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FIRST RECORD OF OCTOCHAETID EARTHWORMS FROM A SELECTED REGION OF THE GANGETIC PLAIN OF BIHAR, INDIA

ROHIT SRIVASTAVA[1]*, MRIDULA KUMARI[2], DEOKANT[3], SAMIR KUMAR MANDAL[1], SHEELU KACHHAP[1], SHALINI[1], SWETA SUBARNA[1], NEHA SWATI BAXLA[1], MANOJ KUMAR[4], SUKUMAR DANDAPAT[1], RAKESH RANJAN[1] AND MANORANJAN PRASAD SINHA[1]

[1]Department of Zoology, Ranchi University, Ranchi-834 008, Jharkhand
[2]Department of Zoology, Yadunandan College, Dighwara-841 707 Saran, Bihar
[3]P.G. Department of Botany, Samastipur College, Samastipur-848 134, Bihar
[4]Department of Zoology, St. Xavier's College, Ranchi - 834-001, Jharkhand
e-mail:*drrohitsrivastava1974@gmail.com

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***Corresponding author**

ABSTRACT

The paper deals with the earthworm diversity belonging to the family Octochaetidae form selected area of the Gangetic plain of Bihar. This is the first record of earthworms from this region as no previous systematic report in the earthworm biodiversity is available till date. Five Octochaetide species were found during the study belonging to four genera *Octochaetona, Dichogaster, Lennogaster* and *Eutyphoeus*. The five species recorded are *Octochaetona surensis* Michaelsen, *Dichogaster affinis* Michaelsen, *Dichogaster bolaui* Michaelsen, *Lennogaster pusillus* Stephenson *Eutyphoeus waltoni* Michaelsen. The two species namely *Dichogaster affinis* and *Dichogaster bolaui* are peregrine and epigeic while *Lennogaster pusillus* is native and epigeic. Rest two species *Octochaetona surensis* and *Eutyphoeus waltoni* are native and endogeic species.

INTRODUCTION

On global level some 6200 species of earthworms have been described (Csuzdi, 2012; Csuzdi and Szlavecz, 2016), while in India the description of 560 species is on record (Julka *et al*.,2009). As estimated the total number of earthworm species will rise up to 8000 (Magalhaes *et al*., 2021). The description of earthworm species dates back to 1758 when Carolus Linnaeus described the first earthworm species *Lumbricus terrestris* while Templeton (1844) was the first to provide the detail of earthworms from Indian subcontinent. The process of surveying the earthworms and describing the species since then is continuing but needs more attention as good number of species are, supposed, due to be described both at national and international level (Phillips *et al*., 2019). The current statistics indicates that India harbours some 9.03% of earthworm diversity which was said to be 11% (Mubeen and Hatti, 2018) is an indication that the description in India has been slow in comparison to international attempts.After Templeton (1844) contribution from Indian subcontinent and subsequent contribution by Michaelsen (1907), Stephenson (1923, 1924, 1925, 1931), Gates (1972), Julka (1976), Bano and Kale (1991), Julka *et al*., (1997, 2004), Julka and Paliwal (2000, 2005) Narayanan *et al*., (2014, 2016a, 2016b, 2017, 2019a, 2019b, 2020, 2021), Sinha *et al*.,(2003a, 2003b, 2003c, 2013) and Srivastava *et al*.,(2003) resulted in addition of new species and/or new records from different parts of India. Recently a number of workers have surveyed and studied the earthworm fauna in different parts of India. Some important contributions from Indo Gangetic plains are Verma *et al*., (2010) surveyed the earthworm resource of Gangetic plain of Uttar Pradesh, Sharma and Bhardwaj (2014) who studied earthworms in trans gangetic habitat of Haryana. New species of the family Octochaetidae *Eutyphoeus naurangiyai* has been recorded from West Champaran district (Mondal *et al*., 2017). But on the whole there is paucity of knowledge on the Indian earthworm diversity and systematics particularly with respect to varied geographical areas and climoedaphic condition of the country. The earthworm fauna of the Gangetic plain of Bihar has not been surveyed and described systematically till date. The present communication is an attempt to bridge the gap of knowledge and describes the earthworms of the family Octochaetidae from some selected areas of this region.

MATERIALS AND METHODS

Earthworms were sampled by monolith method and hand sorted once per month from an area of 25 X 25 cm during morning hours following Sinha and Srivastava (2001). After sorting worms were separated into different age groups on the basis of length and clitellar development. Earthworms were preserved in 70% ethanol with little amount of glycerine. Sampling was started in 1999 and could not be continued due to separation of Jharkhand state in 2000. Again sampling

was done in 2019 – 2020. Apart from sampling the earthworms, the soil samples were also analysed for few physico-chemical characteristics which influence the earthworm population. The pH and temperature was measured by portable digital pH meter and soil thermometer. Moisture content was estimated by oven drying method while total organic matter (TOM) and organic carbon(OC) content was estimated following Walkley and Black (1934).

Sampling area

The Gangetic plain covers 44,900 square kilometres of Bihar. Some portion of this huge area falling in the districts of Vaishali, Samastipur, Saran and Muzaffarpur have been selected and sampled. The main sampling points in vicinity of which samplings were done has been indicated in Table 1 with their geographical location. The sampling was done mainly from agroecosystem, grasslands and also from some garbage dumping sites.

RESULTS

The physico chemical properties of soils of sampling sites have been presented in Table -1 which shows that the soil is alkaline in nature having moderate or low amount of total organic matter and organic carbon. Soil moisture was never found less than 25% where earthworms were found. Soil was sandy loam type. At the garbage dumping site where decomposition was going on total organic matter was high ranging from 9.23-13.27% while pH was low.

table1

A total of five species belonging to family Octochaetidae have been identified. A systematic account on the Octochaetide earthworms of some area of Gangetic plain of Bihar has been presented.

