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Taxonomical Studies on Earthworm *species* of Agra Region (Uttar Pradesh)

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Abstract: ***Earthworm are very important organisms of soil they are called friends of the farmer. They are important environmentally and economically so that their identification and classification is very essential. Taxonomy aims to classify organisms based on their similarities and differences. The present study was carried out during 2008 and 2010 in south - western semi dry region of Uttar Pradesh, focusing on identification and classification of local species of earthworm. The earthworm were collected and preserved and then carefully examined in the laboratory. The earthworms identified are belonging to 7species of 2 Families, Family octochaetidae species Eutyphoeus orientalis Beddard, Eutyphoeous waltoni Michaelsen, Eutyphoeus incommodus Beddard Family Megascoecidae species Metaphire posthuma vaillant, Mataphire anomola Michaelsen, Lampito mauritii kingberg, Polypheretima elongata kinberg***

Keywords: Earthworm diversity, soil analysis, earthworm sampling, earthworm identification, earthworm species of Agra region, (Uttar Pradesh).

1. Introduction

Comprehensive taxonomic and distributional survey of Oligochaetes, particularly the Indian earthworms was done by Stephenson (1923) and published under the title *Fauna of British India series.* Later, this work became obsolete due to nomenclatural changes and discovery of new taxonomic characters. Julka (1988) filled this gap in taxonomic and distributional studies and reviewed the publications of Gates (1937) and others of Earthworms. Presently, Julka's publication titled "Indian Earthworm" is taken as the most recent and scientifically acceptable work on taxonomy of Indian earthworm. Some biological studies of Indian earthworms (Dutt, 1948; Joshi et al., 2000; Nijahwan and Kanwar, 1952; Khambata and Bhatt, 1957, Bhatt et al., 1960) dealt with earthworms role in soil aggregation, effect on soil fertility and their association with micro flora.

India is diverse country harbouring a very high diversity of earthworms. The land area of India is only 2% of world's total land mass but it supports 10.5% of total known global earthworm diversity. The Indian earthworm fauna is predominantly represented by native species which constitute about 89% of total earthworm diversity in the country (Julka and Paliwal, 2005). Julka (1988) described nine families comprising 53 genera and more than 400 species from India. The Family Octochaetidae with 26 genera is more commonly found in Indian ecosystem.

Earthworm resources of India are known particularly from Himalayan, Indo - Gangatic and Deccan peninsula (Julka, 1988). The Deccan peninsula is rich in earthworm fauna and harbours many epigeic and anecic species such as *Dichogaster bolaui*, *Drawida willsi*, *Perionyx excavatus*, *P. sansibaricus*, *Lampito mauritti*, Pellogaster bengaensis and other species, which have great potentiality for use in vermitechnology (Dash and Senapati, 1985; Dash, 1999). The north - east and Himalayan regions are also rich in many endemic and few exotic species of earthworms (Bhadauria and Rama Krishnan, 1989; Bhadauria et al., 2000; Sinha et al., 2003). However, throough human transports, many exotic species have been imported from many other regions of the worlds, especially from Europe, Africa and America and some groups have been distributed worldwide (Jamieson, 1978; Reynolds and Cook, 1976). Besides Deccan peninsula and Himalayan regions, the Indo - Gangatic plain is also rich in earthworm fauna, especially the endemic species of *Eutyphoeus* in alluvial soils.

Verma et all (2010) surveyed Gangetic plane of Uttar Pradesh, India during August to October 2008, and collected 11 taxa of earthworms belonging to 6 genera and two families. This constitutes 26.3 % of total Indian earthworm fauna. Of these, 4 taxa are exotic with extra Indian origin. Based on survey of earthworms in Doon valley of Western Himalayan region conducted by Verma and Shweta (2011) in September 2009 to 2012 enlists species belonging to 7 generas and 4 families.

Based on this rationale, the present study has been undertaken in certain selected districts of Agra region of U. P (India) with a view to (i) study earthworm biodiversity in the study area; (ii) search for more native species which are very specific and could be used for vermicomposting; (iii) contribute material for preparation of earthworms inventory of the study area; (iv) suggest measures for their conservation and protection, particularly those species which are on the a verge of extinction.

The present attempt, therefore, is to scientifically update investigation, identification and documentation of contemporary earthworm fauna of the study area with special reference to search for native vermicomposting species.

