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# PRELIMINARY STATUS OF NATIVE EARTHWORMS IN JOTSOMA VILLAGE OF KOHIMA DISTRICT

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**KEYWORDS**
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## ABSTRACT

The present study was carried out to examine the distribution of native earthworms around Jotsoma village , Kohima. The survey was performed from September 2021-April 2022 in four study Sites *viz* Grassland, Vegetable garden, Reserved Forest and Residential area. Soil temperature and pH of the soil were recorded from the sampling sites. Based on their habitat and important morphological characters such as colour, length, presence of the clitellum and their behaviour, five genera and three families of earthworms were represented among 9 species found at the study sites.The three families recorded were; Megascolecidae, Moniligastridae and Octochaetidae. Among the 9 species, 7 species were classified under the family Megascolecidae and a single species each represented family Moniligastridae and Octochaetidae respectively. This study showed that Family Megascolecidae was more abundant amongst the three recorded families. The species recorded were: *Perionyx excavatus, Perionyx* sp. 1*, Perionyx* sp. 2*, Metaphire houlleti, Metaphire* sp. 1*, Amynthas corticis, Amynthas* sp. 1*, Drawida* sp. and *Eutyphoeus* sp. Genus *Perionyx* was found to be the dominant species while genus *Drawida* and *Eutyphoeus* exhibited the least count.

## INTRODUCTION

Earthworms are soil macro-invertebrates that play an important role in maintaining soil fertility by cycling of nutrients and decomposition of Organic matter (Ansari *et al.*, 2011 & Domìnguez *et al.*, 2011). According to Debbarma and Chaudhuri (2019), earthworms play an important role in the decomposition of organic matter, nutrient cycle and enhanced the availability of plant nutrients for plant growth. They account for approximately 80% of the total soil invertebrate biomass (Lavelle and Spain, 2001). Earthworms are grouped into two earthworms: megadriles which are terrestrial worms and microdriles which are aquatic worms (Kumar *et al.*, 2018). The Oligochaeta class consists of 36 families,with about two-thirds of them being aquatic Oligochaeta and the remaining families consist of terrestrial earthworms (Bohlen *et al.*, 2004).

Based on morphological features such as clitellum, prostomium and setae etc. the earthworms can be taxonomically classified (Bouchè, 1977).

Terrestrial earthworms are categorized on the basis of their location in soil layers based on some specific characters: Epigeic, endogeic and anaemic earthworms (Kumar *et al.*, 2018). Narayanan et al. (2021) accounted 8 families ,representing 81 species and subspecies of earthworms belonging to 21 genera from Sri Lanka. Garg and Julka (2017) recorded a total of 14 species spanning across all land use categories in Yamuna Nagar. Haryana. Kumar et al. (2018) recorded a totality of 14 species of earthworms which belongs to four families in Karnataka state. Goswami (2018) collected 10 species from Satkoshia-Baisapalli Wildlife Sanctuary in Odisha, India. Ahmed and Julka (2021) reported 47 species belongs to 23 genera and 6 families in Himachal Pradesh which constitute about 11% of the total country fauna. Debbarma and Chaudhuri (2019) also reported 11 earthworm species in the pasture ecosystems of Tripura. Chakraborty *et al.* (2023) reported a total of 125 species from 10 families and 28 genera which were obtained from various land use patterns in the North East region, India. Miglani *et al.*(2022) recorded 52 species which represented 20 genera and 8 families in Uttarakhand,India. Lalthanzara *et al.* (2020) did a work on diversity of earthworms in Arunachal Pradesh and listed 12 earthworm species and four families. Jing *et al* (2022) documented 12 earthworm species at Minkong forest Mokokchung, Nagaland,India. Thyug and Kakati (2018) also listed seven species of earthworms which belongs to three families from the subtropical hilly forest of Mokokchung District, Nagaland. But till date, there has been no report of earthworms from Kohima district.

## METHODOLOGY

### Study area and Sites:

The study was conducted at Phezhu locality of jotsoma village which is located 7 km towards west from district headquarter Kohima. The geographical coordinates of Jotsoma village is 25.673°N latitude 94.0632°E longitude. The total geographical area of the Jotsoma village is 6400 Hectares. The village altitude is of about 1300-3048 meters and falls under the Barail mountain range.

### CLIMATIC CONDITIONS

The region has cool winters which start from December to February with a maximum temperature of about 20°C, and a minimum temperature below 10°. In summer the village witnesses sub-tropical climate. The summer average temperatures is between 20°C-25°C, while the Minimum temperature settles between 12°C and 16°C. In the monsoon season the Village experiences heavy to very heavy rainfall accounting to 1400 mm annualy.

**COLLECTION OF EARTHWORMS**

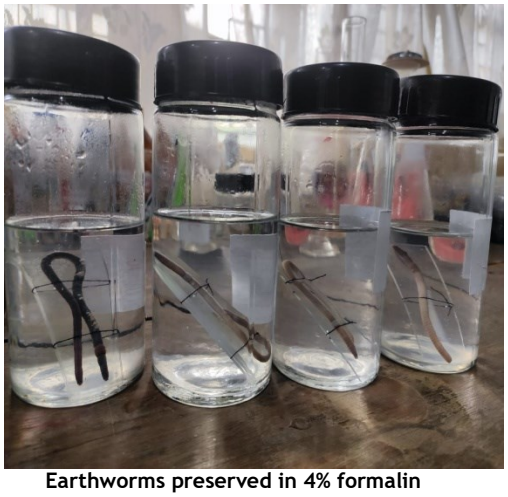
Four sites were selected after preliminary survey viz. Site 1 (Grassland) Site 2 (Vegetable garden) Site 3 (Reserve Forest) and Site 4 (Residential area). The earthworm samples were collected through digging and hand sorting method (Julka, 1988). Soil temperature and pH of the soil were recorded from the sampling site. The habitat of the earthworm and their morphological characters such as colour, length, presence of the clitellum and their behavior were noted down. The specimens were identified with the help of monocular compound microscope by following all standard methods of cleansing and preservation (Goswami,2018) (Saikia *et al.*,2021)

