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Biodiversity of Earthworms Species (Annelida: Oligochaeta) from Pandavapura Taluk of Mandya District, Karnataka, India

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Abstract

For ecological study, environmental management, and conservation initiatives, it is essential to understand the diversity of earthworm species within particular regions. The diversity of earthworm species in Pandavapura Taluk, which is located in the Mandya District of Karnataka, India. The main goals of the research area's land use systems like agricultural, residential, and industrial were to identify the species of earthworms and their distribution. The results showed a varied collection of 11 earthworm species from 06 families, with the majority being Megascolecidae with 05 species and Moniligastridae with 02 species, followed by each of the following: Rhinodrilidae, Eudrilidae, Acanthodrilidae, and Lumbricidae with 01 species. For every sampling site, diversity indices were computed in order to measure species richness, abundance, and evenness. 06 Exotic species of species were found in large numbers in the current study, while 04 native species followed by 01 sub endemic species is documented. As the first study to document the range of earthworm species present in the Pandavapura taluk, it lays the foundation for further investigations and advances our knowledge of biodiversity and its ecological importance in a variety of environments.

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Introduction

Earthworms are incredibly interesting animals that are essential to all terrestrial ecosystems. They belong to the class Clitellata of the phylum Annelida, and their lengthy and segmented body is frequently connected to their habit of burrowing in soil. They have been on our planet earth for more than 600 million years.[1] Sir Charles Darwin conducted the pioneering research during 1881 and referred them to be "*the farmer's friend*." Cleopatra in 50 BC was first recognised its importance and proclaimed them as vital. Famous Greek philosopher Aristotle (384–322 BC) was considered that, the earthworms as the "*intestine of the earth*." This was due to their role in turning over soil from the earth's depths.[2]

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While most earthworms prefer their natural habitats, some exotic species that are widely distributed have been successfully introduced into various agro-ecosystems.[3] The success of exotic species in colonizing nearly all of India's agroclimatic zones can be attributed to their innate resistance to disruption and interference. Their distribution has been divided into several zones in the country, including mega diversity, high diversity, medium diversity, low diversity, and poor diversity zones.[4] Some widely distributed native peregrine species are able to tolerate disturbed conditions. Epigeic, endogeic, and anecic earthworm ecological types are among those that have been recognised.[5]

Earthworms are considered as fundamental organisms; because, they perform a broad range of functions in the entire ecosystem.[6] These included composition of soil organic matter, releasing of plant nutrients into soil, and in turn allowing water infiltration and percolation in the soil profile.[7] It has piqued scientists' interest in exploring the vast resource of worm diversity. They have been dubbed the major ecological engineers due to their significance to the ecosystem.[8] In addition, they are regarded as the most valuable biological resources in agro-ecosystems because of their significant effects on the physical structures of the soil, the dynamics of organic matter, and the promotion of plant growth.[9,10] Many biotic and abiotic elements influence the biodiversity and distribution patterns of various earthworm species, such as soil properties, surface vegetation dynamics, local or regional climate, and other human-related activities.[11,12]

On Global basis, according to published data, around 7000 species of earthworms have been described[13] of which only 3000-3500 species were regarded legitimate and around 150 species are classified as peregrine.[14] Many studies on the diversity have been piled by numerous researchers around the world.[15] Robert Templeton, a British biologist, pioneered earthworm research in the Indian subcontinent.[22,23] World-famous researchers like G. E. Gates, John Stephenson, and Wilhelm Michaelsen rendered significant improvements to the field of oligochaeta between 1901 and 1947.[16,17,18,19,20] India accounts for 11.1% of the world's total earthworm variety.[21] As of now, the earthworm fauna of India comprises about 457 species spanning across 73 genera and 09 families.[44] Earthworm studies in Karnataka state started by Michaelsen (1910) followed by several workers.[24.25,26,27,28] There are close to 130 recognised varieties of earthworms in Karnataka.[44] An overview of earthworms from the regions of Hyderabad, Karnataka, Gulbarga, Udupi, in addition Dakshina Kannada was noticed.[29,30,31,33,34,35,36,45,46]

To the maximum extent of my knowledge, no reports reside describing the geographical dispersion structure, diversity, and community structure of earthworms across Pandavapura. Only limited data have been available on diversity, species distribution and abundance of earthworm species in different regions of Karnataka, India. Pandavapura is the integral part of the agricultural area of the state. The latest investigation was made to explore the diversity of earthworms in the aforementioned field because there was a dearth of scientific information over the earthworm fauna in the area.