Templeton (1844) when he discovered Megascolex caeruleus from Sri Lanka. However, Perrier (1872) was the first to describe earthworm species from the Indian mainland. Subsequent noteworthy contributions on the taxonomy of Indian earthworm are those of Bourne (1886), Beddard (1902), Michaelsen (1907, 1910a), Stephenson (1914, 1915, 1916, 1917, 1923), Aiyer (1929) Gates (1937, 1938a, 1939a, 1939b, 1942a, 1942b, 1945, 1947, 1972), Jamieson (1977), Julka (1976a, 1976b, 1978, 1981, 1983, 1988a, 1988b), Senapati et al., (1990) Julka and Paliwal (1993, 1994), Julka et al., (1997), Paliwal and Julka (2005) have provided comprehensive checklists for earthworms of western Himalaya and Tamil Nadu. The earthworm fauna of

India is well reported as compared to other Asian Countries (excluding Myanmar). Presently, 418 valid species / subspecies of earthworms under 69 genera are known from the Indian territory, Including the islands of Andaman, Nicobar and Lakshadweep have reported 9 families (as per Brinkhurst and Jamieson's classification of Oligochaeta, and Gates classification of Megascolecidae), Endemism, both at genera and species level, is very high; about 71% of genera and 89% species are endemic. Some exotic peregrine species of earthworms are also found and these are now widespread in disturbed habitats following deforestation and intensive cultivation practices.

2. Material and Methods

Study Site

South western semidry region (district: Agra, Aligarh, Etah, Mathura) in Indo - genetic plain is among the most extensive fluvial plains of the world and cover several state of northern, central and eastern part of India.

The study area is situated between $27^0$9'2" N latitude and $77^0$57'39" E longitude, 169 meter altitude, highly fertile with alluvial soil affected by salts, having flat topography broken by numerous ponds, lakes, rivers like Ganga, Yamuna. The minimum amd maximum temperature range from 01^0 C to 47^0 C for the month of January to May respectively, with an annual rainfall 662 mm. The vegetation is tropical dry and dry deciduous type.

Date (s) of survey	Location Covered	Altitude	Latitude	Longitivity
18 - 08 - 08 to 20 - 08 - 08	Aligarh	42	52^O N	76^O 5' E
20 - 08 - 08 to 22 - 08 - 08	Mathura	287	27^O41' N	77^O 6' E
23 - 08 - 08 to 25 - 08 - 08	Etah	557	27^O58' N	74^O 4' E
26 - 08 - 08 to 28 - 08 - 08	Agra	169	55^O N	78^O 2' E

Earthworm Sampling:

The methodology adopted for earthworm collection was based on Julka (1988). Collected worms were washed in fresh water and stored in test tubes in the field. Ethyl alcohol was gradually added to the test tube and then transferred to the dish containing a solution of 5% formalin for fixation and kept for a period of 6 - 8 hrs, followed by their preservation in the 70% ethyl alcohol or 5% formalin. All specimens were serially numbered. Earthworms were identified with the help of monographs and other available literature on the subject (Stephenson, 1923; Gates; 1972, Julka, 1988) at the vermiculture Research Station (VRS), D. S. College, Aligarh and later confirmed at Zoological Survey of India, Kolkata. Voucher specimens examined and reported in the present work are deposited in the Museum of VRS, for future reference and study.

Analysis of soil sample:

Soil samples collected from various study sites were analysed for soil colour (Biswas and Narayan sami 1998), pH (Biswas and Narayan sami 1998), soil moisture (Santhanam at el., 1989), total organic carbon (Hesse, 1971), nitrogen (Black and Neely, 1975), phosphorous (Jackson, 1967).

3. Results

Soil Analysis:

Results of the soil analysis show, the pH ranges from 7.45 ± 0.005. Colour may be brown, light brown, deep brown or olive brown. Soil moisture ranges from 20.5 ± 6.0. Total organic carbon ranges from 0.25 ± 0.07. Nitrogen ranges from 0.057 ± 0.01. Phosphorous ranges from 20.40 ± 0.019. The details are shown in table (1.1)

Table 1.1 Occurrence of Earthworm species in the study area in different ecological conditions.