**Fig 1: Study Site 1 (Grassland)**

**Fig 2: Study Site 2 (Vegetable garden)**

**Fig 3: Study site 3 (Reserve Forest)**

**Fig 4: Study site 4 (Residential area)**



**Earthworms preserved in 4% formalin**

**Monocular compound microscope**

**PHOTO GALLERY**

**FAMILY: MEGASCOLECIDAE**

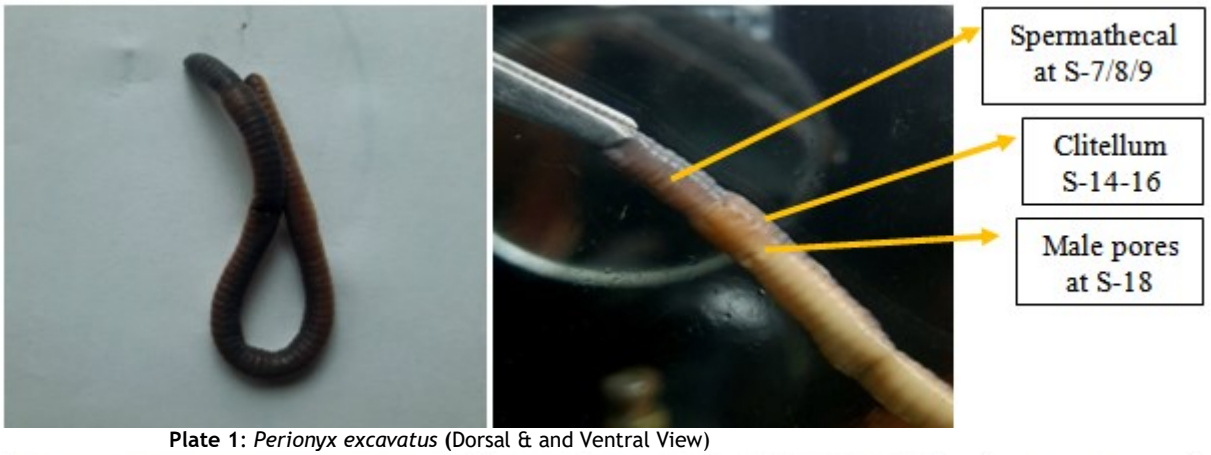



**Plate 1**: *Perionyx excavatus* **(**Dorsal & and Ventral View)

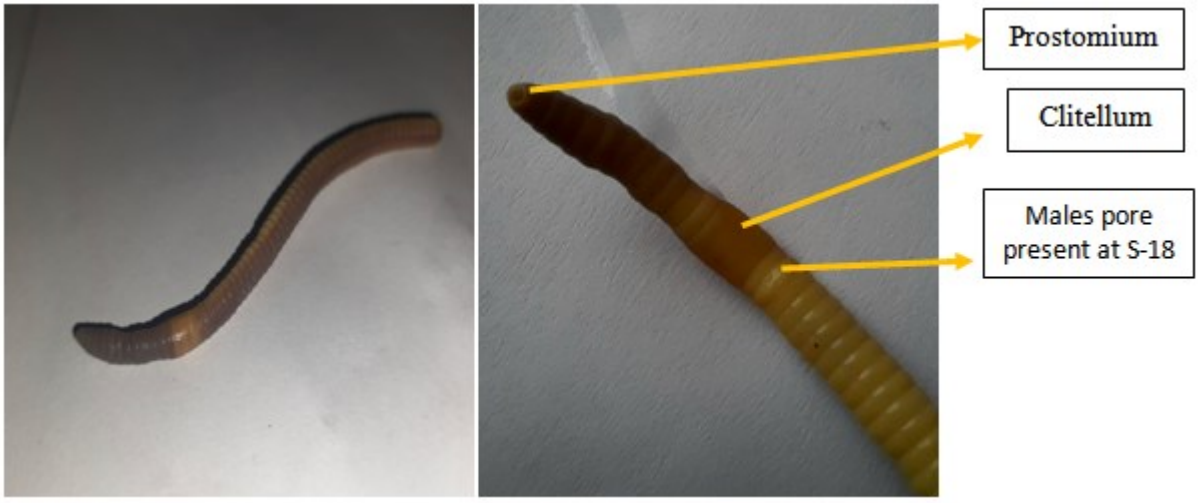



**Plate 2** *: Perionyx* sp *1.* (Dorsal & Ventral View)

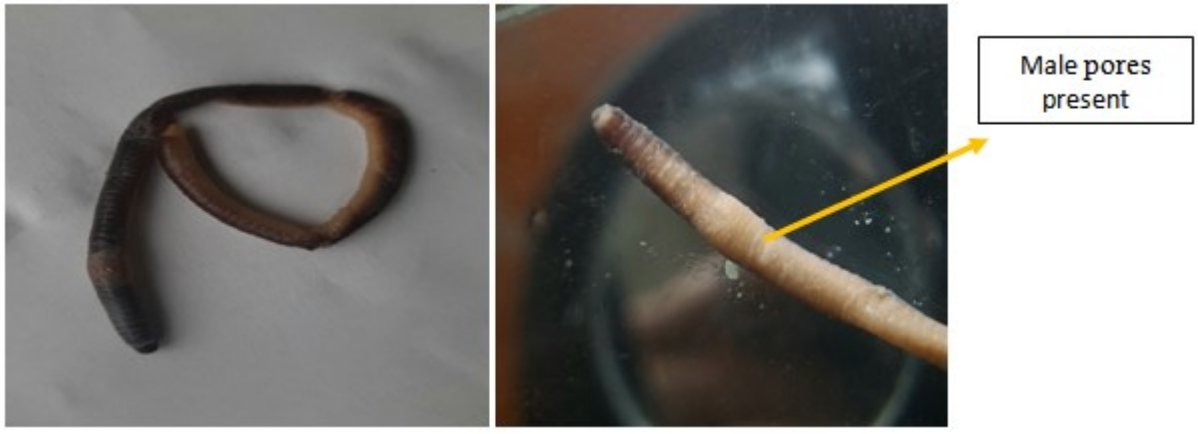