Material and Methods

Description of Sampling Location

Pandavapura Taluk (12°29'22"N and 76°40'40"E) is a region located in the Mandya District, Karnataka, India (Figure 1). The sampling sites were broadly divided into residential, agricultural and industrial land use types. The major plants in the residential area include *Cocus nucifera* (Coconut), *Musa* sp. (Banana), *Tectona grandis* (Teak), *Mangifera indica* (Mango), *Artocarpus heterophyllus* (Jack fruit), *Tamarindus indica* (Tamarind), *Psidium guajava* (Common guava) and *Carica papaya* (Papaya). The agricultural area crops like *Saccharum officinarum* (Sugar cane) *Oryza sativa* (Paddy), *Cocus nucifera* (Coconut), *Eleusine coracana* (Ragi) and in the industrial land use consisting of the sugarcane crushing and Jaggery industries. The soils of Pandavapura taluk can be grouped in to three important categories, red sandy loam soil, red clay loam soil & gravel mixed red soil. Water bodies like Cauvery River basin, Visveswaraya canal, Lakes, Ponds and Bore wells were also observed in study area.

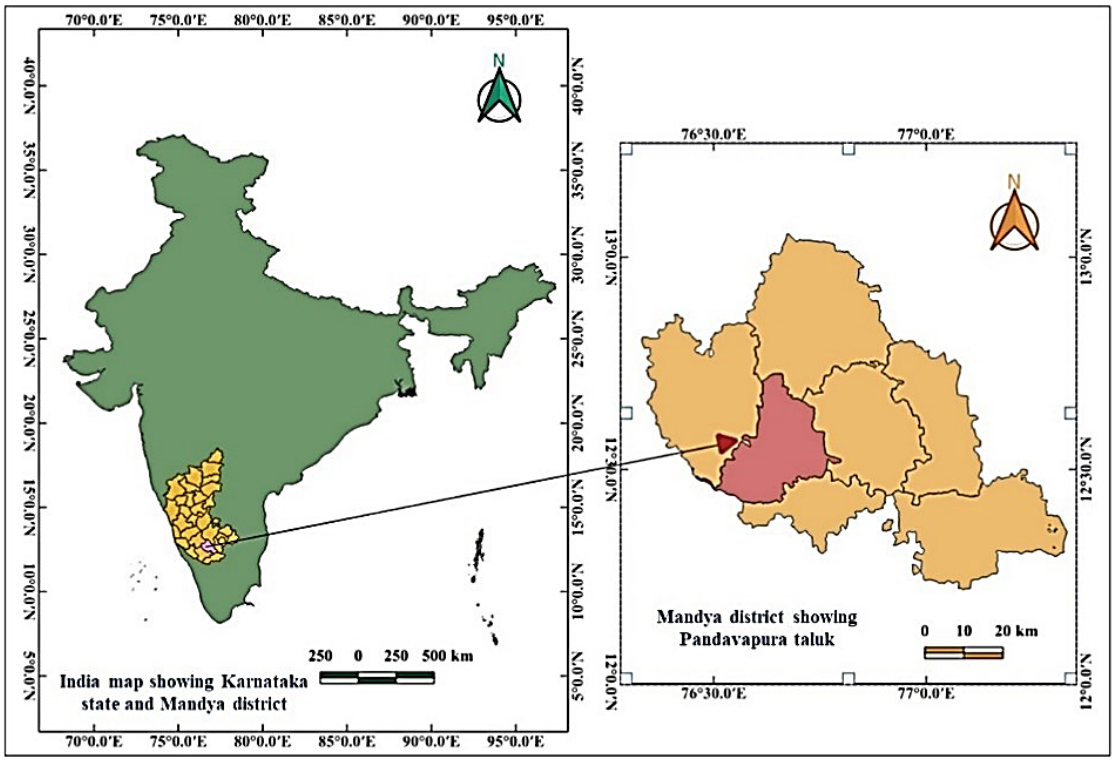

Fig. 1: Study area map

Sample Collection and Preservation

Beginning with July 2021 to June 2023, a monthly earthworm survey was executed in the chosen agricultural, residential, and industrial land use system of Pandavapura taluk in the Mandya district of Karnataka, India. Based on the accessibility and availability of earthworms, sampling points were decided across the study area. Digging and manual sorting were the methods employed collect the worms.[37] Further, adult worms was collected to examine the species. After being meticulously washed with tap water, the adult worms were placed in a petri dish, narcotized (adding 30% ethyl alcohol), straightened, and fixed in 5% formalin. Under a stereo-zoom binocular microscope anatomical details were examined using reputable references, the species was identified.[37,38,39] The application PAST (version 4.03), was employed for interpreting the acquired data for Ecological diversity indices.

Results and Discussion