Family and Earthworm species	Soil Temperature	Soil Moisture (%)	Soil pH	Soil Organic Carbon (%)
Octochaetidae				
Eutyphoeus orientalis	26.75 ± 0.48	23.5 ± 4.0	7.45 ± 0.002	0.97 ± 0.002
Eutyphoeous waltoni	26.08 ± 0.10	20.5 ± 5.0	7.48 ± 0.005	0.54 ± 0.002
Eutyphoeus incommodus	25.95 ± 0.33	24.5 ± 5.0	7.38 ± 0.005	1.04 ± 0.004
Megascolecidae				
Metaphire posthuma	25.33 ± 0.20	25.5 ± 5.0	7.59 ± 0.005	0.25 ± 0.007
Metaphire anomala	25.02 ± 0.08	23.5 ± 5.0	7.48 ± 0.005	0.25 ± 0.005
Lampito mauritii	25.67 ± 0.08	27.7 ± 5.0	7.79 ± 0.002	0.65 ± 0.005
Polypheretima elongata	24.67 ± 0.05	28.0 ± 6.0	7.38 ± 0.004	0.54 ± 0.004

Identification Earthworms:

The earthworms found in all sites belong to two families. Family octochaetidae species *Eutyphoeus orientalis* Beddard, *Eutyphoeous waltoni* Michaelsen, *Eutyphoeus incommodus* Beddard Family Megascoecidae species *Metaphire posthuma* vaillant, *Mataphire anomola* Michaelsen, *Lampito mauritii* kingberg, *Polypheretima elongata* kinberg.

Family: Octochaetidae

Distinguish feature: Body cylindrical, dorsal pores present, male pore in front of Clitellum, occupied xvi - xviii segments spermathecal pores present, terrestrial in habitat, arrangement of setae - Lumbrine (8 setae in each segment in 4 pairs) and prostate gland tubular.

Distribution: Africa, Australia, India and Burma.

Earthworm species collected from the study area:

1) Eutyphoeus orientalis Beddard
2) Eutyphoeus waltoni Michaelsen
3) Eutyphoeus incommodus Beddard

Eutyphoeus orientalis Beddard (Fig.1.1)

Origin: Native of India
Body lengt: 70 mm - 120 mm
Body segments: 130 - 111
Prostomium: Combined Pro / tanylobic; Mouth Fleshy lobe like circular structure.
Setae: Lumbricine arrangement (8 setae / segment in 4 pairs; widely paired)
Clitellum: Saddle shape; located ½xiii - xvii segments.
Male pore: xvi segment; discharge into the body surface through circular aperture.

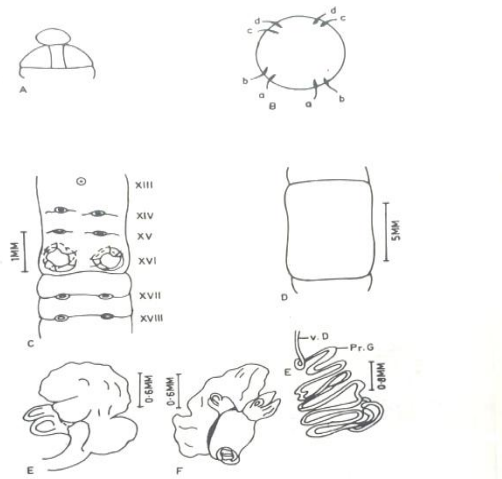


Figure 1.1: Diagramatic representation of *Eutyphoeus orientalis* Beddard A, Prostomium; B, Setae; C, Genital region; D, Clitellum; E, Prostate gland; F, Spermathecae; VD, Vasa deferentia; Pr. G, Prostatic gland.

Female pore: xiii segment; single.
Genital markings: xiv / xv segment; xvii / xviii segment. in pairs.
Spermathecal: vi / vii / viii segment; with median diverticula.
Dorsal pore: Present
Prostate gland: Tubular type; with vasa differentia.
Collection & Locality: G/124, Fort Agra
Zone: North - east
Date (s) of collection: 19 - 09 - 2008
General habitat: Grassland (ungrazed).

Eutyphoeus waltoni Michaelsen (Fig.1.2)

Origin: Native of India
Body length: 60 mm - 140 mm
Body segments: 125 - 130
Prostomium: Prolobic, fleshy lobe like circular structure mouth closed.
Setae: Widely paired (8 setae / segment in 4 pairs) Lumbricine arrangement.
Clitellum: Saddle shaped; located in xiii - xvii segments.
Male pore: Located in xvii segment; male pores discharge into deep, paired opening on the body surface, through circular aperture.
Female pore: Located xiii segment; single on the left side.
Genital markings: xiii / xiv and xvi segment; in paired.
Spermathecal: vii / viii / ix segment; bound together with connective tissue.
Dorsal pore: Present
Prostategland: Tubular type; with vasa deferentia and prostatic duct.
Zone: North - east
Collection & Locality: G/127, Park Agra
Date (s) of collection: 19 - 09 - 2008
General habitat: River Bank.