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 **MEGASCOLECOIDEA**

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

Family **OCTOCHAETIDAE**

Fender and McKey-Fender (1990) has rightly commented that the family-level classification of the megascolecid earthworms is in chaos. Creation of new families and sub families as well as omitting the names of earlier formed families has created really a chaos. Earlier earthworm taxonomy has been termed as nightmare for taxonomists (Beddard, 1883). Recently after the classificatory scheme proposed by Reynolds and Cook (1976, 1981, 1989, 1993) the issue has been reviewed by time and again by Blakemore (1994, 1997, 2000, 2002, 2005). Blakemore (2005) reviewed the taxonomical status of earlier proposed family level schemes using both deductive (morphological) and objective (molecular) evidences, to explore options for consensus. His idea of consensus, was both in the historical as well as the taxonomic context, of the suborders Lumbricina including Moniligastrida which has been found to have minimum 7 and maximum 20 families under various classifications currently proposed and espoused. Blakemore (2005) used morpho-molecular evidence,

Table 1. Sampling centres with their latitude and longitudes and some edaphic characteristics.

District	Sampling sites	Latitude	Longitude	pH M ± SD	Moisture content M ± SD	OM M ± SD	OC M ± SD
Vaishali	Minapur (S1)	25.74°N	85.199° E	7.7 ± 0.61	28.5 ± 2.28	7.9 ± 0.063	4.6 ± 0.036
	Panapur (S2)	25.66°N	85.27° E	7.2 ± 0.57	25.3 ± 2.02	7.4 ± 0.059	4.3 ± 0.034
	Goraul (S3)	25.93°N	85.33°E	7.6 ± 0.6	27.2 ± 2.17	6.7 ± 0.053	3.9 ± 0.031
	Lalganj (S4)	25.86°N	85.17°E	7.8 ± 0.62	26.4 ± 2.11	4.8 ± 0.038	2.8 ± 0.022
	Bhagwanpur (S5)	25.85°N	85.29°E	8.1 ± 0.64	24.9 ± 1.99	4.9 ± 0.039	2.9 ± 0.023
Samastipur	Hetampur (S6)	25.50°N	84.41°E	7.2 ± 0.57	27.3 ± 2.18	5.1 ± 0.041	3.0 ± 0.024
	Rosera (S7)	25.75°N	86.027°E	8.3 ± 0.66	25.3 ± 2.02	4.3 ± 0.034	2.5 ± 0.02
	Tajpur (S8)	25.849°N	85.666°E	7.6 ± 0.6	26.4 ± 2.11	5.5 ± 0.044	3.2 ± 0.025
	Pusa (S9)	25.978°N	85.648°E	7.8 ± 0.62	27.3 ± 2.18	3.7 ± 0.03	2.2 ± 0.017
	Kalyanpur (S10)	25.957°N	85.778°E	7.9 ± 0.63	26.3 ± 2.1	5.3 ± 0.042	3.1 ± 0.024
Saran	Dighwara (S11)	25.74°N	85.01°E	7.2 ± 0.57	27.4 ± 2.19	7.4 ± 0.059	4.3 ± 0.034
	Basatpur (S12)	25.999°N	84.689°E	8.1 ± 0.64	24.9 ± 1.99	6.5 ± 0.052	3.8 ± 0.03
	Malkhachak (S13)	25.747°N	85.02°E	8.3 ± 0.66	26.3 ± 2.1	6.3 ± 0.051	3.7 ± 0.029
	Salhadi (S14)	25.736°N	85.037°E	7.9 ± 0.63	27.1 ± 2.16	6.2 ± 0.049	3.6 ± 0.028
	Sobarna (S15)	25.728°N	84.929°E	7.6 ± 0.6	25.4 ± 2.03	8.1 ± 0.064	4.7 ± 0.037
	Chapra (S16)	25.781°N	84.75°E	7.6 ± 0.6	28.4 ± 2.27	6.7 ± 0.053	3.9 ± 0.031
	Ekma (S17)	25.96°N	84.53°E	7.1 ± 0.56	27.4 ± 2.19	6.7 ± 0.053	3.9 ± 0.031
	Sonepur (S18)	25.69°N	85.178°E	7.6 ± 0.6	28.6 ± 2.28	6.2 ± 0.049	3.6 ± 0.028
Muzaffarpur	Minapur (S19)	26.34°N	85.60°E	7.8 ± 0.62	26.8 ± 2.14	7.2 ± 0.057	4.2 ± 0.033
	Sakra (S20)	25.97°N	85.56°E	8.1 ± 0.64	24.6 ± 1.96	7.7 ± 0.062	4.5 ± 0.036
	Motipur (S21)	26.25°N	85.35°E	7.9 ± 0.63	25.8 ± 2.06	5.1 ± 0.041	3.0 ± 0.024
	Turki (S22)	26.03°N	85.35°E	7.4 ± 0.59	27.3 ± 2.18	5.6 ± 0.045	3.3 ± 0.026
	Dholi (S23)	25.99°N	85.59°E	7.7 ± 0.61	25.4 ± 2.03	6.8 ± 0.055	4.0 ± 0.032

pH in units , moisture in %, TOM and OC in mg g^{-1} soil .

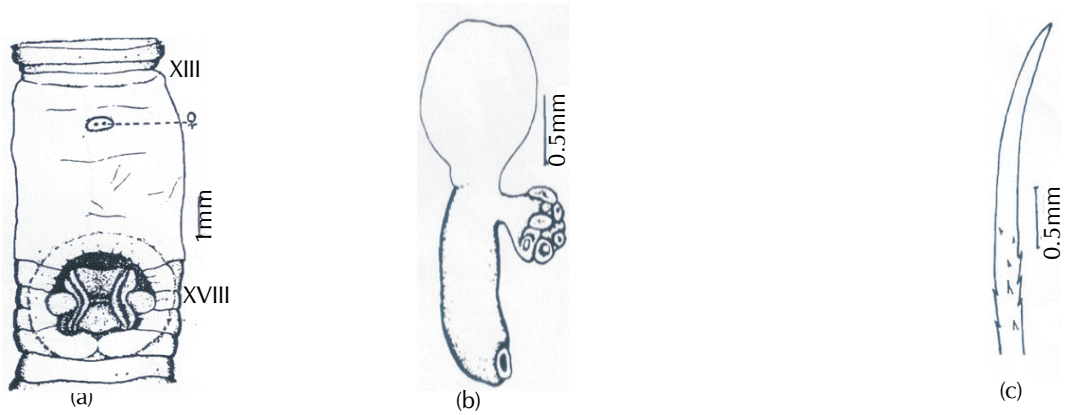

Figure 1: ***Octochaetona surensis*** **Michaelsen (a) Male genital region (b) Spermatheca (c) Penial seta**

