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

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ABSTRACT

The family Megascolecidae, which is the most speciose family of earthworms, has been found to be represented by five species belonging to three genera *Lampito* Kinberg, *Metaphire* Sims and Easton and *Perionyx* Perrier and the species are *Lampito mauritii* Kinberg, *Metaphire planata* Gates, *Metaphire posthuma* Vaillant, *Perionyx sansibaricus* Michaelsen, *Perionyx millardi* Stephenson, which is the first report from the Gangetic plain of Bihar. Out of these five, three species, *Lampito mauritii*, *Perionyx sansibaricus* and *Perionyx millardi* are native and rest two are peregrine. Three species out of the five namely *Lampito mauritii, Metaphire planata and Metaphire posthuma* are endogeic and *Perionyx sansibaricus* and *Perionyx millardi* are epigeic from ecological category view point. The occurrence of these species has been discussed in particular reference to habitat characteristics.

INTRODUCTION

The four ecosystem functions namely- transformation, nutrient cycling, edaphic structure maintenance and population regulation, control the ecosystem services (Groot *et al.,* 2002; Kibble white *et al.,* 2008) which are though mainly, but not exclusively under the regulation of soil biodiversity (Bullock *et al.,* 2011). Ecosystem services are actually direct or indirect benefits made available to mankind by natural ecosystems. The soil forming processes, one of the services accounts for one third of the total ecosystem services which is around 33 Trillion US$ (Sharma *et al.,* 2017).

The nutrient cycling or the biogeochemical cycle is regulated by soil organisms particularly soil engineers which are mainly earthworms and termites (Jouquet *et al.,* 2006; Barrois, 2007). The earthworms play a major role in soil transformation by virtual of being most important detritivores in terrestrial ecosystem in terms of both biomass and activity (Laossi *et al.,* 2010). In this way the earthworms have come to play very important role in evolutionary history of man by converting land into soil and are still contributing in various ways .

The various roles played by these creatures underlined the importance of earthworms in soil sub system (Lavelle, 1984, 1988; Lavelle *et al.,* 1997; Fragoso *et al.,* 1993; Singh *et al.,* 2020). Earthworms have been studied from different parts of the globe (Jamieson, 2000; Csuzdi and Mischis, 2010; Blakemore, 2010, 2013; Plisko and Nxele, 2015; Chang *et al.,* 2017; Phillips *et al.,* 2019; Bora *et al.,* 2021).Significant contribution in earthworm studies have been made by Michaelsen (1907), Stephenson (1923, 1924, 1925, 1930, 1931), Gates (1972), Jamieson (1977a, 1977b), Julka (1988), Haldar (1998), Haldar *et al.,* (2004), Mandal and Haldar (2004), Gobi *et al.* (2004), Julka *et al.*, (1997, 2004), Julka and Paliwal (2000, 2005), Narayanan *et al.*, (2014, 2016, 2019, 2020, 2021), Sinha *et al.,* (2003a, 2003b, 2003c, 2013), Mubeen and Hatti (2018) and Srivastava *et al.,* (2003, 2021) in India but there is no report about the earthworms from gangetic plains of Bihar except that of Srivastava *et al.,* (2021) who reported for the first time the earthworms belonging to family Octochaetidae from the gangetic plain of Bihar. Keeping in view the gap of knowledge the present communication records for the first time the earthworms belonging to the family Megascolecidae.

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 influences 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 and organic carbon content was estimated following Walkley and Black (1934).

Sampling area

The Gangetic plain of Bihar covers 44,900 square kilometers. Some portion of this huge area under the districts of Vaishali, Samastipur, Saran and Muzaffarpur have been 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 garbage dumping sites.

RESULTS

Table -1 embodies details of the physico chemical profile of soils of sampling sites. The data showed that the soils have moderate amount of total organic matter (TOM) which is the food of earthworms. TOM in soil determines the variety of earthworm to be found in that soil. The soil appeared to be alkaline in nature. The sampling points always showed moisture content to be more than 25% which is an essential edaphic factor to sustain earthworms. Soil texture was in general sandy loam type. The soils of garbage heaps, compost pit where sampling was done showed variation in TOM from 9.23-13.27%. The pH of these soils was recorded comparatively low.

