115-142 segments. Prostomium absent or rudimentary. First dorsal pore in 10/11 or 11/12. Clitellum annular, *xiv-xvi*. Setae 75-87 on *viii*, 63-78 on *xii*, 55-65 on *xx*, 35-42 between spermathecal pores, 8-14 between male pores. Male pores paired, on *xviii*. Female pores single, median, presetal on *xiv*. Spermathecal pores paired, minute, on anterior margins of *vii* and *viii*. Genital markings small, circular, 1-4 slightly median to each spermathecal pore, 8-13 on roof and walls of each copulatory pouch.

Septa 6/7/8 muscular, 8/9/10 absent, 10/11-12/13 slightly muscular. Intestine begins in *xv*; intestinal caeca paired, simple originating in *xxvii* and extending forward to *xx*; typhlosole simple, lamelliform. Last pair of hearts in *xiii*. Holandric, testes and male funnels contained in paired sacs in *x* and *xi*, testis sacs of *x* ventral, those of *xi* vertical and include seminal vesicles of *xi*; seminal vesicles in *xi* and *xii*. Spermathecae paired in *vii* and *viii*, each with a diverticulum which is longer than the main axis. Genital marking glands composite, stalked.

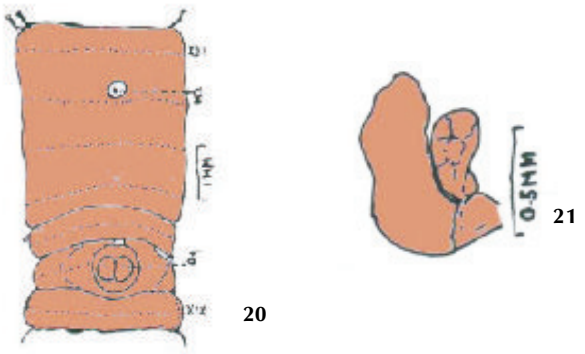
Distribution: India: Jharkhand : Harmu, Lalpur, Chutia, Bero, Dhurwa, Orissa; Assam; West Bengal; Andaman Islands. Burma, Bangladesh, Thailand, Malaysia.

Metaphire posthuma Vaillant

(Fig.–18, 19; Plate – 7a)

1868. *Pheretima posthuma*, Vaillant, *Annls. Sci. nat. (ser. 5)*, **10**: 228 (Type locality: Java); 1900. *Pheretima posthuma*, Michaelsen, *Tier.* **x** :295; 1909. *Pheretima posthuma*, Michaelsen, *Mem. Ind. Mus.,* **i**: 189; 1914. *Pheretima posthuma*, Stephenson, Rec. Ind. Mus., **x**: 342; Stephenson, 1923, *Fauna Br. India, Oligochaeta*: 309-311; Gates, 1972 *Trans. Am. phil. Soc.*, **62** (7): 212; 1972. *Metaphire posthuma*, Sims and Easton, *Biol. J. Linn. Soc.* **4**(3): 239.

Diagnosis: Length 60-140 mm, diameter 3-8 mm, 91-124 segments. Prostomium epilobic, tongue usually open. First dorsal pore in 12/13. Clitellum annular, *xiv-xvi*. Setae 106-129 on *viii*, 63-75 on *xii*, 60-95 on *xx,* 36-44 between spermathecal pores, 16-22 between male pores. Male pores on *xviii*, 0.25 body circumference apart. Female pore single,



20 21

Figure 20 to 21: *Perionyx sansibaricus* (Michaelsen); 20. Male genital region; 21. Spermatheca

median, presetal on *xiv*. Spermathecal pores paired, minute in 5/6-8/9, 0.26-0.33 body circumference apart. Genital markings paired, usually on setal arcs of *xvii* and *xix* slightly median to male pore lines, sometimes on *xvi* and a few segments posterior to *xix*.

Septa 5/6-8/9 muscular, 9/10 absent. Intestine begins in *xv*; intestinal caeca paired, simple, originating in *xxvii* and extending anteriorly to *xxiv*; typhlosole simple, lamelliform. Last pair of hearts in *xiii*. Holandric, testes and male funnels enclosed in unpaired sacs, those of *x* ventral, those of *xi* vertically U-shaped; seminal vesicles in *xi* and *xii*, those of *xi* small, included in the testis sac; pseudovesicles small, in *xiii*. Spermathecae paired, in *vi-ix,* each with an ental diverticulum of variable length, Genital marking glands sessile.

Distribution: India: Jharkhand: HEC, Harmu, Kanke, Kokar, Khunti, Ramgarh, Gumla, Hazaribagh. Orissa; West Bengal; Bihar; Uttar Pradesh; Punjab; Rajasthan; Madhya Pradesh; Maharashtra; Andaman & Nicobar Islands. Bangladesh, Burma, Pakistan, Thailand, Malaya Peninsula, S.E. Asia, Formosa, Indonesia, Philippines, U S A.

Material examined: 4 clitellate, Dhurwa, 1 clitellate, Harmu.

Habitat: It inhabits subsoil at 10-20 cm depth in sandy loam soil with a high organic content (> 5%). It is usually found in grassland, lawn and kitchen garden.

Biology: At one site near a well in grassland at Baleswar the population density was 30 worms m^{-2}. Breeding is interrupted by summer and the worms undergo quiescence. However, breeding is apparently possible throughout the year where adequate moisture is available (Bahl, 1925). Incubation period is about 8 weeks in the field and 4-5 weeks under the laboratory conditions (Tembe and Dubash, 1959). Usually one young hatches from each cocoon, which is spheroidal in shape. A newly hatched worm matures after 8 weeks (Gates, 1972). *Metaphire posthuma* is geophagous and feeds underground. Casts are deposited on the soil surface in the form of small heaps of loose ovoidal pellets.