based on recent rDNA analyses, for the phylogeny of earthworm families Acanthodrilidae, Octochaetidae, Exiidae, and Megascolecidae as per his own scheme (Blakemore 2000). His work supported Csuzdi and Zicsi (1994) for Benhamiinae, Michaelsen,1895/7 separated from meroic Octochaetidae, Michaelsen,1900; and possible restoration of Diplocardiinae, Michaelsen, 1899 separate from holoic Acanthodrilidae, Claus, 1880. The four classificatory scheme of different authors Michaelsen (1900, 1921), Stephenson (1930), Blakemore (2000, 2005) have been compared where Octochaetidae has been retained as family. In the present communication the Octochaetidae has been taken *as sensu* Blakemore (2005).

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

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

Genus **Octochaetona Gates**

Diagnosis. Setae lumbricine. Male pores are paired, located in seminal grooves, on *xviii*. Prostatic pores paired, at the ends of seminal grooves, on segment *xvii* and *xix*. Oesophagus with a single gizzard and one pair of discrete, extramural, usually asymmetrical calciferous glands close to the attachment of septum 15/16; intestinal caeca and supra-intestinal glands absent,typhlosole ventrally bifid. Micromeronephridia astomate paired, enteronephric tufts in *iv,* several biramous, exonephric, on the body wall in *v* and posteriad segments, slightly enlarged and stomata in caudal segments with preseptal and intrasegmental funnels; megameronephridia absent.

Distribution. Peninsular India, Pakistan, Nepal, Burma, Malay Peninsula, Philippines.

Octochaetona surensis Michaelsen

1962.*Octochaetona surensis,* Gates, *Ann. Mag. Nat. Hist. (ser. 13),***5** : 213; Gates. 1972. *Trans. Am phil. Soc.* **62**(7): 309.

Diagnosis. Length usually 60-140 mm, with diameter 2.5-6 mm,segmentsnumber between 111 -180. Prostomiumepilobic tongue closed. First dorsal pore 12/13. Clitellum annular, *xiii-xvi, xvii*. Setae *aa*= 2.7-4.3*ab* = 1.1*bc* = 1.4-2.5*cd* = 0.15-0.16*dd* on *xii*, *aa* = 3.3-3.4*ab* = 1.2-1.3*bc* = 1.9-2.5*cd* = 0.16-0.19*dd* on *xxiv,a, b* on *viii* and *ix* copulatory, being surrounded by tumescences. Male genital field *xvi-xx,* with deep transverse depressions on *xvii* and *xix*. Male pores minute, median to *b*. Prostatic pores minute at *b*. Seminal grooves convex. Female pores paired, presetal, within *a* lines, sometimes single and median. Spermathecal pores paired, minute, on or close to the setal arcs of *viii* and *ix,* at *ab*. Genital marking oval, paired or unpaired and median, postsetal on some of *xviii-xxii*, at *aa* or *bb*.Septa 4/5, 8/9-10/11 muscular, 5/6/7/8 absent. Gizzard between septa 4/5 and 8/9. Intestine begins in *xvii*, typhlosole in *xxii-xxiii* to *ci-cxv*. Last pair of hearts in *xiii*. Holandric, testes and male funnels in cylindrical sacs in *x* and *xi*, seminal vesicles in *ix* and *xii*. Penial setae ornamented with a few longitudinal rows of triangular teeth, tip pointed or claw-shaped, 1.2-1.8 mm long, 25-30 μ diameter. Spermathecae paired in *viii* and *ix,* each with a shortly stalked, multiloculate ental diverticulum. Copulatory setae ornamented with longitudinal rows of spikes or thornlike protuberances, tip claw-shaped, 0.85-1.2 mm long, 20-25 μ diameter. Genital marking glands absent.

Distribution: India: Bihar(S1, S4, S6, S8, S12, S13, S18 and S21) Jharkhand, Uttar Pradesh, Chattisgarh, Assam, Madhya Pradesh, Orissa, Burma.

Material examined: Several juvenile, aclitellate, clitellate

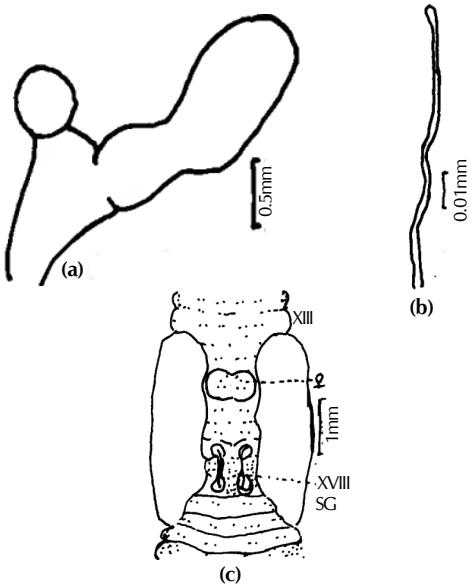

Figure 2: ***Dichogaster affinis*** **Michaelsen (a) Spermatheca (b) Penial seta (c) Male genital area**

specimens from different district of Bihar.

Habitat: Generally found in grasslands, hillocks, compost pits, upland crop fields and around roots of potted plants. It is dominant in clay loam and sandy loam soils with low organic matter (5 g %) content.