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

SYSTEMATIC ACCOUNT

Class Oligochaeta of Phylum Annelida includes Order Haplotaxida

Order HAPLOTAXIDA

Diagnosis- Interseptal male funnels and Testes, male funnels are one segment anterior to that bearing the male pores.

Suborder **LUMBRICINA**

Diagnosis- Male pores at least 2 segments posterior to testes. Multiple layers of cells forms the Clitellum.

Superfamily MEGASCOLECOIDEA

Diagnosis – Large ovaries, fan to rosette-shaped with the oocytes forming several egg strings.

Family MEGASCOLECIDAE Rosa, 1891

Family Megascolecidae Rosa, 1891 is the most speciose family of earthworms with 2,208 spp. and 127 subspecies and belonging to 85 genera. The genera *Metaphire* (242 spp./ sspp.), *Pheretima* (171 spp./ sspp.), and *Megascolex* (104 sp./ sspp.) are among the most speciose genera of the family. According to Blakemore (2013) the taxa named under the current conventions of ICZN (1999) code should be considered while attempting to redefine some megadrile families based on moleculocladistics. He further emphasized that 'molecular phylogeny' of some worms presented by James and Davidson (2012) must be treated with caution since seeking taxonomic solution from genetics may not always be appropriate. The weakness in their study was failure to follow

Table 1. Geographical location and some edaphic characteristics of sampling sites.

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

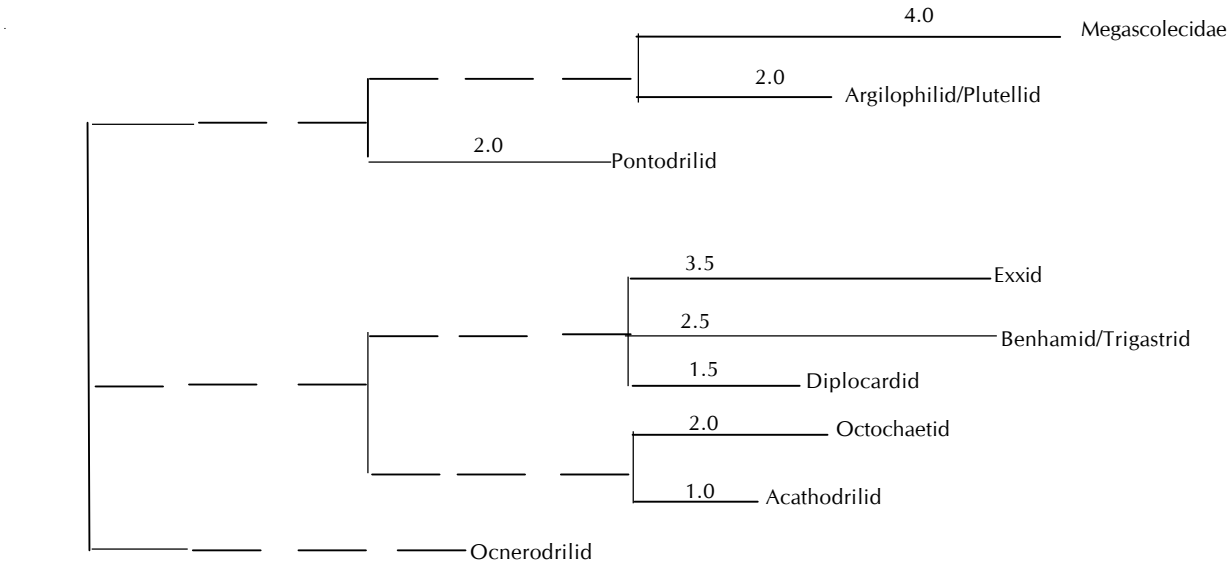

Fig.1: Phylogeny of the Megascolecoidea taxa constructed on weighted morphology of their types after Blakemore (2008) corresponding to an actual molecular phylogram presented in Blakemore (2005, 2008) (After Blakemore, 2013).