**Plate 3:** *Perionyx* sp *2* **(**Dorsal & Ventral View)

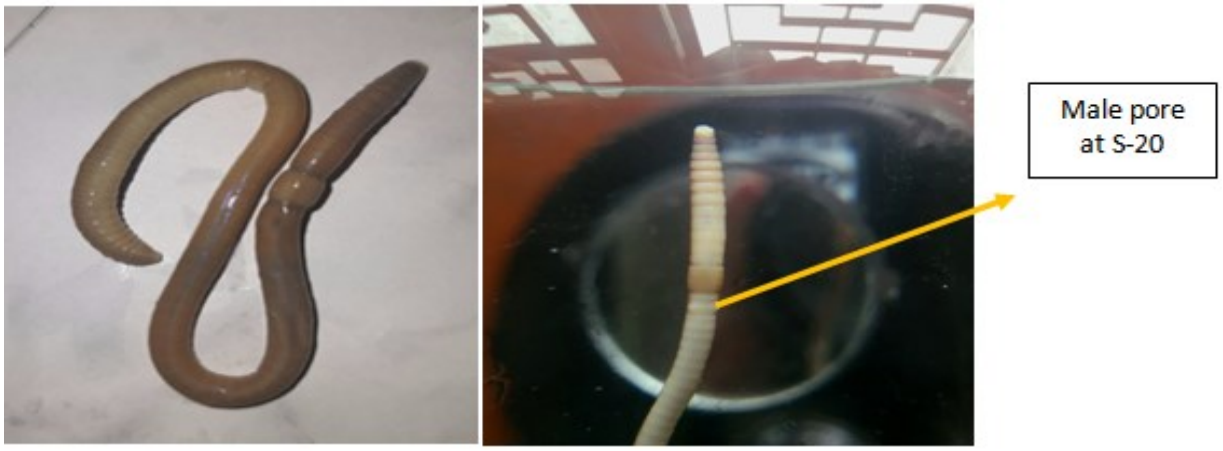



**Plate 4 (a):** *Metaphire houlleti* (Dorsal & Ventral view)

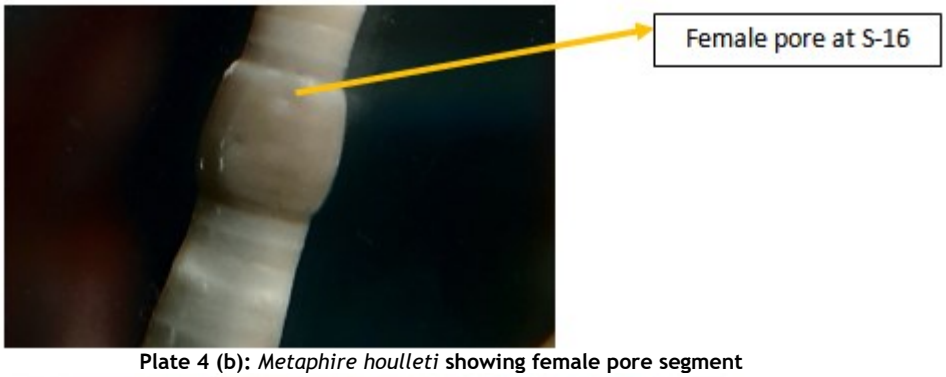



**Plate 4 (b): *Metaphire houlleti* showing female pore segment**

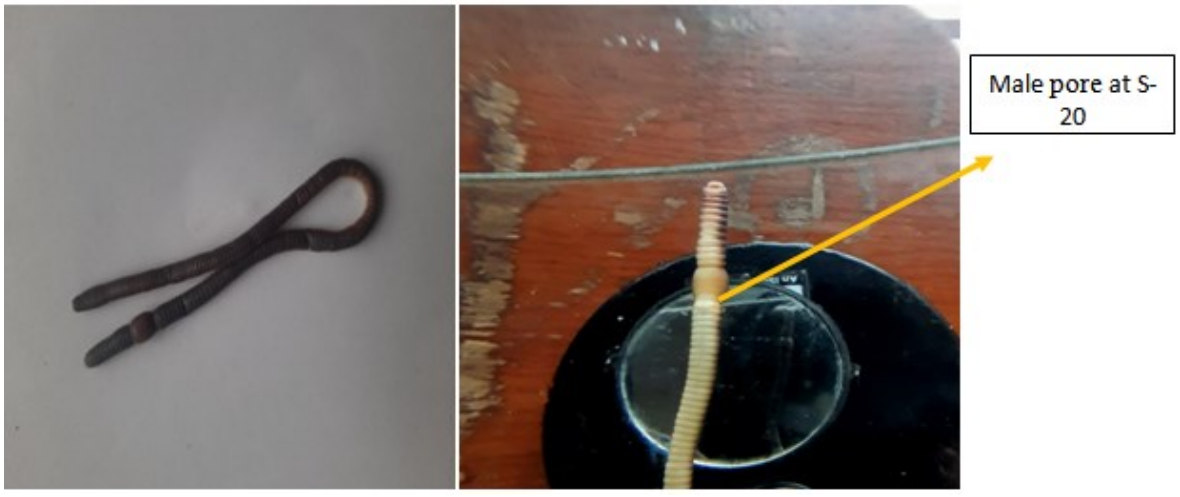



**Plate 5***: Metaphire* sp *1* (Dorsal & ventral view)

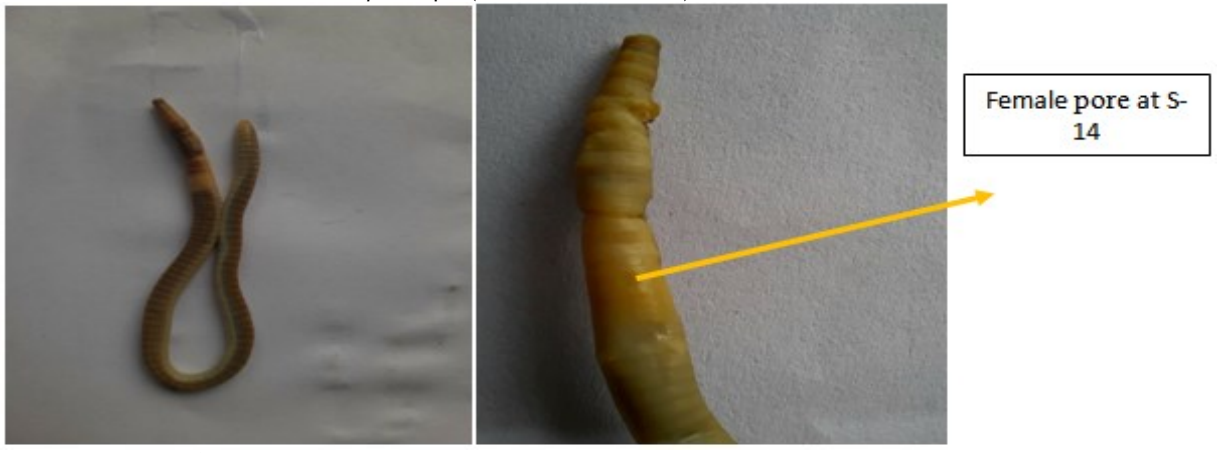



**Plate 6:** *Amynthas corticis* (Dorsal & Ventral view)

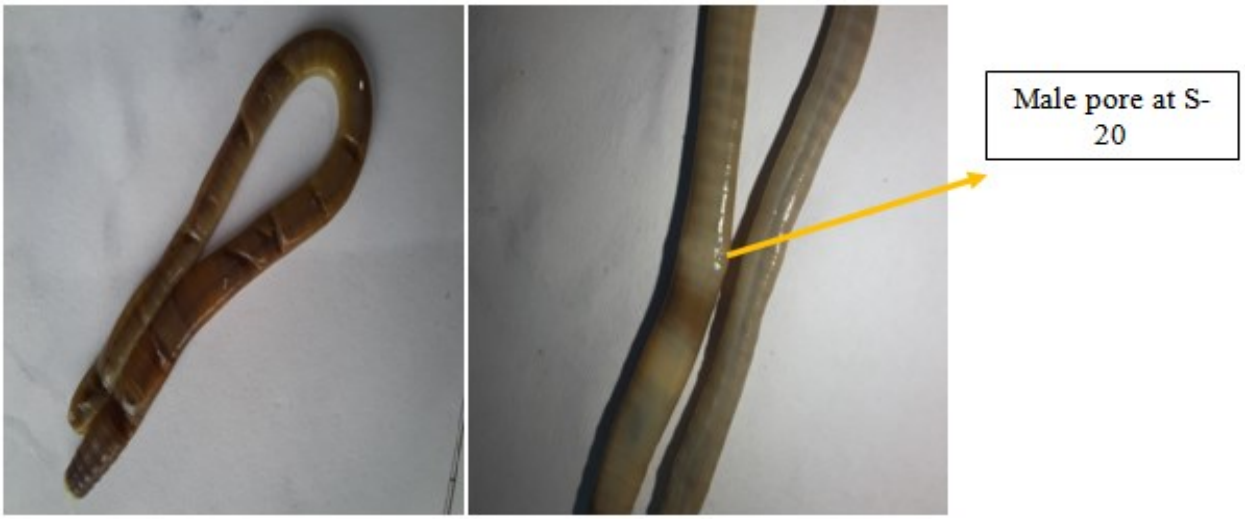



**Plate 7:** *Amynthas* sp *1* (Dorsal & ventral view)

**FAMILY MONILIGASTRIDAE**

**Plate 8:** *Drawida* sp (Dorsal & ventral view)

**FAMILY OCTOCHAETIDAE**


**Plate 9:** *Eutyphoeus sp* (Dorsal & Ventral view)

**RESULTS AND DISCUSSION**

A Total of 9 types of earthworms belonging to 5 genus and three families viz Megascolecidae, Moniligastridae, Octochaetidae, were collected and identified; *Amynthas corticis, Amynthas sp1, Drawida sp, Eutyphoeus sp , Metaphire houlleti ,Metaphire sp* 1, *Perionyx excavatus ,Perionyx* sp1, *Perionyx sp* 2. The earthworms were collected from the four sampling sites.