Biology: It is geophagous. Maximum population density of 186/m^2 and 133/m^2 has been observed in an ungrazed upland pasture and grazed upland pasture respectively (Dash and Senapati, 1980; Senapati, 1980). Cocoons are spherical and thin-walled having an average weight of 31.5 mg, the length and diameter of the cocoon is 5.34 mm and 4.09 mm respectively, cocoon colour initially is pale lemon yellow which gradually changes to deep green to brownish red. Usually one juvenile hatches from each cocoon.

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* widely transported to various parts of the world.

Dichogaster affinis Michaelsen

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 *lxviii-lxxvi*, *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*,

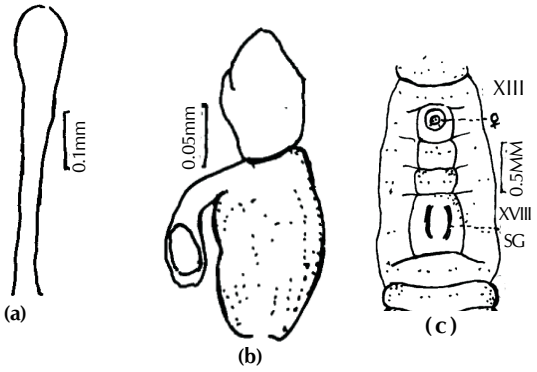

Figure 3:*Dichogaster bolaui* Michaelsen (a) Penial setae (b) Spermatheca (c) Male genital region

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; Bihar(S3, S7, S10, S11, S16, S18, S20, S21).The species was sampled from compost dumps. Jharkhand, Orissa, Kerala, Karnataka, Arunachal Pradesh, Gujarat, Meghalaya, Madhya Pradesh, Maharashtra. Sri Lanka, Burma, Thailand, Pacific Ocean Islands, Cape Verde Island, Southwest Africa, Madagascar, Zanzibar, Comoro Island, Mexico, El Salvador, French Guiana, Brazil, West Indies.

Material examined: Several clitellate specimens from different district of **Bihar**.

Habitat: Generally found in forest, grasslands, compost pits, and Sewage sites.

Biology: It is phyto geophagous.

Dichogaster bolaui Michaelsen

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 19-43 mm, 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 $aa = 2.5\text{-}3.3ab = 0.8$ $bc = 2.5\text{-}3.3$ $cd = 0.08 - 0.09$ *dd* on *xii*, $aa = 2.3\text{-}2.8$ $ab = 0.9$ $bc = 2.3\text{-}2.8$ $cd = 0.1$ *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: Bihar(S2, S9, S10, S14, S19, S22, S23), It was sampled from garbage dumping cyte.Orissa, Jharkhand, Meghalaya, Sikkim, Andaman and Nicobar Islands, Arunachal Pradesh, West Bengal, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala.

Material Examined : 10 clitellate, 8 non clitellate specimens from different parts of Bihar during 2020.

Habitat. It is usually present in soils with high organic matter content (>10 g%), kitchen waste, compost pits, rotten wood.

Biology: An average population of about 1447/m^2 and 1665/m^2 was noted in the pasture and compost pit site. Peak population of 8038/m^2 in pasture and 12617/m^2 in compost pit was reported by Sahu et al., (1988). Cocoons are oval in shape having lemon yellow colour, length and breadth of cocoon is 2 mm and 1.25 mm respectively.

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. Micromeronephridia 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, Burma, Bangladesh.

Lennogaster pusillus Stephenson

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 between 20-68 mm, wnd diameter in between 1-2.5 mm, number of segments 105-132. 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-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: Bihar(S4, S5, S9, S12, S15, S17, S20), species were sampled from garbage and compost pit sites. Jharkhand, Orissa, Karnataka, Uttar Pradesh, Himachal Pradesh.

Material examined. 12 clitellate specimen.

Habitat. Generally found in the top layer of soil (0-5cm) with high organic matter (>10g%). Other places of their occurrence are kitchen waste, compost pit near cow shed and in roofs of thatched houses.

Biology: The density of worm ranged between 75 – 415 (No m^{-2}) from shorea plantation site at Bero, Ranchi (Gupta, 2006). Cocoons are usually small and round with ornamentations, initially the colour of cocoon is pale lemon which gradually changes to greenish-reddish brown, single juvenile hatches from each cocoon.

Eutyphoeus Michaelsen

1883.*Typhoeus,* Beddard, *Ann. Nat. His. (ser. 5)*, **12**: 219 (non Leach, 1815, *Brewster's EdinEncy.*,**9**(1):97.

1888.*Typhoeus,* Beddard, *Q, Jlmicrosc. Sci.,* **28**: 403.

1900.*Eutyphoeus,* Michaelsen,*Tierreich*, **10**: 322.

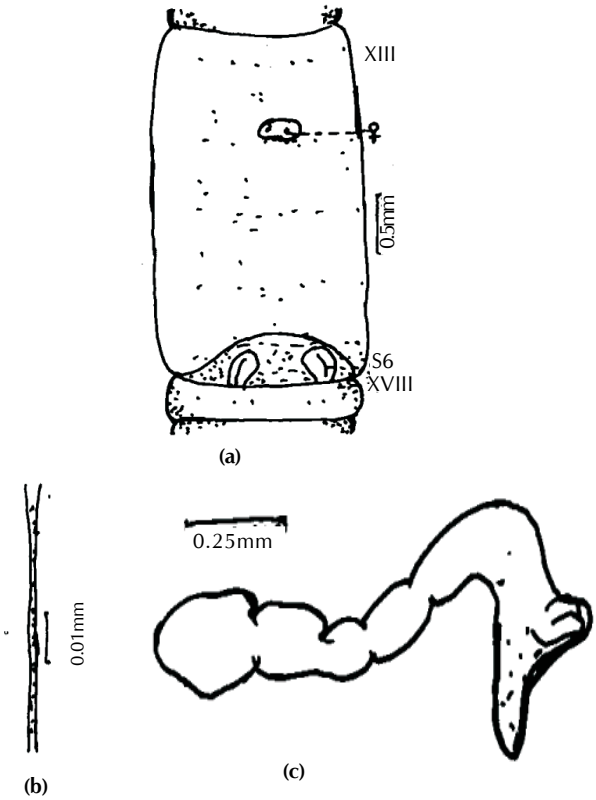

Figure 4: *Lennogaster pusillus* Stephenson (a) Male genital region (b) Penial seta (c) Spermatheca

1923.*Eutyphoeus* ,Stephenson, *Fauna Br. India, Oligochaeta*: 420.