ICZN (1999) whereby a family is defined on the basis of the characteristics of a representative type genus implicit in the name of the family. Blakemore(2013) suggested that if molecular cladists follow a Phylo code instead of using Linnean taxonomy, which was earlier independently suggested by Timm (2005) to be a better option. An 'ideal' phylogenetic arrangement for these megascolecoid taxa based on weighted morphology of their primary types is shown in Fig. 1.

Any family reviewed without consideration of types becomes meaningless. But if monophyly is strictly employed then each type deserves its own unique family or else all families may telescope into the earlier taxon. It is clear that a rational moderation is required (Blackmore, 2013).But there are authors who believe that not only the morphological and anatomical details but also the available molecular studies advocate its monophyly with slight differentiation inside the family. These evidences contradict taxonomic divisions put forward by Jamieson *et al.,* (2002) and Blakemore (2013).

Some species of the family belonging to genera *Amynthas* and *Metaphire,* as well as *Perionyx excavatus* Perrier, are known to be the most widely distributed earthworms in the world (Blakemore, 2009). Some species have been extensively transported to different parts of the world by human interference from their native range. Owing to the presence of parthenogenetic morphs, and wide plasticity in terms of soil and habitat preferences in several of these species are found to be excellent invaders, particularly in subtropical, tropical and even temperate regions (Brown *et al.,* 2006; Chang *et al.,* 2017).

Diagnosis- Body cylindrical. Presence of dorsal pores, Male pores posterior to *xvi*. pre-testicular segments bears spermathecae, racemose prostates with no 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 - Perichaetine setae. Male pores are paired on *xviii*; paired female pores on *xiv*. Oesophagus with a single gizzard in *v*, calciferous lamellae in *x-xiii*, absence of intestinal caeca and supra-intestinal glands, presence of typhlosole. 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, Uttar Pradesh, Odisha, Karnataka, Palni and Cardomom Hills. *Lampito mauritii* is widely distributed throughout India and also to other parts of the world probably due to transportation.

Lampito mauritii Kinberg

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 95-155 mm, diameter 3-6 mm, 157-201 segments. epilobic prostomium, closed tongue. 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*. Paired spermathecal pores 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

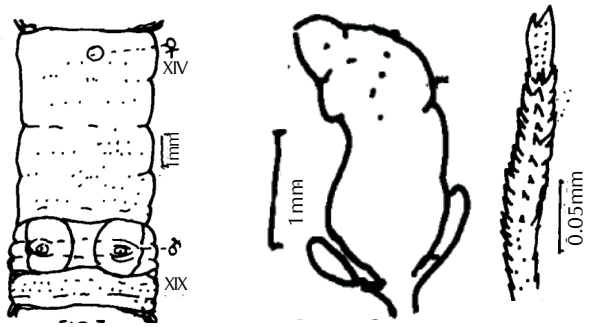

Fig-2: *Lampito mauritii* Kinberg (A) Male Genital Region (B) Spermatheca (C) Penial setae

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, Odisha, Uttar Pradesh, Karnataka, Rajasthan, West Bengal, Bihar (S2, S3, S8, S10, S11, S12, S16, S18, S20, S23), Andaman and Nicobar Islands, Laccadive and Minicoy. Sri Lanka, Maldives, Burma, Bangladesh, Sumatra, 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-28 clitellate specimens from different districts of Bihar.

Biology- Maximum monthly population in some habitats are 255 m^{-2} in cropland and 320m^{-2} from grassland (Kumari, 2013), 37 m^{-2} from grazed upland pasture and 42 m^{-2} from ungrazed upland pasture (Senapati and Dash, 1981); grazed forest 64 m^{-2} (Mishra and Dash, 1984); ungrazed lowland pasture 240 m^{-2} (Dash and Patra, 1977).

Oval cocoons are with a hatching and a non-hatching end, average length and diameter of the cocoon is 4.7 mm and 3.35 mm respectively, incubation period is around 4 weeks. Usually one, juvenile hatch out from each cocoon (Dash and Senapati, 1980).

Genus **Metaphire** Sims and Easton

Diagnosis- Perichaetine Setae. Paired male pores (combined with prostatic pores) 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.