Economic importance: It is most commonly used as a laboratory material in India.

Genus ***Perionyx*** Perrier

Diagnosis: Setae perichaetine. Male pores (combined with prostatic pores) paired, on *xviii*; female pore unpaired, median, presetal on *xiv*. Oesophagus without or with a single, small gizzard in *v* or *vi*; discrete calciferous glands, intestinal caeca, supra-intestinal glands and typhlosole absent. Holonephric.

Distribution: India, Burma, possibly Sri Lanka and Malaysia.

Perionyx sansibaricus Michaelsen

(Fig. – 20, 21; Plate – 7b) 1891. *Perionyx sansibaricus,* Michaelsen, *Mitt. Naturh. Mus. Hamb.*, **9**:4 (Type locality: Zanzibar); 1903. *Perionyx sansibaricus,* Michaelsen, *Sb. Bohm. Ges. Prag,* **xl**: 8; 1921. *Perionyx sansibaricus,* Stephenson, *Rec. Ind. Mus.* **xxii**: 761; Stephenson, 1923, *Fauna Br. India, Oligochaeta* : 356.

Diagnosis: Length 32-120mm, diameter 2.5-3.5mm, 84-108 segments. Prostomium epilobic, first segment with a mid-dorsal groove. First dorsal pore in 2/3, but variable in location. Clitellum annular, *xiii-xvii*. Setae 54 on *ix*, 58 on *xii*, 47 on *xix*. Male pores usually presetal, near mid-ventral line, in a slightly depressed transverse male field. Spermathecal pores paired, near mid-ventral line, in 6/7/8/9. Genital markings absent. Nephridiopores conspicuous, in two series on each side, alternately dorsolateral and ventrolateral.

Septa present from 4/5. Gizzard slightly developed in *vi*; oesophagus widened in *xiii*; intestine begins in *xvi*. Last pair of hearts in *xii*. Holandric, testes and male funnels free, in *x* and *xi*; seminal vesicles racemose, in *xi* and *xii*. Penial setae absent. Spermathecae paired, in *vii-ix*, each with an ental pear-shaped, shortly stalked, multiloculate diverticulum. Nephridia vesiculate.

Distribution: India: Jharkhand: Morhabadi, Dhurwa, Ratu, Orissa; Maharashtra; Gujarat; Madhya Pradesh; Uttar Pradesh; Tamilnadu; Kerala; Zanzibar.

Material examined: Several juvenile, immature and mature specimens from Morhabadi in Ranchi district.

Habitat. It is usually found in grass land, kitchen garden, garbage dumping and compost pit sites at a depth of 0-20cm.

Biology: At a garbage dumping site near Morhabadi, the population density of worm ranged between 375-10050 m^{-2} with a biomass of 11.53 – 328.38 g dry weight m^{-2} (Sinha and Srivastava, 2001).

Economic importance: This species is suitable for utilisation as a waste conditioner.

Perionyx excavatus Michaelsen

1888, *Perionyx excavatus,* Rosa, Ann. Mus, Genova, (2) vi, p.157; 1890, *Perionyx excavatus*, Rosa, Ann. Mus. Genova, (2) x, p. 121; 1892, *Perionyx intermedius,* Beddard,P.Z.S. 1892, p. 689; 1895. *Perionyx excavatus + P. intermedius + P. gruenewaldi,* Beddard, Mong. Pp. 436,437; 1900. *Perionyx excavatusP. intermedius*, Michaelsen, Tier. X, pp. 208, 209; *1903. Perionyx excavatus,* Michaelsen, Sb. Bohm. Ges. Prag, xl, p.12; 1909.*Perionyx excauatus,* Michaelsen, Mem, Ind. Mus. i, p. 175; 1910. *Perionux excauatus,* Michaelsen, Abh. Ver. Hamburg, xix, p. 61; *1921. Perionyx excavates,* Stephenson, Rec. Ind. Mus. xxii, p. 760; *1922. Perionyx excavatus* Stephenson, Rec, Ind. Mus. xxiv, p. 435; 1872. *Perionyx excavates*, E. Perrier, N. Arch. Mus. Paris, viii, p.126, pl. iv, figs. 73, 74; 1886 *Perionyx excavates*, Beddard, P.Z.S. 1886, p. 308, text-figs. 3-6.

Diagnosis: Length 23-120 mm, diameter 2-5 mm. Segments 75-165. Colour from deep purple to reddish-brown dorsally,

pale ventrally. Prostomiumepilobous 3/5 – 2/3. First dorsal pore in 4/5 or 5/6. Setal rings almost closed, ventrally more nearly than dorsally, or the mid ventral break may be absent; no setae specially en-larged, and no great differences in the setal intervals; numbers 36-40, behind clitellum may rise to 54. Clitellum ring-shaped, xiii or part of xiii-xvii (=5 or less). Male pores approximated, in a common transversely oval small depressed area, each on a small transversely oval papilla, or sometimes represented by a small transverse slit; the anterior and posterior margins of the depressed area well marked, the lateral indistinct. Spermathecal pores in 7/8 and 8/9, approximated, about the same distance apart as the male pores.

No septa specially thickened. Gizzard vestigial, in vi, or may be unrecognizable. No calciferous glands; oesophagus swollen in xiii. Intestine begins in xv. Last heart in xii, Nephridia end in the same longitudinal line or nearly so. Testes and funnels free in x and xi. Seminal vesicles .in xi and xii-xiv. Prostates small, usually confined to xviii, somewhat fissured, compact, sessile on body-wall; duct short and straight. Spermathecae with large ovoid ampulla; duct short and narrow; diverticula one to four, very small, wart-like, on the duct, or diverticula may be quite unrecognizable. Penial setae may be in a group of 4-6 on each side, medial from the male pores; 0.6mm. long, with indistinctly quadrangular smooth tip and many rings of long thin teeth

Remarks, This is one of the commonest worms in India. Besides the more usual situations it has been met with under logs, under bark, and in rotten wood; in the leaves of water -plants; under stones, or in mud by the side of a tank; and worms probably belonging to this species have been found in the hollows of trees in accumulations of dead leaves and rain-water; it is thus able to adapt itself to very various surroundings.