**Table-1:**

| FAMILY 1: MEGASCOLECIDAE | | | |
|---|---|---|---|
| **Species** | **Ecological habitat** | **Diagnosis** | **Distribution** |
| **1.** .*Perionyx excavatus* (Perrier, 1872) **(Plate-1)** | They are epigeic earthworm. it was found in vegetable garden in the month of October. | They are small to medium size, active, high level of pigmentation, clitellum present in 14-16 segments, male pores present in 18 segments, spermathecal pores paired in 7/8/9 segment. Body length 11.2 cm, genital markings absent (Julka and Senapati, 1987). | Uttar Pradesh, Orissa, Assam, Arunachal Pradesh, W.Bengal, Himachal Pradesh, Maharastra, Andaman & Nicobar Islands. Widely transported, successful colonization restricted to tropical lowlands from Madagascar east to the Hawaiian Islands (Julka and Senapati, 1987). |
| **2.***Perionyx* sp *1*(Perrier, 1872) **(Plate-2)** | They are epigeic and were collected in the month of September. | Body length 7.2cm, male pores present at 18 segments. Dark brownish in color in the dorsal side(Julka and Senapati, 1987). | India, Burma, possibly Sri Lanka and Malaysia (Julka and Senapati, 1987). |
| **3.** *Perionyx* sp *2* **(Plate-3)** | It was collected from reserved forest in the month of October. | Body length 10.1 cm, male pores present at 18 segments, Genital markings absent (Julka and Senapati, 1987). | India, Burma, possibly Sri Lanka and Malaysia (Julka and Senapati,1987). |
| **4.** *Metaphire houlleti* (Perrier, 1872) **(Plate-4)** | It was collected from the grassland and vegetable garden during September and October respectively. They are epigeic earthworms. | Body length 13.9cm, Clitellum well developed, prominent, pouch like. Female pore single on 16 segment on the clitellum. Segements 6-9 exhibit paired spermathecal pores,male pore present on the 20 segment, segments constitutes about 95–100, the dorsal region has a brownish appearance, external genital absent (Goswami,2018) | India, Australia, Bahamas, Bangladesh, Caroline Islands, China, Cuba, Fiji, France, French Guiana, Indonesia, Madagascar, Malay Peninsula, Myanmar, Nepal, Pakistan, Philippines, Salvador, Sierra Leone, Singapore, Sri Lanka, Thailand,USA (Florida), Vietnam. Type locality: Kolkata,West Bengal,India (Goswami,2018). |
| **5.** *Metaphire* sp *1* (Sims and Easton, 1972) **(Plate 5)** | It was found in grassland and was collected in the month of October. | Body length 14.1 cm, male pores at 20 segments, well defined pouch, female pore absent.(Julka and Senapati,1987). | Oriental region from Japan southwards through the Indo-Australasian archipelago to the rain forests of Australasia through Oceania (Julka and Senapati, 1987). |
| **6.***Amynthas corticis* (Kinberg, 1867) **(Plate -6)** | It was found in the residential areas and was collected in the month of April. | Body length 11.1cm, annular clitellum in 14-16, body segments more prominent, body brownish in colour, the pairing of Spermathecal pores is observed in segments 5/6-8/9. Single female pore is present at 14 segment, paired male pores present at 18 segment(Lalthanzara *et al.*,2020).Septa 5/6 - 7/8, thickened in 10/11 - 13/14 aseptum on 8/9/10 (Julka and Senapati, 1987). | India, ArunachalPradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Karnataka, Manipur, Meghalaya, Mizoram, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal. Elsewhere: Argentina, Australia, Bangladesh, Bhutan, Bolivia, Brazil, China, Colombia, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Indonesia, Jamaica, Japan, Korea, Madagascar, Mexico, Myanmar, Nepal, New Zealand, Pakistan, Panama, Papua New Guinea, Peru, South Africa, Taiwan United Kingdom and Venezuela (Ahmed and Julka, 2021). |
| **7.** *Amynthas* sp *1* **(Plate 7)** | They are epigeic earthworms, found in garden and residential areas. It was collected in the month of April. | Body length 11.2 cm, male pore present after a segment of the clitellum in S- 20, clitellum in the segment between 14 – 18.Minute setae are evenly distributed around each segment,without any pairing or concentration on specific body regions, female pore not found (Julka and Senapati, 1987). | India: Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Karnataka, Manipur, Meghalaya, Mizoram, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal. Elsewhere: Argentina, Australia, Bangladesh, Bhutan, Bolivia, Brazil, China (Ahmed and Julka, 2021). |

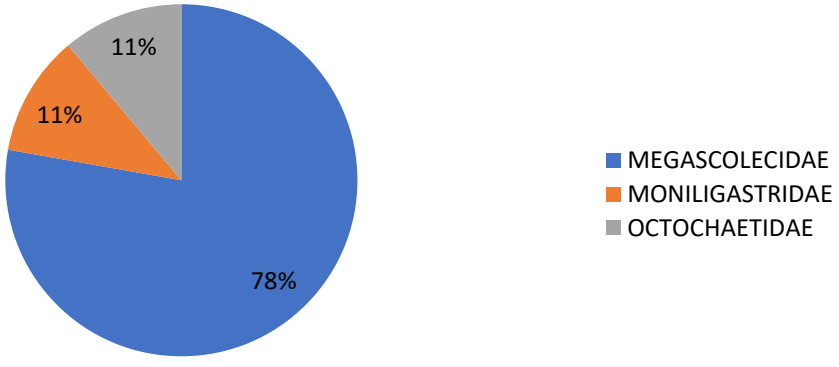
| | | | |
|---|---|---|---|
| **FAMILY 2: MONILIGASTRIDAE** | | | |
| **8.** *Drawida sp* (Michaelsen 1900) **(Plate 8)** | They are Anecic earthworms and was collected from Reserved Forest in the month of October. | Paired male pores located near segment a 10/11; female pores are paired in the region 11/12 segment; segment 7/8 features paired spermathecal pores paired. Septa all present from 4/5, 5/6-9/10(Julka and Senapati, 1987). | India, Nepal, Burma, Malay Peninsula, Thailand, Indo-China, China, Korea, Manchuria, Siberia, Japan, Philippine(Julka and Senapati,1987). |
| **FAMILY 3: OCTOCHAETIDAE** | | | |
| **9.***Eutyphoeus sp (*Michaelsen 1900) **(Plate 9)** | They are endogeic and were found in vegetable garden in the month of October. | Body length 19 cm, Body colourless & transparent. Male pores paired in S-24/25, very prominent male pores and spermathecal pores present in S-9\10. (Julka and Senapati, 1987). | India (from Burma border to the Gangetic plain and west through the Himalayas), Burma, Bangladesh, Nepal (Julka and Senapati, 1987). |