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

Metaphire planata Gates

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 64-176 mm, diameter 4-7 mm, 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, Odisha, Bihar (S1, S4, S7, S8, S10, S11, S15, S18, S19, S22), West Bengal, Assam, Andaman Islands, Chattishgarh, Burma, Bangladesh, Thailand, Malaysia.

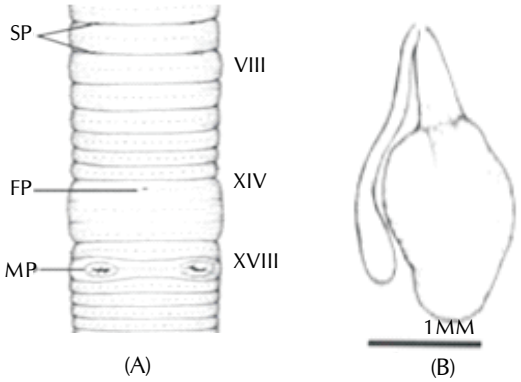

Fig -3: *Metaphire planata* Gates (A) External ventral view (B) Spermatheca (SP = Spermathecal pore, FP = Female pore, MP = Male pore)

Metaphire posthuma Vaillant

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, 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, Maharashtra, Orissa, Rajasthan, West Bengal, Punjab, Bihar (S3, S5, S6, S10, S12, S13, S14, S17, S19, S21, S22), Uttar Pradesh, Madhya Pradesh, Andaman and Nicobar Islands. Indonesia, Burma, Bangladesh, Thailand, Malaya Peninsula, Philippines.

Material examined- 15 clitellate worms.

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- *Metaphire posthuma* is geophagous and feeds underground. 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.

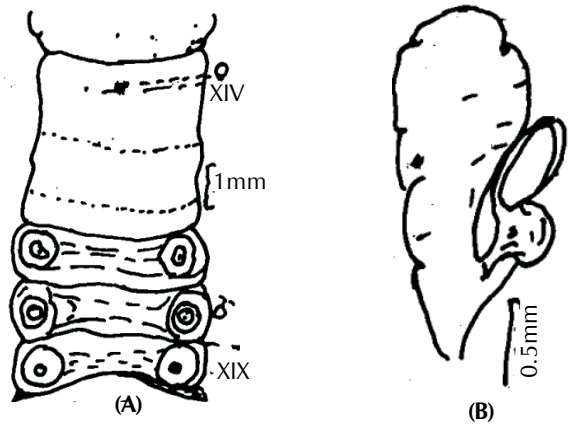

Fig-4: ***Metaphire posthuma*** **Vaillant (A) Male Genital Region (B) Spermatheca**

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). Casts are deposited on the soil surface in the form of small heaps of loose ovoidal pellets.

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, Sri Lanka and Malaysia.

Perionyx sansibaricus Michaelsen

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 32-120 mm, diameter 2.5-3.5 mm, 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: Bihar (S1, S2, S5, S6, S7, S9, S13, S14, S16, S21, S23), Jharkhand, Gujarat, Tamilnadu, Kerala, Odisha, Maharashtra, Madhya Pradesh, Uttar Pradesh.

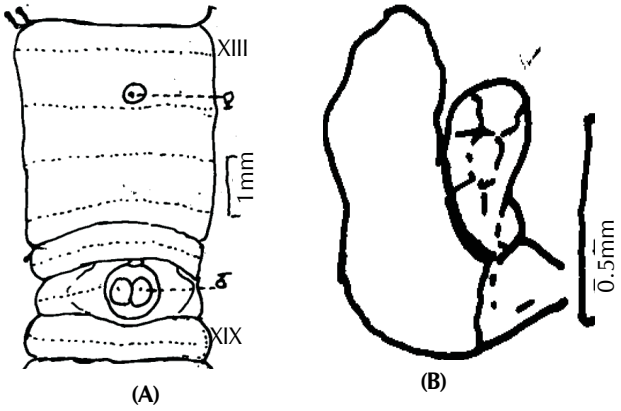

Fig-5: ***Perionyx sansibaricus*** **Michaelsen (A) Male Genital Region (B) Spermatheca**

Material examined- Several juvenile, immature and mature specimens from different district of Bihar.