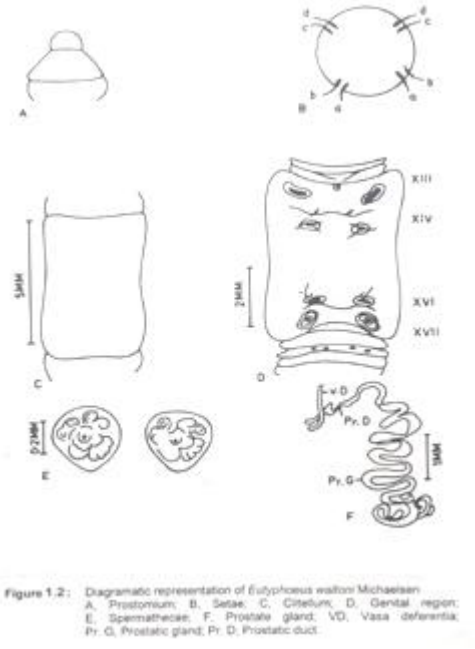
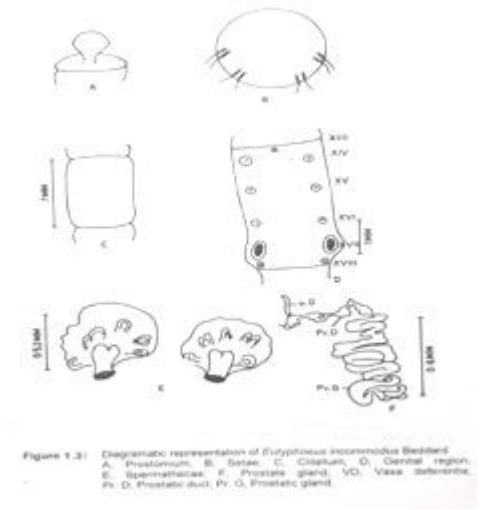


Figure 1.2: Diagramatic representation of Eutyphoeus waltoni Michaelsen A, Prostomium; B, Setae; C, Clitellum; D, Genital region; E, Spermathecae; F, Prostate gland; VD, Vasa deferentia; Pr. G, Prostatic gland; Pr. D, Prostatic duct.

Eutyphoeus incommodus Beddard (Fig.1.3)

Origin: Exotic
Body length: 32 mm - 53 mm
Body segments: 87 - 117 Segments
Prostomium: Open epilobic type; tongue outside from mouth.
Setae: Closely paired; lumbricine arrangement, 8 setae per segment in 4 pairs.
Clitellum: Saddle shaped; 7mm, in length cupied xiii to xvii segment.
Male pore: xvii segment; discharge on to body surface.
Female pore: xiii segment; median in location.
Genital markings: xiv to xvi and xviii segment; paired.
Spermathecal: vi / vii intersegment; one pair spermatheca, each with 2 median shortly stalked diverticula in the form of circle of 4 opening into short duct.
Dorsal pore: Present
Prostate gland: One pair, tubular type, with vasa differentia and prostate duct.
Zone: Tarai, Western plain, South - western semidry region



Collection & Locality: D/01, Malviya Library, Aligarh; D/05, Dept. Chemistry A. M. U. Aligarh; D/17, Agricultural Research Training center, Mathura
Date of collection: 18 - 08 - 2008 to 17 - 10 - 2008
General habitat: Grassland (ungrazed), cultivated land, wasteland.

Family: Megascolecidae

The Megascolecidae is the largest and widely distributed family of the Oligachaeta; it comprises 30 Indian genera, of which *Pheretima* (*Metaphire*) is represented by the largest genus having 13 Indian species. Mostly these are highly peregrine and have established themselves in most of the warmer region of the globe. The distribution range of the family extends between warm - temperate Asia and Australia, Two genera of the pheretimoid group, Amynthas and Metaphire are endemic in Burma, and Andaman and Nicobar Islands, but are peregrine in other parts. While is Pheretima and Polypheretima are exotic in the subcontinent (julka, 1993).