**Table-2: Distribution of earthworms in four different Sites**

| Sl. No. | Name of the Species | Site - 1 (Grassland) | Site - 2 (Vegetable garden) | Site - 3 (Reserved Forest) | Site- 4 ( Residential area) |
|---|---|---|---|---|---|
| 1 | *Perionyx excavatus* | - | + | - | - |
| 2 | *Perionyx* sp 1 | + | - | - | - |
| 3 | *Perionyx* sp2 | - | - | + | - |
| 4 | *Metaphire houlleti* | + | + | - | - |
| 5 | *Metaphire* sp1 | + | - | - | - |
| 6 | *Amynthas corticis* | - | - | - | + |
| 7. | *Amynthas* sp1 | - | - | - | + |
| 8. | *Drawida* sp | - | - | + | - |
| 9. | *Eutyphoeus* sp | - | + | - | - |

**Table-3: Soil parameters**

| Study sites | Soil pH | Soil temperature ◦c |
|---|---|---|
| **Grassland** | 6.4 | 26.3 |
| **Vegetable garden** | 5.5 | 21.6 |
| **Reserved Forest** | 5.6 | 23.5 |
| **Residential area** | 5.4 | 25.3 |




**Pie Chart I: Observed Percentage of Earthworms under different family**

## DISCUSSION

During the course of study, 9 species of Earthworms belonging to 5 genera (*Perionyx, Metaphire, Amynthas, Drawida, and Eutyphoeus*) and 3 families' *viz*. Megascolecidae, Moniligastridae and Octochaetidae were recorded in the study area (**Table 1**). The family Megascolecidae exhibited the maximum number with 7 species, and constituted 78 % of the earthworms collected whereas family Moniligastridae and Octochaetidae showed minimum record with 1 species each, both constituting 11 % each respectively (**Pie-chart I**). Among the epigeic earthworms collected *Metaphire houlleti* was the most dominant and was found in two sampling sites (**Table 2**). Soil pH and temperatures were recorded in all the study sites (**Table 3**). In site-1, the average soil temperature was highest with 26.3 °C while it was lowest in site-2 with 21.6 °C. Site-3 with 5.6 had the most acidic soil while site-1 and 4 with a pH of 5.4 was the least acidic. However, all the parameters were within the tolerable limits of earthworms.

Julka (1993) recorded 509 species belonging to 67 genera and 10 families from Indian subcontinent, denoting a wide spectrum of variation in the region. Thyug and Kakati (2018) also did similar works on earthworm distribution in Mokokchung and found 7 earthworm species belonging to three families i.e. Megascolecidae, Moniligastridae & Octochaetidae. The present work finds similarity in the earthworm distribution in the three families. Narayanan et al. (2021) in their recent study of earthworms in Sri Lanka recorded that 83% of the species belongs to Megascolecidae family representing 67 species and the remaining families recorded only very few species. Jing et al (2022) also recorded 12 earthworm species from mokokchung district in Nagaland. Saikia ,Chutia and Sarmah (2021) also reported 8 species from different location of Golaghat in Assam. Kumar et al. (2018) in Udupi district, Karnataka, recorded fourteen species of earthworms which belongs to four families, viz., Rhinodrilidae (*Pontoscolex corethrurus*); Megascolecidae (*Lampito mauritii, Megascolex konkanensis, Metaphire houlleti, Metaphire peguana, Perionyx excavatus*); Moniligastridae (*Drawida ampullacea, Drawida kanarensis and Drawida sulcata*) and Octochaetidae (*Dichogaster bolaui, Hoplochaetella karnatakensis, Karmiella karnatakensis, Mallehulla indica, Octochaetona beatrix*) indicating that the family Megascolecidae and Octochaetidae were the dominant family in the selected habitats. Julka and Ahmed (2021) reported 46 species/subspecies in Himachal Pradesh which belongs to 23 genera under six families viz. Moniligastridae, Lumbricidae, Ocnerodrilidae, Acanthodrilidae, Octochaetidae and Megascolecidae.

The distribution of the earthworms highly depends on the soil fertility, temperature, soil parameters, availability of food and other environmental factors. Soil properties are impacted by a range of physiochemical factors,including: pH, electrical conductivity, organic carbon and organic matter, nutrient levels ,C: N ratio, greatly influenced earthworm habitat (Mariappan, *et al.*, 2013). Sharma and Bhardwaj (2014) indicated that microclimatic factors and anthropogenic activities influence the earthworm diversity.