1938. *Eutyphoeus,* Gates, *Rec. Indian Mus.* **40**: 60.

1972.*Eutyphoeus,* Gates, *Trans. Am. phil. Soc.***62**: 281

Diagnosis. Setae lumbricine throughout the body. Clitellum annular. Prostatic and male pores paired near the setal arc of *xvii*, discharging within vestibula or directly into the body surface; male pores near but slightly posterior to the prostatic pores. Female pores minute, paired, presetal *on xiv*, sometimes the pore of the right side rudimentary or absent. Spermathecal pores large, paired, in 7/8. Genial markings usually present. Nephridiopores not recognized.

Septa 4/5/6, 8/9-10/11 muscular, 6/7/8 absent. Oesophageal gizzard single and large located between septa 5/6 and 8/9. Discrete calciferous glands onepair, intramural, longitudinally hemiellipsoidal with flat faces mesially, in *xii*, each gland with numerous vertical lamellae, the interlamellar spaces communication dorsally with the oesophageal lumen. Intestine begins in *xv*; typhlosole lamelliform, ending posteriorly with a short series of supra-intestinal glands; unpaired, anteriorly directed, midventral intestinal caeca anterior to supra-intestinal glands present; paired, lateral intestinal caeca sometimes present. Single dorsal vessel, complete or aborted anteriorly; single supra-oesophageal vessel, *x-xiii*; extra-oesophageal and latero-parietal vessels paired, passing to anterior and posterior ends of calciferous glands respectively; absence of subneural vessel; lateral hearts with connectives to the dorsal and supra-oesophageal vessels in segment *xi-xiii*, last pair of hearts in *xiii*. Prostates paired; vas deferens enlarged ectally into bulbs ejaculatrice. Spermathecae paired, diverticulate. Ovisacs absent. Micromeronephridiaastomate, 4-5 pairs of enteronephric tufts in *iii*, numerous, biramous and y-shaped, exonephric on the body wall in *v* and posteriad segments; paired stomata, exonephric, megameronephridia in each segment posterior to the supra-intestinal glands, funnels close to the nerve cord.

Distribution. India (from Burma border into the Gangetic plain and west through the Himalayas, and Orissa), Burma, Bangladesh, Nepal, Pakistan.

Eutyphoeus waltoni Michaelsen

1907.*Eutyphoeus waltoni* (in part) Michaelsen, *Jb. hamb. wiss. Anst.* **24**:179.

1923.*Eutyphoeus waltoni*, Stephenson, Fauna Br. India, Oligochaeta. 455

1938 *Eutyphoeus waltoni*. Gates, *Rec. Indian Mus*. **40**:112

Diagnosis. Length 53-230 mm, diameter 4-8 mm, 115-201 segments Prostomium pro-or tanylobic. First dorsal pore 11/12. Clitellum *xiii*, ½*xiii-xvii*. Setae aa = 1.7–2.4 *ab* = 1 –1.2 *bc* = 1.4-1.9 *cd* = 0.12–0.14 *dd* on *xii*, *aa* = 2.4–3.2 *ab* = 1.2–1.7 *bc* = 2.1–2.8 *cd* = 0.15 *dd* on *xxiv*. Male pores discharge into deep, well-like paired vestibula (bivestibulate) opening onto the body surface through circular apertures or transverse slits, at *ac*;penes elongate tubular, 1 mm long. Female pore single on the left side, presetal, slightly lateral to *a*. Spermathecal pores small, transverse slits, the centres at or slightly median to *c*. Genital markings paired (sometimes one of the pair absent), postsetal one *ix,* sometimes on *viii*, *x*, intersegmental on 14/15/16, 18/19, occasionally on 13/14, 16/17, 19/20-22/23.

Lateral intestinal caeca absent, median ventral intestinal caeca 24-29 in *xxxiii-lxii*, supra-intestinal glands 4-5 pairs in *lxxvi-lxxxvi*, typhlosole begins in xxvii-xxviii. Dorsal vessel terminates posterior to gizzard in vii. Metandric, testis sac ventral, seminal vesicles in *xii*, extending to *xiii-xiv*. Penial setae ornamented with fairly closely crowded circles of small, fine teeth, tip spoon-shaped, 4-5 mm long, 20-30 μ diameter. Each spermatheca with a median and a lateral ental diverticula, often directed posteriorly, sometimes bound together in a connective tissue, duct slender, comparatively long, *c.* 2 mm in length. Genital marking glands sessile.

Distribution. India:West Bengal,Bihar(S1, S2, S6, S8, S14, S15, S17, S18, S23).The species were dominant in compost heaps. Uttar Pradesh, Madhya Pradesh, Rajasthan, Delhi, Chandigarh, Jammu and Kashmir, Himachal Pradesh, Punjab and Jharkhand.

Biology. Its habitats include alluvial soils with pH range of 7.5-8.6, cultivated fields, plant nurseries, gardens, flower pots, manure heaps and banks of a tank.