Michaelsen draws attention (54) to the variations met with, especially in the size. The spermathecal diverticula may be mentioned as another variable feature, and also the male field; the depression in which the male pores lie may be quite indistinct. Beddard has found very large variations in the numbers and position of the genital apertures (108).

Distribution: In the E. Himalayas-Dibrugarh and Sadiya (Assam), Darjiling, Kumaon,Dharadun, Simla and the Simla Hills, Calcutta, Pilibhit, Munbai, Andaman . We reported from Jharkhand- Jamshedpur area, Chaibasa, Mnoharpur, Ghatshila, Saraikela

Outside India the species has been met with in the Philippines, Malay Archipelago, Siam, Cochin China, and Burma, Sri Lanka.

Order **MONILIGASTRIDA**

Diagnosis: Testes and male funnels intraseptal in paired dorsal testis sacs; male pores at or close to the intersegmental furrow immediately posterior to the testis sac.

Family **MONILIGASTRIDAE**

Diagnosis: Dorsal pores absent. Male pores at or close to 10/11 or 11/12 or 12/13. Spermathecal pores anterior to male pores. Oesophageal gizzards posterior to the ovarian segment. Ovaries band-shaped, ova large, yolky. Holonephric.

Distribution: Southeast and eastern Asia, from South India to Manchuria, Korea, also Japan, the Philippines, Borneo, Sumatra.

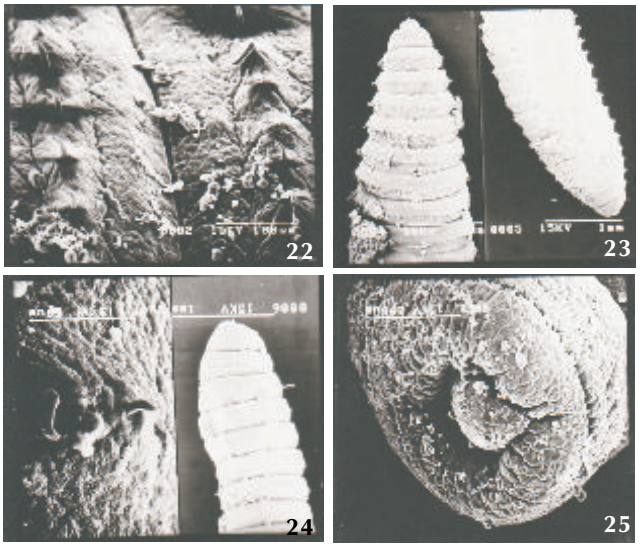


Figure 22 to 25: *22.*Arrangement of setae in *Perionyx sasibaricus, 23.* another view of arrangement of setae in juvenile form 24. Genital setae and genital appurture in *Perionyx sasibaricus, 25.* Epilobous prostomium in *Perionyx sansibaricus*

Genus ***Drawida*** Michaelsen

Diagnosis. Setae lumbricine. Male pores paired, at or near 10/11; female pores paired, at or just posterior to 11/12; spermathecal pores paired, at or close to 7/8. Septa all present from 4/5, 5/6-9/10 muscular. Oesophagus with one to several gizzards, in *xii-xxvii*; intestinal caeca and supra-intestinal glands absent. Capsular prostates paired, in *x*. Holonephridia in *iii* and posteriad segments.

Distribution: India, Nepal, Burma, Malay Peninsula, Thailand, Indo-China, China, Korea, Manchuria, Siberia, Japan, Philippine Islands, Borneo, Sri Lanka, Sumatra and Java.

Drawida calebi Gates (Plate – 8a)

1945. *Drawida calebi,* Gates, *Proc. Indian Acad. Sci.,* **21** (B): 211 (Type locality : Jubbalpore, Madhya Pradesh, India); Julka, 1976, *Mitt. Zool. Mus. Berlin*. **52**(2): 322.

Diagnosis: Length 32-83 mm, diameter 2-4.5 mm, 115-170 segments. Male pores paired, transverse slits, at mid *bc*. Spermathecal pores paired, slightly median to *c* lines. Genital markings small, pre or postsetal, usually single and median, widely paired in *bc*, on *vii-xiii*; sometimes widely paired in *ab* on *xii* and closely paired in *aa* on *vii-x;* one of the paired markings sometimes absent or doubled or tripled. Nephridiopores in a single series close to *d* lines.

Gizzards 2-4, in *xii-xvii*: intestine begins in *xxvi* (±1). Vas deferens short, in a small column of loops in *ix*, almost straight in *x*, entering the antero-median aspect of the prostate directly. Prostates muscular, almost spheroidal, sessile, with an internal ventral portion protrusible as a shortly tubular penis. Spermathecal atrium conical, in *viii*, smaller than prostate. Genital marking glands spheroidal to shortly oval, concealed beneath longitudinal muscles.

Distribution: India: Jharkhand: Ranchi, Dhurwa, Pundag, Harmu, Ramgarh, Khunti. Orissa; Madhya Pradesh; Uttar Pradesh; Karnataka.

Habitat: Geophagous; usually found in pastures, grasslands,

lawns, upland crop fields and compost pits at a depth below 10 cm of soil.