Among the four sampling sites, Site-4 (Residential area) showed more variety of earthworm presence with 6 earthworms. While Site -2, 1 and 3, collected 5, 4 and 3 earthworm species respectively. Earthworms are distributed unevenly (Singh et al., 2016), their distribution tends to vary according to the surface soil type (Curry, 1998) and environmental factors, particularly soil-related conditions such as moisture and temperature, play a crucial role in ecological aspects (Kaleemurrahman and Ismail, 1981; Lalthanzara and Ramanujam, 2014), soil nutrients and rainfall patterns (Fragoso and Lavelle, 1995) and land-use systems (Chauhan *et al.*, 2015).Changes to natural systems can alter the soil environment, making it less conducive to earthworm habitation (Chauhan, 2014). Earthworms typically prefer soils with temperatures within 10-35°C, moisture of 12-34%, pH of about 7 and C:N ratio 2-18 (Edward and Lofty1977), (Lee,1985) (Kale,1981). The soil temperature plays an important role in maintaining earthworm population (Senapati and Dash, 1984). The distribution and occurrence of earthworms are largely influenced by soil moisture levels, (Bahadauria and Ramakrishnan, 1991; Gonzalex *et al.,* 1996). The distribution pattern in the present study may also have been influenced by the same parameters.

## CONCLUSION

The present study was conducted from September, 2021 to April, 2022 in four different sampling sites. A total of 9 species viz. *Perionyx excavatus, Perionyx sp 1, Perionyx sp 2, Metaphire houlleti, Metaphire sp 1, Amynthas corticis, Amynthas sp 1, Drawida sp, Eutyphoeus sp.* belonging to 4 genera and 3 families viz. Megascolecidae, Moniligastridae, Octochaetidae were recorded from the study sites. Genus *Perionyx* exhibited maximum presence and genus *Drawida* and Eutyphoeus had minimum distribution. This study indicates that epigeic earthworms are more widely distributed with 7 species.

## REFERENCES


- **1.Ahmed, S. and Julka, J.M. (2021).** Annelida: Clitellata: Megadrili (Earthworms). *Zoological Survey India* 26: 57-70.
- **2.Ansari, A.A. and Saywack P. (2011).** Identification and classification of Earthworm Species in Guyana. *International Journal of Zoological Research* 7 (1):93-99.
- **3.Bhadauria, T. and Ramakrishnan, P.S. 1991.** Population dynamics of earthworms and their activity in forest ecosystems of North East India. *J. Trop. Ecol.*, 7: 305â€“318.
- **4.Bohlen, P.J., Groffman, P.M., Fahey, T.J. and Fisk, M.C. (2004)**. Influence of earthworm invasion on redistribution and retention of soil carbon and nitrogen in northern temperate forest Ecosystem, *Springer link*, 7: 13 -27.
- **5.Bouchè, M.B. Strategies lombriciennes. In: U. Lohm and T. Persson (eds.) (1997).** Soil organisms as components of Ecosystems. *Ecological Bulletins* (Stockholm), 25: 122-132.
- **6.Chakraborty, S., Debbarma, B., Chaudhuri, P. (2023)**. Ecology and diversity of earthworms in different land use systems of northeast India: A review. *Asian Journal of Conservation Biology* 12(2):268-287.
- **7.Chauhan, R.P., Pande, K.R., Shah, S.C. and Dhakal, D.D. (2015).** Soil properties and earthworm dynamics affected by land use systems in Western Chitwan, Nepal. J. Inst. Agri. Anim. Sci., 33, 123-128.
- **8.Chauhan, R.P. (2014).** Role of Earthworms in Soil Fertility and Factors Affecting their Population Dynamics*: A Review.International Journal of Research* ,1:642-649.
- **9.Curry, J.P.: Factors affecting earthworm abundance in soils (1998)**. In: *Earthworm Ecology* (Ed.: C.A. Edwards). St. Lucie Press, Boca Raton, Florida, pp. 37-64.
- **10.Debbarma, B., and Chaudhuri, P. (2019).** Earthworm Communities under Pasture Ecosystems in Tripura, India. *International Journal of Ecology and Environmental Sciences* 45 (2): 179-190.
- **11.Dominguez, J. and Edwards, C.A. (2011)**. Biology and ecology of earthworm species used for vermicomposting. Pages 249-261. In: Edwards, C.A.; Arancon, N.Q. and Sherman, R. (Editors) Vermiculture Technology. CRC Press, Boca Raton, Florida.
- **12.Edward,C.A., and Lofty, J.R. (1977)**.Biology of Earthworm(2)
- **13.Fragoso, C., James, S.W. and S. Bonges (1995).** Native Earthworms of the Neotropical regions: current status controversies. In: Hendrix, P.F. (Ed.), Earthworm Ecology and Biogeography. *Lewis publishers*, Boca Raton, USA, PP. 67-115.
- **14.Fragoso,C. and Lavelle,P.(1995)**.Are Earthworms important in the decomposition of tropical litter?.Soil organiser and litter decomposition in tropics.Oxford & IBH Publishing Co. New Delhi.103-112.