Distinguish Features: Body cylindrical, dorsal pores present, male pore in front of clitellum located in xviii segment, female pore in xiv segment, genital marking present in all species except *Lampito mauritii* and *Metaphire birmanica;* Clitellum annular type, spermathecae present in all species but absent in *Metaphire anomala;* Prostomium rudimentary in *Polypheretima elongate*; Prostate gland racemose type.

***Metaphire posthuma* Vaillant (Fig.1.4)**

Origin: Native of India
Body length: 60 mm - 150 mm
Body segments: 122 - 190 segments
Prostomium: Open epilobic, Mouth open
Setae: More than 8 setae in each segment Perichitine arrangement in regular rows
Clitellum: Clitellum annular type, xiv - xvi segments.
Male pore: Male pore in xviii segmented in pouch
Female pore: In xiv segment along the mid ventral line
Genital markings: Pouch like body extended from xvii and xix segment in pair
Spermathecael: v / vi / vii / viii / ix segment unidiverticulate, one small diverticula aries from main ampulla
Prostate gland: Racemose type, each with prostatic duct
Collection & Locality: D/01, Malviya Library Garden Aligarh; D/03, Jawahar National Horticulture Garden Aligarh D/30, Rambagh Agra; D/32, Yamuna River Agra; D/34, Naripur Agra; D/36, Padmanagla Agra; Sophia School Raya Mathura
Zone: Semidry region
Date of collection: 18 - 08 - 2008 to 18 - 10 - 2008
General habitat: Grassland (ungrazed), cultivated land, river bank, agriculture land, irrigation canal

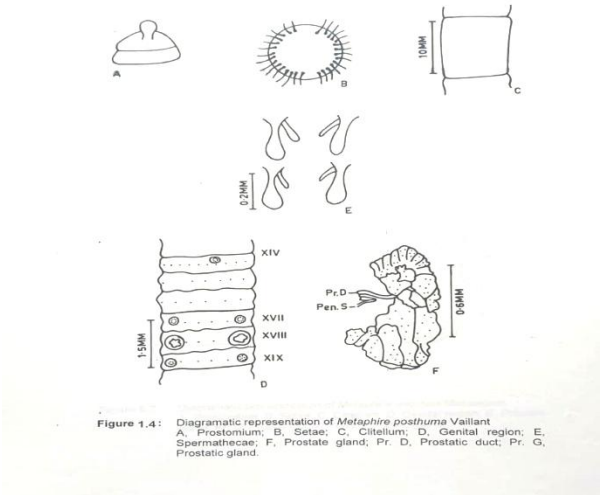


Figure 1.4: Diagramatic representation of *Metaphire posthuma* Vaillant
A, Prostomium; B, Setae; C, Clitellum; D, Genital region; E, Spermathecae; F, Prostate gland; Pr. D, Prostatic duct; Pr. G, Prostatic gland.

***Metaphire anomala* Michaelsen (Fig.1.5)**

Origin: Native of India
Body length: 50 mm - 100 mm
Body segments: 107 - 120 segments
Prostomium: Open epilobic type
Setae: More than 8 setae in each segment, Perichitine arrangement Clitellum: Clitellum saddle shaped extend from xiv to xvi segment
Male pore: Male pore in xx segment in pair discharge in body surface each within conspicuous pouch Female pore: Single median in xiv segment
Genital markings: Genital marking present in xvii, xviii, xix and xxi, xxii, xxiii segment in body surface
Spermathecal: Absent
Prostate gland: Prostate and one pair racemose type each with prostatic duct
Collection & Locality: B/43, Agra road, Aligarh
Zone: Western plain
Date (s) of collection: 21 - 08 - 2008
General habitat: Cultivated land

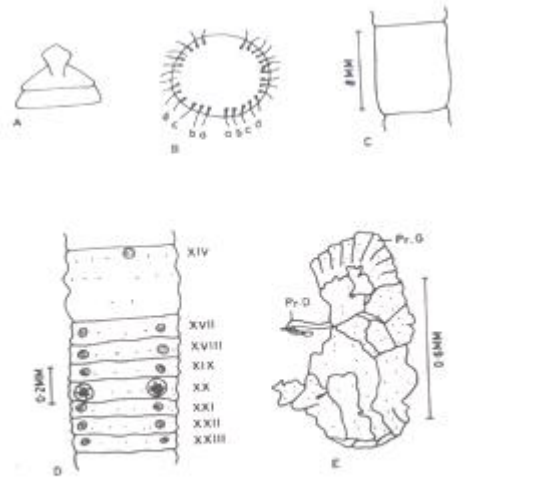


Figure 1.5: Diagramatic representation of *Metaphire anomala* Michaelsen A, Prostomium; B, Setae; C, Clitellum; D, Genital region; E, Prostate gland; Pr. D, Prostatic duct; Pr. G, Prostatic gland.