Biology: A maximum population of 131 m^{-2} and 32 m^{-2} has been reported in an upland pasture (Senapati and Dash, 1981) and a forest (Mishra and Dash, 1984) respectively. It has been estimated that this species comprises about 21% and 29% of total worm population in pasture and forest habitat respectively. Cocoons are round with distinct ornamentation, diameter 4.3 mm, length 4.56 mm, diameter: length ratio 0.94 (Senapati *et al.*, 1979). Live weight of cocoon was about 15.17 mg and the incubation period varied from 3 to 8 weeks. Usually one young worm hatches from each cocoon. A high rate of reproduction (3-5 cocoons per adult/year) and high mortality rate has been reported in a grazed upland pasture as compared to a protected upland pasture (Senapati, 1980). Young hatched worms may take 18-20 months to become adults, with 4-6 months of quiescence. *Drawida calebi* undergoes diapause at low soil moisture (< 10g%) and higher soil temperature (> 30ºC). This species deposits sub-soil casts in the form of globular pellets.

Economic importance. Digestive enzymes like protease, amylase, invertase, cellulase and urease in its gut have been reported by Mishra and Dash (1980a). Abundance of these worms in compost pits and presence of cellulase degrading enzymes in their gut indicate that this species might be important in bio-degradation of waste biomass. Dash *et al*. (1979) have shown selective fungal feeding for this species, hence its importance in the decomposer sub-system.

Drawida willsi Michaelsen (Plate – 8b)

1907. *Drawida willsi*, Michaelsen, *Mitt. Naturh. Mus. Hamb.* **24**: 145 (Type locality: Hyderabad, Andhra Pradesh, India); 1909. *Drawida willsi*, Michaelsen, *Mem. Ind. Mus.,* **i**: 143; Stephenson, 1923, *Fauna Br. India, Oligochaeta*: 161-162; Gates, 1945, *Proc. Indian Acad Sci.,* **21** (B): 214.

Diagnosis: Length 55-60mm, diameter 2.5mm, 155-160 segments. Prostomium prolobic. Clitellum annular, *x-xiii*. Setae *aa = bc*. Male pores paired, minute at or very close to *b* lines; each pore on ventral end of slightly depressed or conically protuberant central area of circular to oval porophore.

Spermathecal pores paired, small at *ab*. Genital markings paired, circular, smaller than male porophores, with minute central pores, on 9/10 on or near *b* lines; one of the paired markings sometimes absent.

Gizzards 2-4, in *xii-xvi*; intestinal origin in *xxi*, sometimes in *xxii* or *xxiii*. Vas deferens rather short, in several loops on anterior and posterior faces of septum 9/10, entering the ental end of the prostate directly. Prostates glandular, erect; capsule digitiform. Spermathecae paired, in *viii*: atrium digitiform, in *vii*, as long as or slightly longer than the prostate, arising from the ental end of the spermathecal duct. Genital marking glands digitiform, occasionally or slightly protuberant into coelomic cavity, smaller than the prostates.

Distribution. India: Jharkhand: Ranchi, Dhurwa, Morhabadi, Kantatoli, Harmu, Ramgarh, Khunti. Orissa; Madhya Pradesh; Andhra Pradesh; Uttar Pradesh.

Material examined: 2 aclitellate, 3 clitellate specimens from Dhurwa, Kantatoli and Harmu in Ranchi district.

Habitat: *Drawida willsi* inhabits soils with high organic matter content (> 10g %). It is abundant in crop fields, compost pits and drains; pH ranging from slight acidic to alkaline soils (6.8-7.5).

Biology: It is phytogeophagous. A maximum population density of 32 m^{-2} in an upland protected pasture, 250 m^{-2} in a low land crop field and 500 m^{-2} in a compost pit has been recorded (Senapati, 1980), whereas maximum density of 2115/m^2 was observed by Srivastava *et al*. (2012) from tropical cropland agroecosystem.

Live cocoons are pale to reddish brown, round (diameter: length = 0.9), 3.2mm long and 2.9mm diameter and weigh around 6 mg. Incubation period is 14 -18 days at 25ºC of soil temperature and 16 g% of soil moisture. Usually two young worms hatch from each cocoon, rarely three, although four worms emerging from a single cocoon have been recorded (Dash and Senapati, 1980). Cocoons are laid throughout the year in complete moist habitats, but in rainfed areas they are found only during post-rainy season. However, in exclusively rain-fed habitats where quiescence disrupts growth, maturity is attained in about 18-20 months. It forms diapause coils during dry summer months.

About 5-6 kg of annual dry cast production per gram dry weight of worm has been estimated under laboratory conditions. Casts are deposited on the soil surface in the form of globular pellets. Rate of cast production has been estimated to be around 10 times higher than that of *Lampito mauritii*. Soil moisture of 15 to 22g% is most suitable for worm cast production.

Economic importance: Dash (1999), reported the presence of cellulase, urease, invertase and protease in its gut. Laboratory observations have shown that this species enhances decomposition of green manure and straw in culture.

DISCUSSION

Studies on different region of the globe and on different ecosystem have revealed that the earthworm diversity is highly variable owing to geographical region, climatic condition and disturbances in habitat concerned. The manipulation of natural habitat by anthropogenic activities has resulted into displacement of earthworm species.

The studies of Fragoso (1993), Fragoso *et al*. (1993, 1995) and Fragoso and Rojas (1994) have shown that in the Mexican humid tropics earthworm diversity is affected greatly when natural systems are modified.

The majority of native species were restricted to natural habitats, whereas, most of the exotic species were found in disturbed ecosystems. The average number of native species in south eastern Mexico region, for example, decreased significantly from natural (4 species per site) to managed ecosystems (1 species per site) (Fragoso *et al*., 1993).