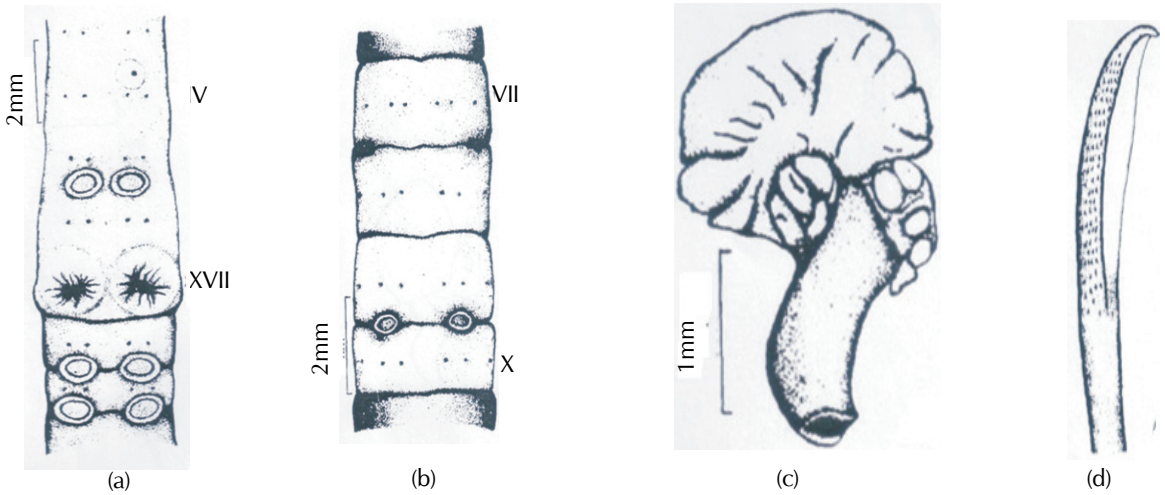

Figure 5: *Eutyphoeus waltoni* Michaelsen (a) Genital region (b) Spermathecal pore region (c) Spermatheca (d) Penial seta

DISCUSSION

Out of 15 agroclimatic divisions of India the Gangetic plain is considered very suitable for earthworm diversity (Julka, 2001). The family Octochaetidae has been reported to have rich taxa in Indian soil. Some 154 taxa including 6 new genera and 16 species are on record (Julka, 1988). Bhist *et al*. (2003) while studying the earthworms from cultivated soil of Doon Valley could not find any representative of the family. Joshi and Aga (2009) recorded 5 species of this family from subtropical ecosystem of Uttarakhand. Verma *et al*. (2010) got five earthworms belonging to Octochaetidae namely *Eutyphoeous incommodus* Beddard, *E. orientalis* Stephenson, *E. pharpingiaus* Michaelsen, *E.waltoni* Michaelsen and *Pellogaster bengalensis* Michaelsen.

From trans Gangetic habitat of Haryana,Sharma and Bhardwaj (2014) reported four native species belonging to family Octochaetidae. They explained the low species richness due to intensive farming despite of varied suitable habitat and good moisture content.

The dominance of native earthworms over the exotic ones is an indication of undisturbed habitat condition (Julka *et al*., 2009). The dominance of native species in the present study indicates that the selected sampled habitat of the Gangetic plain of Bihar is not much disturbed.

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, land use and disturbances in the habitat concerned (Bhadauria and Ramakrishna, 1989). The manipulation of natural habitat by anthropogenic activities has also resulted into displacement of earthworm species. The earlier 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 agricultural practices which modifies the soil have also been reported to have impact on earthworm fauna.

Fragoso *et al*. (1993) also reported restriction of majority of native species were restricted to natural habitats, whereas, most of the exotic species were found in disturbed ecosystems. In the present study out of five species found, three are native and two are exotic (Table-2). The native species were mostly found in grasslands which is in conformity with the above finding. The native species are endogeic and aneciec while both the exotic species are epigeic. The average number of native species, decreased significantly from natural (4 species per site) to managed ecosystems (1 species per site) (Fragoso *et al*., 1993). The Octochaetide species recorded during the present investigation were 60% from unmanaged (grassland) and 40% from managed (cropland) ecosystem.

Table 2: Native and Peregrine earthworm genera and species of family Octochaetidae.

General	Species	Native or Peregrine	Epigeic/ Endogeic
Dichogaster	*Dichogaster affinis*	Peregrine	Epigeic
Dichogaster	*Dichogaster bolaui*	Peregrine	Epigeic
Lennogaster	*Lennogaster pusillus*	Native	Epigeic
Octochaetona	*Octochaetona surensis*	Native	Endogeic
Eutyphoeus	*Eutyphoeus waltoni*	Native	Endogeic

Pastures have been characterized by the presence of both native and exotic species, whereas, exotics constituted the dominant group in cropping systems. This means that in most of the cropping systems, unsuitable conditions exist for epigeic life (e.g. lack of litter layer). The findings of the present investigation supports the view. Whenever ploughing or tillage were not used, some stenotopic species have been reported to survive in agroecosystems. The 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.

Dominance of endogeic species is very relevant because it implied that epigeic species are not an important component in earthworm natural communities, and thus perturbation has a smaller effect on functional groups.

A comparative study of earthworm communities by Lavelle and Pashanasi (1988, 1989) in two tropical rain forests against three groups of derived (managed) agroecosystems 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 most of the agro ecosystems, the community structure was greatly simplified, often with only one ecological category either epigeic or endogeic. Qualitative changes were clear in pastures, 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 native epigeic and anecic species were maintained.

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 the community lost two native species but at the same time two other species invaded the community (one native and one epigeic exotic (Bhadauria and Ramakrishna, 1989). It is clear that by change of land use pattern and application of various managemental practices both the taxonomic and ecological categories of earthworms are changed and show differences in different ecosystems.

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 agro ecosystem; the agroecosystem communities were invaded by six peregrine endemic species and no worldwide exotic species were found.

The establishment or dominance of exotic or native species depends upon land use pattern and in the present study though the sampled sites are from intensive farming area but at the same time not much disturbed for harbouring earhworm.Intensive sampling is required for a better way of addressing the issue.

REFERENCES

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

Beddard, F. E. 1883. Note on some earthworms from India. *Annals and Magazine of Natural History*. **(5)12**: 213–224.

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 ecosystem of north east India .*J.Topical Ecology* vol 7: 305 - 318

Bisht, R.,Pandey, H., Bharti, D. and Kaushal, B. R. 2003. Population dynamics of earthworms (Oligochaeta) in cultivated soil of central Himalayan Tarai region. *Tropical Ecology*. **44(2)**:227-232.