***Lampito mauritii* Kinberg (Fig.1.6)** Origin: Native of India
Body length: 60 mm - 150 mm
Body segments: 130 - 307 segments
Prostomium: Open epilobic
Setae: Many setae per segment (Perechitine arrangement)
Clitellum: Annular type, xiv - xvii segments.
Male pore: Male pore on xviii segment on slightly raised areas in body surface, large penial setae projected from each male pore
Female pore: Female pore paired in segment xiv
Genital markings: Absent

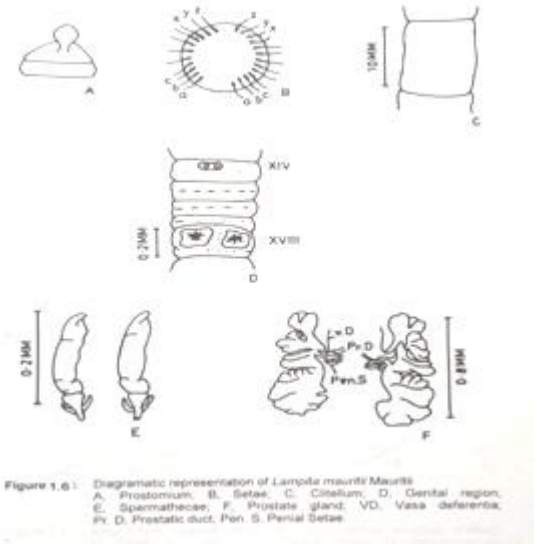


Figure 1.6: Diagramatic representation of *Lampito mauritii* Mauritii A, Prostomium; B, Setae; C, Clitellum; D, Genital region; E, Spermathecae; F, Prostate gland; VD, Vasa deferentia; Pr. D, Prostatic duct, Pen. S, Penial Setae.

Spermathecael: 3 pairs in inter segmental furrow vi / vii / viii / xix segment, each with bidiverticulate two diverticula arise from both side of median duct
Prostate gland: Racemose type one pair each with vasa deferentia, prostatic duct, penial setae present
Collection & Locality: D/02, Tasvir Mahal Aligarh; D/03, Jawahar National Horticulture Garden Aligarh; D/23, Kamalpur (Mango garden) Aligarh; D/24, Kamalpur (Waste land) Aligarh; D/33, Lal Qila Agra; D/34 Naripur Agra
Zone: Western plain, Mid region, South western semidry region
Date (s) of collection: 18 - 08 - 2008 to 16 - 10 - 2008
General habitat: Grassland (ungrazed), cultivated land, river bank, agriculture land, irrigation canal

***Polypheretima elongata* Kinberg (Fig.1.7)**

Origin: Exotic
Body length: 70 mm - 100 mm
Body segments: 106 - 128 segments
Prostomium: Rudimentary
Setae: More than 8 setae in per segment (Perechitine arrangement)
Clitellum: xiv - xvi segments, Annular type
Male pore: Male pore on xviii segment in pouch Female pore: Median single in xiv segment
Genital markings: Present in xix, xx, xxi segments in pair after male pore in body surface
Spermathecael: v / vi / vii intersegment, unidiverticulate
Prostate gland: Racemose type prostate gland with prostatic duct and vasa deferentia

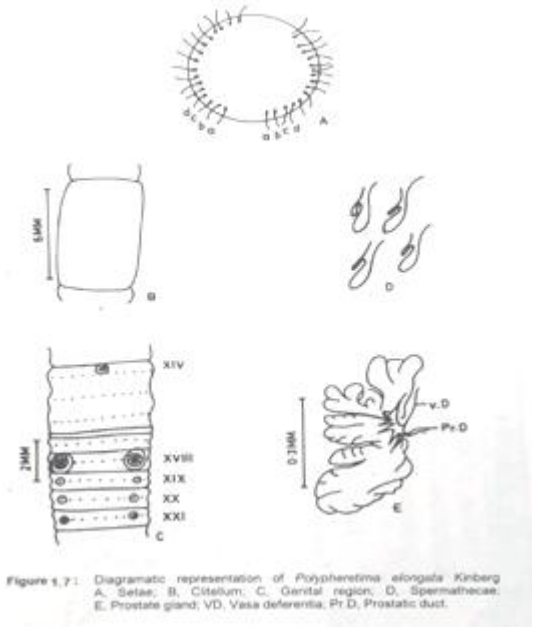


Figure 1.7: Diagramatic representation of *Polypheretima elongata* Kinberg A, Setae; B, Clitellum; C, Genital region; D, Spermathecae; E, Prostate gland; VD, Vasa deferentia; Pr.D, Prostatic duct.