Of the 97 species found in southeastern Mexico (71 native and 26 exotic), only 11 species were widely distributed (five native and six exotic). With the exception of *Kaxdrilus sylvicola*, a native epigeic species restricted to tropical and temperate forests, the other ten species were found both in natural and disturbed ecosystems. The native eurytopic species were polyhumics, whereas, the exotics were polyhumic (three

Dichogaster species), epigeic (*Amynthas gracilis*) and mesohumic (*Polypheretima elongata* and *Pontoscolex corethrurus*) species. Pastures were characterized by the presence of both native and exotic species, whereas, exotics constituted the dominant group in cropping systems. The only species limited to tree plantations was the epigeic exotic species *Amynthas gracilis*. This means that in most of the cropping systems, unsuitable conditions exist for epigeic life (e.g. lack of litter layer). Whenever ploughing or tillage was not used, some stenotopic species were able to survive in agroecosystems (*Ramiellona strigosa, Zapatadrilus* sp.)

In southeastern Mexico (as most of the country), endogeic species were dominant both in natural forests and in the derived agroecosystems. Dominance of endogeic species is very relevant because it implied that epigeic species are not an important component in Mexican earthworm natural communities and thus perturbation has a smaller effect on functional groups.

Lavelle and Pashanasi (1988, 1989) compared earthworm communities from two tropical rain forests against three groups of derived agroecosystems in Peruvian Amazonia. Their results showed that earthworm communities were modified, both at the functional and taxonomic level. Functionally there were changes both in the amount and kind of ecological groups. In the majority of the sampled agroecosystems, for example, the community structure was greatly simplified, often with only one ecological category. Qualitative changes were clear in pastures, fallows and high input cropping systems, where the forest earthworm communities shifted from an epigeic to an endogeic dominated composition. In these systems, from the taxonomic point of view, the four original native forest earthworm species were almost totally supplanted by the exotic *P. corethrurus*. Interestingly in tradition and low input cropping systems and in a palm-tree plantation (Pijuayo-kudzu), native epigeic and anecic species were maintained, as in southeastern Mexico.

With more than 509 species (Dash, 1999) India has one of richest tropical earthworm faunas. Total inventory, however, is far from being completed as new species are still being found (Blanchart and Julka, 1997). A considerable amount of research is required to be carried out in this country, both at the regional and local scale and in natural and derived agroecosystems.

In Orissa about 32 species of earthworms belonging to 6 families and 16 genera have been reported (Julka and Senapati, 1987). Out of these 8 species have been introduced to the main land while 24 species are endemic.

Bhadauria and Ramakrishna (1991) found earthworm communities in temperate forests of northeast India (Meghalaya State) to be composed of three native endogeic species. After slash and burn practices were imposed (Bhadauria and Ramakrishna, 1989), the community lost two native species but at the same time two other species invaded the community (one native and one epigeic exotic). The succession in fallows of different ages never resulted in the restoration of the original community. Even in fallows 35 years old, only *Tonoscolex horaii* remained whereas. *Perionyx* sp. and *Drawida assamensis* became locally extinct. In another study in this region, Darlong and Alfred (1991) found a reduction in the density and biomass of all the original earthworm forest species in another slash and burn system, but no species extinctions nor substitutions by other species were observed.

The Karnataka region (south western India) has also been studied both at the regional and local scales. A regional survey undertaken by Bano and Kale (1991) in southern Karnataka revealed that native species were well adapted to agroecosystems. From a total number of 44 species (36 natives and eight exotics), 25 native species were found only in managed ecosystems. The reason for this adoption is not clear, but it could be related to the prevalence in the region of low input agricultural practices and to the fact that most of these earthworms are endogeic species more resistant to changes in land use practices. In a more local study, Blanchart and Julka (1997) studied earthworm communities in a gradient of forest disturbance, from undisturbed forests to extensive pastures. The communities were composed mostly of endogeic species, with only one epigeic species being found (from a total of 30 spp.). Of the 26 spp. found in the forests ten species disappeared in disturbed sites, whereas the remaining species were able to survive in at least one type of agroecosystem; the agroecosystem communities were invaded by six peregrine endemic species and no worldwide exotic species were found.

In Uttar Pradesh 24 species of earthworms belonging to 5 families and 15 genera have been reported (Singh and Rai, 1997). Of these 24 species, 19 species are endemic while the remaining 5 species are peregrine.

Chaudhuri *et al*. (2011) reported reproductive biology of eight tropical earthworm species of rubber plantation in Tripura. Of the 8 species, 3 species was peregrine while the remaining 5 species were native.

Sathianarayanan and Khan (2006) reported 10 species of earthworms from Pondicherry region belonging to 7 genera and 6 families.

In the present study 15 species of earthworms belonging to 7 families and 10 genera have been identified out of which 5 species are peregrine and the remaining 9 are endemic species (Table 1, 2, 3).

The present finding is based on both surveys on regional and local level. The natural habitats like forests and pastures were found to be dominated by native species like *Glyphidrilus tuberosus, Lampito mauritii, Drawida calebi, Drawida willsi, Lennogaster pusillus, Perionyx sansibaricus, Pellogaster bengalensis* and *Pontoscolex corethrurus*. While the agroecosystem of this region is dominated by peregrine species like *Ocnerodrilus occidentalis*. The agroecosystem of this region were having very scanty number of species while the natural habitats harbour a good number of species.

Our finding that the agroecosystem is dominated by peregrine species is in conformity with the findings of Fragoso (1993), Fragoso *et al*. (1993 and 1995) and Fragoso and Rojas (1994), who reported dominance of peregrine in agroecosystem and dominance of native species in natural habitats in Mexican and Peruvian Amazonia region but in contrast to the findings of Bano and Kale (1991), who in Karnataka region found dominance of native species in agroecosystem.

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REFERENCES

Bahl, K. N. 1925. The Indian Zoological memoirs. I. Pheretima. 1st Edition. Lucknow. *Pub. House. Lucknow*. p. 84.