- **15.Garg, N. and Julka, J.M. (2017).** Biodiversity of Earthworms in Trans-Gangetic Plains of District Yamuna Nagar, Haryana. *Voyager*: Vol. VIII, No. 2, Dec 2017, pp.124- 132.
- **16.González G, Zou X, Borges, S. (1996)** Earthworm abundance and species composition in abandoned tropical croplands: comparison of tree plantations and secondary forests. *Pedobiologia* 40:385–391
- **17.Goswami, R., (2018**). New records of earthworm fauna (Oligochaeta: Glossoscolecidae and Megascolecidae) collected from Satkoshia-Baisapalli Wildlife Sanctuary of Odisha, India. *Journal of Threatened Taxa* 10(9): 12230–12234.
- **18.Jing, L., Mozhui, L., Kakati, L.N. and Thyug, L. (2022)**: Earthworm community structure and population dynamics at Minkong forest of Mokokchung, Nagaland, India. *J. Environ. Biol.*, **43**, 810-817.
- **19.Joshi, N. and S. Aga (2009).** Diversity and distribution of earthworms in a subtropical forest ecosystem in Uttarakhand, India. *Research gate* 9(1):21–25.
- **20.Julka, J.M. (1976).** Studies on the earthworms collected during the Daphabum expedition in Arunachal Pradesh, India. *Record Zoological Survey*. India 69, 229-239
- **21.Julka, J. M. (1993).** Distribution pattern in Indian earthworms. In: Earthworm Resources and Vermiculture, Zoological Survey of India, Calcutta, pp. 27-31
- **22.Kaleemurrahman, M. and Ismail, S.A.: Earthworm (1981).** An index of the physical nature of the soil. In: Progress in Soil biology and Ecology in India (Ed.: Veeresh, GK) *Univ. Agri. Sci.*, Bangalore, pp. 60-63
- **23.Krishnamoorthy, R.V., and Ramachandra, S.(1988)**: Population structure of earthworms in woodlands of Karnataka. *Proc. Indian Acad. Sci. (Anim. Sci)*, 97,355-362.
- **24.Kumar, H., Kanale, T.S., Sreepada, S., Narayanan, S. P., Reynolds, J.W. (2018).** Megadrile Earthworms (Annelida: Oligochaeta) around Udupi power Corporation limited (UPCL), Udupi district, Karnataka, South- West Coast of India. *Research gate*, 23 (5) 80-91
- **25.Kumar, S., Stecher, G. Li, M., Knyaz, C. and Tamura, K. (2018)** MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. *Mol. Biol. Evol.*, 35, 1547-1549. **26.Lalthanzara, H., and Zodinpuii, B.(2021).** Earthworm population dynamics in traditional slash and burn cultivation in Mizoram, Northeast, India. *Journal of Environmental Biology*,42(1),128-134.
- **27.Lalthanzara, H., Zothansanga, C., Lalchhanhima, M., Kumar, N.S., Ngukir, J., Kimsing, A. and Vabeiryureilai, M. (2020).** Diversity and New Records of Earthworms in Arunachal Pradesh, Northeast India. *Journal of Environmental Biology* ,41, 874-883.
- **28.Lalthanzara, H. and Ramanujam, S.N. (2014).** Earthworm cast production and physico-chemical properties in two agro forestry systems of Mizoram (India). *Tropical Ecology.*, 55, 75 – 84.
- **29.Lavelle, P. and Spain, A.V. (2001)**. Soil Ecology. Kluwer Scientific Publications, Amsterdam
- **30.Lee, K.E. (1985)**. Earthworms: Their ecology and relationship with soils and land use. New York: *Academic Press*, 411pp.
- **31.Lirikum. Exploring potential earthworm species for soil nutrient enhancement and vermicomposting in Sub tropical forest of Mokochung, Nagaland,Ph.D. thesis, Nagaland University,2024 at i-249.** http://nuir.inflibnet.ac.in:8080/jspui/handle/123456789/615
- **32.Mariappan V., Karthikairaj K. and Isaiarasu, L. (2013)**. Relationship between earthworm abundance and soil quality of different cultivated lands in Rajapalayam, Tamilnadu. *World Applied Sciences Journal* 27(10): 1278–1281.
- **33.Miglani,R., Shakoor,A., Reynolds,J.W.,Parveen, N., Kumar,A. and Bisht, S.S.(2022).**A Comprehensive checklist of the Earthworms(Annelida:Oligochaeta) of Uttarrakhand,India. *Megadrilogica,*27(10):107-133.
- **34.Narayanan, S.P., Kumari , S., Kurien, V.T., Thomas, A.P., Paliwal, R. and Julka, J.M. (2021).** A comprehensive checklist of the earthworms (Annelida: Clitellata: Megadrili) of Sri Lanka, a component of the Western Ghats – Sri Lanka biodiversity hotspot. *Travaux du Muséum National d Histoire Naturelle* "Grigore Antipa" 64(1): 7–36.
- **35.Padashetty, S. and M. Jadesh (2014).** A preliminary survey of earthworm species composition and distribution in the north Karnataka region, Gulbarga, Karnataka. *International Letters of Natural Science,* 22:54-60.
- **36.Reynolds, J.W. (2014a)**. A checklist by counties of earthworms (Oligochaeta: Acanthodrilidae, Glossoscolecidae, Lumbricidae, Megascolecidae, Ocnerodrilidae and Sparganophilidae) in South Carolina, USA. *Megadrilogica* 16(3): 15-28.
- **37. Saikia, A., Chutia , P. and Sarmah, S. R. (2021).** The diversity and distribution of indigenous earthworm species of Golaghat district of Assam, Northeast India. *Asian Journal of Conservation Biology*, 10 (2), 240–248.
- **38.Senapati, B.K. and Dash, M.C.(1984).**Influence of Soil temperature and moisture on the reproducrive activity of tropical pasture earthworms of Orissa*; J. Soil,Biol.Ecol*.4 13-21
- **39.Sharma, R.K. and Bhardwaj, P. (2014)**. Earthworm diversity in trans-Gangetic habitats of Haryana, India. *Research Journal of Agricultural and Forestry Sciences*. 2(2): 1-7.
- **40.Singh, P.K. and Singh, K. (2023).** Updated Checklist of Earthworm Belonging to the family Megascolecidae(Annelida : Clitellata: Oligochaeta) in India. *Munis Entomology and Zoology*,18 (2):1423-1447.
- **41.Thyug, L. and Kakati, L.N. (2018).** Diversity and distribution of earthworms in a subtropical forest ecosystem of Mokokchung District, Nagaland, India. *The Bioscan*, 13, 775-779.