Blakemore, R. J. 1994. "Earthworms of south-east Queensland and their agronomic potential in brigalow soils." PhD. Thesis, University of Queensland. pp. 605 with the description of 75 species, including 80 figures.

Blakemore, R. J. 1997. Two new genera and some new species of Australian earthworms (Acanthodrilidae, Megascolecidae: Oligochaeta). *J. Natural History*. **31:**1785-1848.

Blakemore, R.J. 2000. *Tasmanian Earthworms*. CD-ROM Monograph with Review of World Families. 'VermEcology', Kippax, Canberra, December, pp. 800 including 222figs.

Blakemore, R.J. 2002. *Cosmopolitan Earthworms – an Eco-Taxonomic Guide to the Peregrine Species of the World*. VermEcology, POBOX 414 Kippax, ACT 2615, Australia. pp.506 + including 80+ figs.

Blakemore, R. J. 2005. *A Series of Searchable Texts on Earthworm Biodiversity, Ecology and Systematics from Various Regions of the World*. CD-ROM, YNU, Yokohama, Japan.

Blanchart, E. and Julka, J.M. 1997. Influence of forest disturbance on earthworm (Oligochaeta) communities in the western Ghats (south-India). *Soil Biol. Biochem*. **29:** 303-306.

Csuzdi, Cs. 2012. Earthworm species, a searchable database. *Opuscula* Zoologica, Budapest. **43(1)**: 97–99.

Csuzdi, Cs. and Zicsi, A. 1994. Revision der Gattung Benhamia Michaelsen, 1889 (Oligochaeta: Octochaetidae). *Revue Suisse de Zoologie*. **101(1)**: 215-231.

Csuzdi, Cs. and Szlavecz, K. 2016. Earthworm (Clitellata: Megadrili) taxonomy in the last 200 years: A homage to András Zicsi (1928"2015). *Opuscula Zoologica*, Budapest. **47**: 1–7.

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

Fender, W. M. and McKey - Fender, D. 1990. Oligochaeta: Megascolecidae and other earthworms from western North America. In: *Soil Biology Guide*. Dindal, D. L. (Ed.). John Wiley & Sons, New York. pp. 357-378.

Fragoso, C. 1993. Les peuplements de vers de terre dans l'est et sud'est du Mexique. Ph.D. Thesis, Universite Paris 6, Paris, France, pp. 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. 1972. Burmese Earthworms, an introduction to the systematic and biology of Megadrile oligochaetes with special reference to South-East Asia. *Transactions of the American Philosophical Society*. **62(7)**: 1-326.

Gupta, D. K. 2006. Studies on population density diversity and dynamics of earthworms from different tropical plantation. Unpublished Ph.D thesis submitted to Ranchi University Ranchi.pp.226.

Joshi, N. and Aga, S. 2009. Diversity and distribution of earthworms in a subtropical forest ecosystem in Uttarakhand, India. *The Natural History J. Chulalongkorn University*. **9(1)**: 21-25.

Julka, J. M. 1976. Studies on the earthworm fauna of Orissa (India). 1. Moniligastridae and Ocnerodrilidae. *Mitteilungen aus dem Zoologischen Museum in Berlin*. **52**: 321-329.

Julka, J.M. 1988. *The Fauna of India and adjacent countries*. ZSI, Calcutta, pp- 400.

Julka, J. M. 2001. Earthworm diversity and its role in agroecosystem.VII National symposium on soil biology and ecology. Bangalore University of Agricultural sciences. Bangalore. 13-17.

Julka, J. M and Paliwal, R. 2000. Oligochaeta. In: Fauna of Renuka wet land: Wetland ecosystem series 2, Zoological Survey of India.21-25

Julka, J. M. and Paliwal, R. 2005. Checklist of earthworms of western Himalaya, India. *Zoos Print J.* **20(9)**: 1972-1976.

Julka, J.M., Giri, S., Panigrahi, P.K. and Senapati, B.K. 1997. *Parryodrilus lavellei* gen. nov. and sp. nov. (Octochaetidae: Oligochaeta) from Western Ghats, South India. *European J. Soil Biology*. **33(2)**: 141-145.

Julka, J.M., Blanchart, E. and Chapuis-Lardy, L. 2004. New genera and new species of earthworms (Oligochaeta: Octochaetidae) from Western Ghats, South India. *Zootaxa*. **486**: 1-27.

Julka, J. M., Paliwal, R. and Kathireswari, P. 2009. Biodiversity of Indian earthworms- an overview. In: *Proceedings of Indo- US workshop on vermitechnology in human welfare*, Edwards, C. A., Jayaraaj, R. and Jayaraaj, I. A. (Eds.),Rohini Achagam, Coimbatore, India. 36 -56.

Lavelle, P. and Pashanasi, B. 1988. Earthworm communities at Yurimaguas (Amazonas, Peru). Effect of management practices. TSBF

Progress report No. 1, pp.13.

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

Linnaeus, C. 1758. Systema Naturae, 10th Edition, Salvi: Holmiae, pp 824.

Magalhaes, W. F., Hutchings, P., Oceguera-Figueroa, A., Martin, P., Schmelz,, R. M. ., Wetzel, M. J., Wilkund, H., Maciolek, N. J., Kawauchi, G. Y. and Williams, J. D. 2021. Segmented worms (Phylum Annelida): a celebration of twenty years of progress through *Zootaxa* and call for action on the taxonomic work that remains. *Zootaxa*. **4979 (1)**: 190–211.

Michaelsen, W. 1900. *Das Tierreich* Vol.10: *Oligochaeta*. Friedländer and Sohn, Berlin. pp. XXIX + 575.

Michaelsen, W. 1907. Oligochaeta. In: *Die Fauna Südwest-Australiens*. **1(2)**: 117-232. Jena: Gustav Fischer.

Michaelsen, W. 1921. Zur Stammgeschichte und Systematik der Oligochäten, insbesondere der Lumbriculiden. *Archiv für Naturgeschichte, Berlin*. **86 (8)**: 130-141.