Bano, K. and Kale, R. D. 1991. Earthworm fauna of southern Karnataka, India. In : *Advances in Management and Conservation of Soil Fauna*. G.K. Veeresh, D. Rajagopal and C.A. Viraktamath (Eds), Oxford and IBH, New Delhi, India, pp. 627-634.

Bhadauria, T. and Ramakrishna, P. S. 1989. Earthworm population dynamics and contribution to nutrient cycling during cropping and fallow phases of shifting agriculture (jhum) in north east India. *J. Appl. Ecol.* **26:** 505-520.

Bhadauria, T. and Ramakrishna, P. S. 1991. Population dynamics of earthworms and their activity in forest ecosystems of north-east India. *J. Trop. Ecol.* **7:** 305-318.

Blanchart, E. and Julka, J. M. 1997. Influence of forest disturbance on earthworm (Oligochaeta) communities in the western Ghats (south-India). *Soil Biol. Biochem*. **25:** 177-190.

Bouche, M. B. 1977. Strategies lombriciennes. In: *Soil organisms as components of Ecosystems*. U.L. Ohmand and T. Person (Eds.), *Ecol. Bull* (Stockholm). **25:** 125-132.

Brinkhurst, R. O. and Jamieson, B. G. M. 1971. *Aquatic Oligochaeta of the world*. University of Toronto Press, Toronto and Buffalo: 1-860.

Byzova, J. B. 1965. Comparative rate of respiration in some earthworms (Lumbricidae: Oligochaeta). *Rev.Ecol.Biol.Sol.* **2:** 207-216.

Chaudhuri, P. S. and Bhattacharjee, S. 2011. Reproductive biology of eight tropical earthworm species of rubber plantation in Tripura, India. *Tropical Ecology*. **52(1):** 49-60**.**

Darlong, V. T. and Alfred, J. R. B. 1991. Effect of shifting cultivation (jhum) on soil fauna with particular reference to earthworm in northeast India. In: *Advances in Management and Conservation of Soil Fauna*. G.K. Veeresh. D. Rajagopal and C.A. Viraktamath (Eds), Oxford and IBH, New Delhi. India. pp. 299-308.

Darwin, C. 1981. The formation of vegetable mould through the action of worms with observations of their *habit, J. Murray,* London, pp. 326.

Dash, M. C. 1978. Role of earthworms in decomposer system. In: Glimpses of Ecology. J. S. Singh and B. Gopal (Eds.) International Scientific Publications, *New Delhi, pp.* 399-406.

Dash, M. C. 1999. Earthworm diversity and Ecophysiology to Vermi-technology for sustainable development. Presidential Address as Sectional President of Zoology, Entomology and Fisheries. 86th session of Indian Science Congress Association. p. 5.

Dash, M. C. and Patra, U. C. 1977. Density, biomass and energy budget of tropical earthworm population from a grassland site in Orissa, India. *Rev. Ecol. Biol. Sol.* **14(3):** 461-471.

Dash, M. C. and Senapati, B. K. 1980. Cocoon Morphology, hatching and emergence pattern in tropical earthworms. *Pedobiologia*. **20:** 316-324.

Dash, M. C., Mishra, P. C. and Behera, N. 1979. Fungal feeding by a tropical earthworm. *Trop. Ecol*. **20:** 9-12.

Dash, M. C., Nanda, B. and Behera, N. 1980. Fungal feeding of Enchytraeidae (Oligochaeta) in a subtropical woodland from Orissa, India. *Oikos*. **34(2):** 202-205.

Dash, M. C. 2012. Charles Darwin's Plough: Tools for Vermitechnology. I. K. International, New Delhi. p. 185.

Evans, A. C. and Guild, W. J. Mc. L. 1947. Studies on the relationships between earthworms and soil fertility. I Biological studies in the field. *Ann. appl. Biol.* **34(3):** 307-330.

Fragoso, C. 1993. Les peuplements de vers de terre dans I'est et sud'est du Mexique. Ph. D. Thesis, Universite Paris 6, Paris, France, p. 225.

Fragoso, C. and Rojas, P. 1994. Soil biodiversity and land management in the tropics. The case of ants and earthworms. In : *Transactions of the 15th World Congress of Soil Science*. J.D. Etchevers (Eds).Vol. **4a:** Commission III, ISSA, Acapulco, pp. 232-237.

Fragoso, C., Barois, I., Gonzalez, C., Arteaga, C. and Patron, J. C. 1993. Relationship between earthworms and soil organic matter levels in natural and managed ecosystems in the Mexican tropics. In : *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture*. K. Mulongoy and R. Merckx (Eds). *Wiley-Sayce Co-Publication, U.K.* pp. 231-239.

Fragoso, C., James, S. and Borges, S. 1995. Native earthworms of the North Neotropical Region : current status and controversies. In: Earthworm Ecology and Biogeography in North America, P. Hendrix (Eds). *Lewis Publishers, Boca Raton*. pp. 67-115.

Gates, G. E. 1940. Indian earthworms. VIII-XI *Rec. Indian Mus.* **42:** 115-143.

Gates, G. E. 1945a. On some Indian earthworms. II. *J. R. Asiat. Soc. Beng*. **11:** 54-91.

Gates, G. E. 1945b. On some Indian earthworms. *Proc. Indian Acad. Sci.* (B) **21:** 208-258.

Gates, G. E. 1959. Earthworms. In: *The Natural History of Rennel Island, British Solomon Islands*. **2:** Danish Science Press, Copenhagen. pp. 7-23.

Gates, G. E. 1970. Miscellanea Megadrilogia VII. *Megadrilocia*. **1:** 1-13.

Gates, G. E. 1972. Burmese earthworms. An introduction to the systematics and biology of megadrile oligochaetes with special reference to southeast Asia. *Trans. Am. Phil. Soc*. **62(7):** 1-326.