Collection & Locality: D/04, Aligarh City School Baroli Nagla road, Aligarh
Zone: South western semidry region
Date (s) of collection: 18 - 08 - 2008
General habitat: Grazed grassland

4. Discussion

The texture of the soil has great influence in the distribution and population structure of earthworm. The soil collection site ranges from clayloam to slity clayloam from Grassland (ungrazed, grazed), mixed forest, river bank, dung heap and cultivated land.

Systematic exploration in the study area were undertaken in certain districts of Agra region of (U. P.). All earthworm specimens were preserved and processed customary way following Julka (1988). The specimens were provisionally identify in the laboratory and later confirmed at ZSI Kolkata in most of the cases.

45 field samples of the existing earthworm were collected and identified. The study has bought to light confirms the existence of 7 species of 2 families octochaetidae species *Eutyphoeus orientalis* Beddard, *Eutyphoeous waltoni* Michaelsen, *Eutyphoeus incommodus* Beddard Family Megascoecidae species *Metaphire posthuma* vaillant, *Mataphire anomola* Michaelsen, *Lampito mauritii* kingberg, *Polypheretima elongata kinbeeg*.

References

[1] Aiyer, K. S. P., 1929. An account of the Oligochaeta to Travancore. *Records of Indian Museum* 31: 13 - 76
[2] Beddard, F. E., 1902. On two new earthworms of the family Megascolecidae. Ann. Mag. Nat. Hist.9: 456 - 463
[3] Bhadauria, T. & Ramakrishnan, P. S., 1989. Earthworm populations dynamics and contribution to nutrient cycling during cropping and fallow phases of shifting agriculture (jhum) in north - east India. Journal of Applied Ecology 26: 505 - 520.
[4] Bhadauria, T., Ramakrishnan, P. S. & Srivastava, K. N., 2000. Diversity and distribution of endemic and exotic earthworms in natural and regeneration ecosystems in the central Himalaya, India. Soil Biol. Biochem 32: 2045 - 2054.
[5] Bhat, J. V., Khambata, S. R. Maya, G. B., Sastry, C. A. . Iyer, R. V., 1960. Effect of earthworms on microflora of the soil. Indian J. Agricultural Science 30: 106 - 114.
[6] Biswas, T. D. and Narayanswami, G., 1998. 'Soil Organic Matter and Organic Residue Management for Sustainable Productivity', Indian Soc. Sci. New Delhi, India, p.164.
[7] Black, W. M. and Neely, D., 1975. Effect of soil injected benomyl on resident earthworm populations. Pestic Sci.6: 543 - 545.
[8] Dutt, A. K., 1948. Earthworm and soil aggregation. J. Am. Soc. Agron.40: 407 - 408.
[9] Gates, G. E., 1937. Indian earthworm: the genus *pheritima*. Records fo Indiam Museum 39: 175 - 212.
[10] Gates, G. E., 1972. Burmese earthworms: An introduction of systemetic and biology of Megadrile Oligochaetes with special reference to Southeast Asia. Trans. Am. Phil. Sos.62 (7): 1 - 326.
[11] Herse, P. R., 1971. A Text book of soil chemical analysis. John Murray, London.
[12] Jackson, M. L., 1967. Soil chemical analysis. Prentice Hall of India (Pvt. Ltd.), New Delhi, pp.205.
[13] Jamieson, B. G. M., 1978. Phycogenetic and phonetic systematic of the opisthoporous Oligochaeta (Annelida: Clitellata). Evolut. Theory 3: 195 - 233.
[14] Joshi, R. C., Matchoc, O. R., Cabigat, J. C. A James, S. W., 2000. Survey of the earthworms in the lfugao rice terraces. Philippines. Journal of Environmental Science and Management 2 (2): 1 - 12.
[15] Julka, J. M., 1976a. Studies on earthworms collection during the Daphabum expedition in Arunachal Pradesh, India. *Record of Zoological Survey of India* 69: 229 - 239.