Mondal,C.K.,Mridha,R.S and Hasan Md .N.2017.*Eutyphoeus naurangiyai* sp.nov.(Clitellata:Octochatidae) . A new from Bihar,India IJARBEST. **3(6):** 41- 45

Mubeen, H. and Hatti, S. S. 2018. Checklist of earthworm diversity of Kalaburagi district of Hyderabad, Karnataka region, India. *International J. Science & Advance Research in Technology*. **4 (3)**: 969-971.

Narayanan, S. P., Sathrumithra, S., Kuriakose, D., Christopher, G., Thomas, A. P. and Julka, J. M. 2014. Earthworms (Oligochaeta: Megadrile) from the Mahatma Gandhi University campus, Kottayam, Kerala. *Malabar Trogon*. **12 (1-3)**: 2-9.

Narayanan, S.P., Sathrumithra, S., Christopher, G., Thomas, A.P. and Julka, J.M. 2016a. Checklist of the earthworms (Oligochaeta) of Kerala, a constituent of Western Ghats biodiversity hotspot, India. *Zootaxa*. **4193(1)**: 117–137.

Narayanan, S.P., Sathrumithra, S., Christopher, G., Thomas, A.P. and Julka, J.M. 2016b. Recent records of rare earthworm genera from Kerala, India. *Malabar Trogon*. **14(1–3)**: 38–43.

Narayanan, S. P., Sathrumithra, S., Christopher, G. and Julka, J. M. 2017. New species and new records of earthworms of the genus *Drawida* from Kerala part of the Western Ghats biodiversity hotspot, India (Oligochaeta, Moniligastridae). *ZooKeys*. **691**: 1-18.

Narayanan, S.P., Sathrumithra, S., Anuja, R., Christopher, G., Thomas, A.P. and Julka, J.M. 2019a. First record of the exotic *Metaphire bahli* (Gates, 1945) (Oligochaeta: Megascolecidae) from India. *Opuscula Zoologica* Budapest. **50(1)**: 99–103.

Narayanan, S.P., Sathrumithra, S., Christopher, G., Thomas, A.P. and Julka, J.M. 2019b. First record of some earthworms species (Oligochaeta: Megadrile) from Kerala part of the Western Ghats biodiversity hotspot. *National Academy Science Letters*. **42(6)**: 509–512.

Naraynan, S.P., Paliwal, R., Kumari, S., Ahmed, S., Thomas, A.P. and Julka, J.M. 2020. Annelida: Oligochaeta. In: *Faunal Diversity of Biogeographic Zones of India: Western Ghats*: 87-102. Published by Director, Zoological Survey of India, Kolkata.

Naraynan, S.P., Shatrumithra, S., Anuja, R., Christopher, G., Thomas, A.P. and Julka, J.M. 2021. Three new species and four new species records of earthworms of the genus Moniligaster Perrier, 1872 (Clitellata Moniligastridae) from Kerala region of the Western Ghats Biodiversity hotspot ,India. *Zootaxa*. **4949(2):**381-397.

Phillips, H.R.P., Guerra, C. A., Bartz, M.L.C., Briones, M. J. I., Brown, G. *et al.* 2019. Global distribution of earthworm diversity. *Science*. **366**: 480–485.

Reynolds,J.W. and Cook,D. G. 1976.*Nomenclatura oligochaetologica. A catalogue of names, descriptions and type specimens of the Oligochaeta*. University New Brunswick, Fredericton, New Brunswick. pp. 217.

Reynolds,J.W.and Cook,D. G.1981. *Nomenclatura oligochaetologica. Supplementum primum. A catalogue of names, descriptions and type specimens of the Oligochaeta*. University of New Brunswick, Fredericton, New Brunswick. pp.39.

Reynolds,J.W. and Cook,D.G. 1989. *Nomenclatura oligochaetologica. Supplementum secundum. A catalogue of names, descriptions and type specimens of the Oligochaeta*. New Brunswick Museum Monographic Series (*Natural Science*). No.**8**: 1-37.

Reynolds,J.W. and Cook,D.G. 1993. *Nomenclatura oligochaetologica. Supplementum tertium. A catalogue of names, descriptions and type specimens of the Oligochaeta.* New Brunswick Museum Monograph Series (*Natural Science*). No.**9:**1-33.

Sahu, S.K., Mishra, S.K. and Senapati, B.K. 1988. Population biology and reproductive strategy of *Dichogaster bolaui* (Oligochaeta: Octochaetidae) in two tropical agroecosystems. *Proc. Indian Acad. Sci. (Anim. Sci.)* **97(3)**: 239-250.

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.

Sharma, R. K. and Bhardwaj, P. 2014. Earthworm diversity in Trans Gangetic Habitats of Haryana, India. *Research J. Agriculture and Forestry Sciences*. **2(2)**: 1-7.

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

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

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

Sinha, M. P., Rohit, S. and Gupta, D. K. 2013. Earthworm biodiversity of Jharkhand: taxonomic description. *The Bioscan*. **8(1)**: 293-310.

Srivastava, R., Kumar, M., Choudhary, A. K. and Sinha, M. P. 2003. Earthworm diversity in Jharkhand state. *Nature Environment and Pollution Technology*. **2(3)**. 2003:357-362.

Stephenson, J. 1923. *The fauna of British India, including Ceylon and Burma. Oligochaeta,* Taylor and Francis. London. pp.518.

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

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

Stephenson, J. 1930. *The Oligochaeta*. Oxford University, Clarendon Press. pp. 978.

Stephenson J. 1931. Description of Indian Oligochaeta. II. *Records of the Indian Museum.* **33**:173-202.

Templeton R. 1844. Description of *Megascolex caeruleus*. *Proceedings of the Zoological Society of London*. **12**:89-91.

Verma, D., Bharti, S. and Yadav, S. 2010. Biodiversity of earthworm resources in Gangetic plain of Uttar Pradesh, India. *Tropical Natural History*. **10 (1)**: 53-60.

Walkley, A. and Black, I.A. 1934. Determination of organic carbon in Soil. *Soil Science*. **37**: 29-38.