Guild, W. J. Mc. L. 1952. Variation in earthworm numbers within field populations. *J. Anim. Ecol.* **21:** 169-181.

Julka, J. M. 1976. Studies on the earthworm fauna of Orissa (India). 1. Moniligastridae and Ocnerodrilidae. *Mitt. Zool. Mus Berlin.* **52:** 321-329.

Julka, J. M. 1978. Studies on the earthworm fauna of Orissa (India). 2. Megascolecidae, Octochaetidae and Microchaetidae. *Mitt. Zool. Mus. Berlin*. **54:** 185-197.

Julka, J. M. 1981. Taxonomic studies on the earthworms collected during the Subansiri Expedition in Arunachal Pradesh, India. *Rec. Zool. Surv. India. Occ.* Pap., no. **26:** 1-37.

Julka, J. M. and Senapati, B. K. 1987. Earthworms (Oligochaeta: Annelida) of Orissa, India. Records of the Zoological Survey of India, *Miscellaneous Publication Occasional Paper* No. 92. pp. 1-48.

Lavelle, P. 1978. Les vers de terre de la savana de Lamto (Cote d Ivoire): peuplements, populations et functions dans L ecosystems; *Publ. Lab. Zool. E.N. S.* **12:** 301.

Lavelle, P. and Pashanasi, B. 1988. Earthworm communities at Yurimaguas (Amazonas, Peru). Effect of management practices. *TSBF Progress report* No. 1, p.13.

Lavelle, P. and Pashanasi, B. 1989. Soil macrofauna and land management in Peruvian Amazonia (Yurimaguas, Loreto). *Pedobiologia.* **33:** 283-291.

Lee, K. E. 1959. A key for the identification of New Zealand earthworms. *Tuatara*. **8(1):** 13-60.

Lee, K. E. 1985. Earthworms. Their Ecology and Relationships with soils and Land Use. *Academic Press, Australia*. p. 411.

Lee, K. E. 1987. Peregrine species of earthworms. In. *On Earthworms. Selected Symposia and Monographs*. A.M. Bonvicini and P. Omodeo (Eds). U. Z. I. 2, Mucchi, Modena, Italy, pp. 315-328.

Michaelsen, W. 1907. Neue Oligochaten von Vorder-Indian, Ceylon, Burma und den Andman Inseln. *Jb. hamb. wiss. Anst*. **24:** 143-188.

Michaelsen, W. 1910. Die Oligochatenfauna der vorderindischeceylonischen Region. *Abh. Geb. Naturw. Hamburg*. 19: 1-103.

Michaelsen, W. 1921. Zur Stammesgeschischte der Oligochaten, inbesondere der Limbriculiden. *Archiv fur Naturgeschischte*. **86A:** 130.

Mishra, P. C. and Dash, M. C. 1980. Digestive enzymes of some earthworms. *Experimentia*. **36:** 1156-1157.

Mishra, P. C. and Dash, M. C. 1984. Population dynamics and respiratory metabolism of earthworm population in a subtropical dry woodland of western Orissa, India. *Trop Ecol*. **25:** 103-116.

Omodeo, P. 1958. La reserve naturelle integrale d Mont Nomba. I. Oligochaetes. *Mem. Inst. fr. Afr. noire*. **53:** 9-10.

Perel, T. S. 1977. Differences in Lumbricid organization connected with ecological properties. In: *Soil organisms as components of Ecosystems,* U.L. Ohmand and T. Person (Eds.), *Ecol. Bull* (Stockholm). **25:** 56-63.

Satchell, J. E. 1955. Some aspects of earthworm ecology In: *Soil Zoology,* D.K. Kevan, and Mc. E. Butterworths (Eds.), London. pp. 180-201.

Sathianarayanan, A. and Khan, A. B. 2006. Diversity distribution and abundance of earthworms in Pondicherry region. Tropical ecology. **47(1):** 139-144.

Senapati, B. K. 1980. Aspects of Ecophysiologial studies on tropical Earthworms (Distributon, Population dynamics, Production, energetics and their role in the decomposition process) *Ph.D. Thesis submitted to Sambalpur University, Orissa, India*. pp. 154.

Senapati, B. K. and Dash, M. C. 1981. Effect of grazing on the elements of production in the vegetation of oligochaeta components of a tropical pasture land. *Rev. Ecol. Biol. Soil*. **18(4):** 487-505.

Senapati, B. K. and Dash, M. C. 1982. Earthworm as waste conditioners. *Ind. Eng. J.* XI. **2:** 53-57.

Senapati, B. K., Dash, H. K. and Dash, M. C. 1979. Seasonal dynamics and emergence pattern of a tropical earthworm, *Drawida calebi* (oligochaeta). *Int. J. Invertbr. Reprod.* **1:** 271-277.

Sims, R. W. 1980. A classification and the distribution of earthworms suborder Lumbricina (Haplotaxida : Oligochaeta). *Bull Br. Mus. nat. Hist. (Zool.)*. **39(2):** 103-124.

Singh, J. and Rai, S. N., 1997. Earthworm farming and vermicomposting : A boon for sustainable agriculture. *J. Soil. Biol. Ecol*. **17(1):** 65-72.

Sinha, M. P. and Srivastava, R. 2001a. Seasonal variation in density and biomass of earthworms *Perionyx sansibaricus* (Michaelsen) in garbage dumping site at Ranchi, India. *Journal of Science and Techn.*; Sambalpur University (SUJST). **XIII(A):** 64-68.

Sinha, M. P., Srivastava, R., Ghosh, S. R., Choudhary, A. K. and Kumar, M. 2002a. Interspecific competitive inhibition of respiration among some earthworms in laboratory experiment. In: Biodiversity Conservation, Environmental Pollution And Ecology - Proceeding of 11th All India Congress of Zoology. pp. 197-204.