Habitat- It is usually found in grassland, 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).

Perionyx millardi Stephenson

1915. *Perionyx millardi* Stephenson, *Mem. Indian Mus.,* **6**: 74 (Type locality: Bombay, India); Stephenson, 1923, *Fauna*

Br. India, Oligochaete: 342.

Diagnosis- Length 40-90 mm, diameter 2-2.5 mm, 126-170 segments. Prostomium epilobic, tongue closed or open. First dorsal pore in 4/5 or 5/6. Clitellum annular, *xiii-xvii*. Setae 40 on *ix,* 41 on *xii,* 48 on *xix*. Male pores near mid-ventral line, on small papillae. Spermathecal pores paired, in 7/8/9, near mid-ventral line, at *b*. Genital markings absent. Nephridiopores inconspicuous, in a rather irregular longitudinal rank on each side.

Septa all present from 4/5. Gizzard slightly developed in *vi*. Intestine begins in *xviii* or *xix*. Last pair of hearts in *xiii*. Holandric, testes and male funnels free, in *x* and *xi* ; seminal vesicles in *xi* and *xii,* those of *xii* extend posterior to septum 13/14. Penial setae ornamented with 9 to 10 circles of fairly sized spines, 0.44-0.65 mm long, 15-18 μ diameter. Spermathecae paired, in *viii* and *ix,* each with an ental diverticulum. Nephridia avesiculate.

Distribution- India: Orissa, Bihar (S3, S4, S7, S9, S11, S14, S15, S17, S20, S21, S22), Jharkhand, Madhya Pradesh, Maharashtra.

Material examined- 7 aclitellate, 13 clitellate.

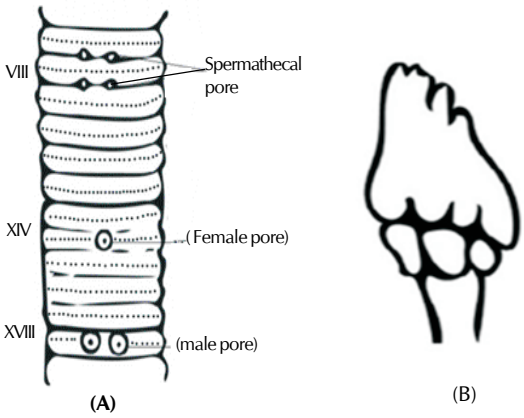

Fig-6: *Perionyx millardi* Stephenson (A) Genital region (B) Spermatheca

Habitat- Usually found in neutral soils (pH 7) having high organic material and moisture content ($\geq$ 10g%).

Biology- Population density at Jyoti Vihar ranged from 50/m^2 to 500/m^2 during summer and rainy months respectively. Cocoons are elongate and 'S'-shaped which are of light colour initially but turns dark later on. Incubation period is about 3-4 weeks. Usually one young worm emerges from each cocoon (Senapati, 1980).

DISCUSSION

The diversity, density and distribution of earthworm on regional and even on global scale are dependent on habitat characteristics. A number of climoedaphic factors influence density, diversity and activity of the earthworms such as food quality and quantity (Lee, 1985; Curry, 2004, Sinha *et al.,* 2013), soil temperature and moisture (Berry and Jordan, 2001; Wever *et al.,* 2001; Sinha and Srivastava, 2001; Sinha *et al.,* 2002, 2003d, 2003e, 2008; Srivastava and Sinha, 2004a, 2004b; Srivastava *et al.,* 2012, 2013) and soil structure and texture (Nuutinen *et al.,* 1998; Baker and Whitby, 2003; Smetak *et al.,* 2007).The relationship of earthworm activity to soil physical and chemical properties has been well documented (Whalen, 2004; Marhan and Scheu, 2005; Ammer *et al.,* 2006), in pasture (Baker *et al.,* 1992; Decaens *et al.,* 2004; Winsome *et al.,* 2006) and agricultural systems (Edwards *et al.,* 1995; Lamande *et al.,* 2003), but has not been well studied in Indian conditions which has diverse climoedaphic regions. Selected sampling areas for the present study are from Gangetic plain of Bihar which is highly fertile land and intensive farming is the practice.