[16] Julka, J. M., 1976b. Studies on earthworms fauna of Orissa (India); Moniligastocidae and Ocnerodrilidae. Mitt Zool. Mus. Berlin 52: 321 - 329.
[17] Julka, J. M., 1978. Studies on earthworms fauna of Orissa (India); Moniligastocidae and Ocnerodrilidae. Mitt Zool. Mus. Berlin 54: 185 - 197.
[18] Julka, J. M., 1981. Texonomic studies on earthworms collection during the Subansiri expedition in Arunachal Pradesh, India. *Record of Zoological Survey of India* 26: 1 - 37.
[19] Julka, J. M., 1983. A new genus and species of earthworm (Octochaetidae: Oligochaeta) from south India. *Geobios New reports* 2: 48 - 50.
[20] Julka, J. M., 1988. The fauna of India and the adjacent countries. Magadrille: Octochaetidae Haplotaxida, Lumbricina: Megascolecidae: Octochaetidae XIV. . *Record of Zoological Survey of India* pp.400.
[21] Julka, J. M., Paliwal, R., 1993. Distribution pattern in Indian earthworms In: Earthworm Resources and Vermiulture. *Zoological Survey of India* pp.27 - 31.
[22] Julka, J. M., Paliwal, R., 2005. Annelida: Oligochaeta in fauna of westurn Himalaya. *Record of Zoological Survey of India* pp.53 - 90.
[23] Khambata, S. R. and Bhatt, J. V., 1957. A contribution to the study at intestinal microflora and Indian earthworms. *Arch. Mikrobiol*.38: 69 - 80.
[24] Michaelsen, W., 1907. New Oligochaten von vorder Indian, Ceylon, Burma and the Andaman Islands. Man. Indian Mus.1: 103 - 253.
[25] Michaelsen, W., 1910a. Oligochaten von den Aru and Kei - Inseln. Abhandlungen, herausgegeben von der *Senkenbergischen naturforschenden Gesellschaft*.33: 251 - 261.
[26] Nijhawan, S. D., Kanwar, D. S., 1952. Physicochemical properties of earthworm casting and their effect on the productivity of the soil. Indian J. Agril. Sci.22: 357 - 373.
[27] Perrier, E., 1872. Recherches pour Servir a1' histofie des Lombriciens terrestres. Nouv. Arehs. Mus. Hist. Nat. Peris 8: 5 - 198.
[28] Reynolds, J. w., Cook, D. G., 1976. Nomenclature Oligochaetologia: A catalogue of the names, descriptions and type specimens of the Oligochaeta. The University of New Brunswick, Fredericton, p.217.
[29] Sanathanam, R., Velaycitham, P. and Jegatheesam, 1989. A manual of fresh water Ecology, Daya Publishing House, Delhi, p.134.
[30] Senapati, B. K., Julka, J. M., Dash, M. C., 1990. New species of earthworm Lennogaster Gatu (Octochaetidae: Oligochaeta) from India, *Rev. Ecol. Biol. Soil.27*: 467 - 470.
[31] Sinha, B., Bhadauria, T., Ramakrishnan, K. G., Saxena, T., Makhuri, R. K., 2003. Impact of landscape modification of earthworm density and abundance in the Hariyal Sacred landscape Garhwal Himalaya *Pedobiologia* 47: 357 - 370.
[32] Stephenson, J., 1914. On a collection of Oligochaeta mainly from Northern India. *Records of Museum* 10: 321 - 365.
[33] Stephenson, J., 1915. On some Oligochaeta, mainly from Southern India and Ceylon. *Records of Museum* 6: 35 - 108.
[34] Stephenson, J., 1917. On a collection of Oligochaeta from various parts of India.
[35] *Records of Museum* 13: 353 - 416.

[36] Stephenson, J., 1923. Oligochaeta: The Fauna of British India, including Ceylon and Burma, Taylor and Francis Limited, London.
[37] Templeton, R., 1844. Description of Megascolex caeruleus. Proceeding of Zoological Society London 12: 89 - 91.
[38] Verma, D., Shweta, 2011. Earthworm resources of western Himalayan region, India. Int. J. Soil Sci.6: 124 - 133.
[39] Verma, D., Bharti, S., Yadav, S., 2010. Earthworm resources in Gangetic plains of India. International Journal of Biodiversity and Conservation 2: 134 - 139.