Sinha, M. P., Srivastava, R., Kumar, M. and Singh, M. P. N. 2003a. Laboratory observation on C/N ratio of soil by earthworm inoculation.

Asian J. Microbiology Biotechnology and Env. Sci. **5(2):** 225-227.

Sinha, M. P., Kumar, M. and Srivastava, R. 2001b. Bioaccumulation of zinc in earthworm *Perionyx sansibaricus* and its impact on growth and metabolism. *J. Ecophysiol. Occup. Hlth.* **1:** 265-274

Sinha, M. P., Srivastava, R., Kumar, M., Gupta, D. K. and Kumari, S. 2003b. Secondary production of the earthworm *Perionyx sansibaricus* (Michaelsen) in a garbage site at Ranchi, Jharkhand. *J. Science and Techn*. Sambalpur University (SUJST). **XIV & XV(A):** 39-45.

Sinha, M. P., Srivastava, R., Ghosh, S. R. and Choudhary, A. K. 2002b. Distributional pattern of *Ocnerodrilus occidentalis*: A dominant earthworm of grassland ecosystem. In: Biodiversity Conservation, Environmental Pollution And Ecology - Proceeding of 11th All India Congress of Zoology. pp. 197-204.

Sinha, M. P., Srivastava, R., Kumar, M., Gupta, D. K. and Sen, N. S. 2003c. Population biology and reproduction strategy of ocnerodrilus *Occidentalis* (Oligochaeta: ocnerodrilidae) form tropical agro-ecosystem at Ranchi, Jharkhand, India. *Trans. Zool. Soc. East. India*. **7(2):** 33-41.

Sinha, M. P., Srivastava, R., Swarnim, K. and Kumar, M. 2002c. Population density, biomass and secondary production of *Ocnerodrilus occidentalis* (Eisen) from a tropical cropland agroecosystem at Ranchi, Jharkhand, India. *Proc. Zool. Soc. India*.

Sinha, M. P., Srivastava, R., Gupta, D. K. and Kumar, M. 2003d. Systematic of earthworms from Jharkhand. I. Moniligastridae. *Proc. Zool. Soc. India*. **2(2):** 15-20.

Sinha, M. P., Srivastava, R., Kumar, M. and Choudhary, A. K. 2002d. Vermiculture biotechnology for pollution control. *J. Nature, Environment & Pollution Technology*. **1(4):** 401-405.

Sinha, M. P., Srivastava, R., Kumar, M. and Gupta, D. K. 2003e. Systematics of earthworms from Jharkhand. II. Octochaetidae and Ocnerodrilidae. *Proc. Zool. Soc. India*. **2(2)**: 21-28.

Sinha, M. P., Srivastava, R., Gupta, D. K. and Kumar, M. 2003f. Systematics of earthworms from Jharkhand. III. Megascolecidae. *Oikoassay*. **17(2):** 49-55.

Srivastava, R. and Sinha, M. P. 2004. Bioenergetics of a peregrine earthworm *Ocnerodrilus occidentalis* (Eisen) from a tropical cropland agroecosystem of Ranchi (Jharkhand). Proceeding of 13th All India Congress of Zoology. Published by ZSI. pp. 154-171.

Srivastava, R., Gupta, D. K. and Sinha, M. P. 2012. Monthly Variation in the Density of *Drawidawillsi*(Michaelsen) in relation to Some Climatic-Edaphic Factors. *Nature Environment and Pollution Technology*. **11(4):** 725-728.

Srivastava, R., Kumar, M., Choudhary, A. K. and Sinha, M. P. 2003. Earthworm diversity in Jharkhand state. *J. Nat., Env. & Poll. Tech.* **2(3):** 357-362.

Stephenson, J. 1914. Littoral Oligochaeta form the Chilka Lake. *Rec. Indian Mus.* **5:** 141-146.

Stephenson, J. 1915. Fauna of the Chilka Lake. *Oligochaeta. Mem. Indian Mus.* **10:** 255-260.

Stephenson, J. 1921. Oligochaeta from Manipur, the Laccadive Island, Mysore and other parts of India. Rec. *Indian Mus.* **22:** 745-768.

Stephenson, J. 1923. Oligochaeta. The Fauna of British India, including Ceylon and Burma,. Taylor Francis Ltd., London. pp. xxiv + 518.

Stephenson, J. 1924. On some Indian Oligochaeta, with a description of two new genera of Ocnerodrilidae. *Rec. Indian Mus.* **26:** 317-365.

Stephenson, J. 1925. On some Oligochaeta mainly from Assam, South India and the Andaman Islands. *Rec. Indian Mus.* **27:** 43-73.

Stephenson, J. 1926. Description of Indian Oligochaeta. *Rec. Indian Mus.* **28:** 249-268.

Stephenson, J. 1930. The Oligochaeta, *Oxford Univ. Press.* p. 978.

Stephenson, J. 1931. Description of Indian Oligochaeta. *II. Rec. Indian Mus*. **33:** 173-202.

Stephenson, J.1916. On a collection of Oligochaeta belonging to the Indian Museum. *Rec. Indian Mus*. **12:** 299-354.

Svendsen, J. A. 1957. The distribution of Lumbricidae in an area of Penine moorland (Moor House, Nature Reserve). *J. Anim. Ecol*. **26(2):** 411-421.

Tembe, V. B. and Dubash, P. J. 1959. A preliminary note on the culture and development of Indian earthoworms. *J. Bombay Nat. Hist. Soc*. **56:** 643 - 646.

Templeton, R. 1844. Description of *Megascolex caeruleus*. *Proc. zool. Soc. Lond.* **12:** 89-91.