The agricultural soils differ from grassland and forest soils in the type and degree of human alteration that has occurred during farming. Original soil profiles in crop fields are substantially altered due to agricultural practices which become the reason of decreasing diversity and density of soil organisms, most important among them is earthworms (Scheyer and Hipple, 2005). Management practices including mulch-mowing, irrigation, fertilization and their intensity have been reported to affect earthworm activity and population. It has been reported that earthworms are affected by habitat disturbance and management practices and can influence soil profile development significantly (Lee, 1985; Edwards and Bohlen, 1996), soil structure (Kladivko *et al.,* 1986; Oades, 1993), nutrient cycling, and plant productivity (Blair *et al.,* 1995; Stephens and Davoren, 1996), therefore, it is of value to study the earthworm faunal diversity in intensively agricultural area of the Gangetic plain of Bihar which has not been studied earlier.

Among the sampled species *Lampito mauritii*, *Metaphire posthuma*, *Metaphire planata* are the endogeic species that create horizontal burrows and feed on organic matter while other two species of the family belonging to the same genera *Perionyx sansibaricus* and *Perionyx millardi* are epigeic and dwells and feeds on surface litter (Bouche, 1977). Among the recorded species 66.66 % is native earthworm species collected mostly from grassland sites. Only 33.33% species has been found in agricultural fields which are peregrine (Table 2).

The lower number of native species is consistent with results of studies conducted in agricultural fields within the study area (Fauci and Bezdicek, 2002; Johnson-Maynard *et al.,* 2007). Alteration in habitat has been considered as the main factor for establishment of exotic earthworm population (Kalisz

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

Genera	Species	Epigeic / Endogeic	Native or Peregrine
Lampito	*Lampito mauritii*	Endogeic	Native
Metaphire	*Metaphire planata*	Endogeic	Peregrine
Metaphire	*Metaphire posthuma*	Endogeic	Peregrine
Perionyx	*Perionyx sansibaricus*	Epigeic	Native
Perionyx	*Perionyx millardi*	Epigeic	Native

and Wood, 1995; Hendrix and Bohlen, 2002). It has also been reported that the native earthworms inhabiting the undisturbed habitat might have been removed from the habitat or killed after on setting of disturbances due to anthropogenic activities. This is supposed to provide a way to the establishment of earthworm populations dominated by exotic species which may be better suited to survive in disturbed soil conditions (Smetak *et al.,* 2007). In the present study exotic species were found in agricultural fields which is disturbed due to agricultural practices while native species were found in grassland which was less or not disturbed.

Earthworm diversity tended to be low with one to three species present within a locality (Smetak, 2007) is justified by the present study. Low earthworm species diversity within a site has not been found to be uncommon. Most earthworm diversity studies report the presence of between two and five species at any one location (Lee, 1985, Srivastava *et al.,* 2003, 2012, 2013; Sinha *et al.,* 2003e, 2008; Srivastava and Sinha, 2004a, 2004b).

Very few reports are available on earthworm diversity of the Gangetic plain. Kaushal *et al.,* (1999) reported 9 species of Megascolecid earthworms from Kumaon Himalaya namely *Amynthas alexandri, A. corticis, A. gracilis, A, morrisi, E. annaldeli, Metaphire anomala, M.sirancea, M.houletti and Perionyx excavatus*. Bhist *et al.,* (2002) on the other hand reported only four species belonging to this family (*Amynthas alexandri, A. morrisi, Perionyx excavatus and Metaphire posthuma*) from Doon Valley. From Gangetic plain of Uttar Pradesh while studying the earthworm resources, Verma *et al.,* (2010) found six Megascolecid species *Lampito mauritii, Metaphire anomala, M. biramica, Metaphire posthuma, Perionyx sansibaricus and Polypheretima elongata*. The present study is in conformity with the record of the number of species from the gangetic plain adjoining to the present sampling area. More vigorous sampling may result into enlistment of more species which is on the way.

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