The current study's findings indicate that 11 earthworm species from 06 families have been found in various locations throughout Pandavapura Taluk. (Table 1) (Figure 2). The reported species are *Drawida modesta; Drawida nepalensis; Pontoscolex corethrurus; Eudrilus eugeniae; Eutyphoeus orientalis; Eisenia fetida; Perionyx excavates; Metaphire anomala; Metaphire posthuma; Lampito mauritii; Amynthas alexandri,* (Table 2a and 2b). Further, Megascolecidae is the most dominant family represented by five species followed by Moniligastridae with two species and Rhinodrilidae, Eudrilidae, Acanthodrilidae and Lumbricidae families with one species each and their occurrence is depicted in Table 3.

Table 1: Species List of Earthworms Collected from Various Habitats in Pandavapura Taluk, Mandya district, Karnataka.

Order	Family	Scientific name	Reg. No
Moniligastrida (2 Species)	Moniligastridae	*Drawida modesta* Rao,1921	An7291/1
		Drawida nepalensis Michaelsen, 1907	An7278/1
	Rhinodrilidae	*Pontoscolex corethrurus* (Muller,1856)	An7279/1
Opisthopora (09 Species)	Eudrilidae	*Eudrilus eugeniae* (Kinberg, 1867)	An7280/1
	Acanthodrilidae	*Eutyphoeus orientalis* (Beddard, 1833)	An7281/1
	Lumbricidae	*Eisenia fetida* (Savigny, 1826)	An7290/1
	Megascolecidae	*Perionyx excavates* Perrier, 1872	An7289/1
		Metaphire anomala (Michaelsen, 1907)	An7283/1
		Metaphire posthuma (Vaillant, 1868)	An7282/1
		Lampito mauritii Kinberg, 1866	An7288/1
		Amynthas alexandri (Beddard, 1900)	An7287/1

Table 2a: Taxonomic characters of the Earthworm species from Pandavapura taluk of Mandya district, Karnataka

Characters	*Drawida modesta*	*Drawida nepalensis*	*Pontoscolex corethrurus*	*Eudrilus eugeniae*	*Eutyphoeus orientalis*	*Eisenia fetida*
Colour	Creamy grey	Reddish	Unpigmented Yellowish	Reddish brown to dark violet	Reddish brown	Reddish
Length (mm)	75-100	75-131	50-85	90-185	100-250	35-130
Width (mm)	04-May	3.5-4	03-May	05-Aug	07-Aug	04-May
No. of segments	207-230	142- 172	102-120	145-196	250-300	100 -120
Prostomium	Prolobous	Prolobous	Prolobous	Epilobous, Tongue open	Epilobous	Epilobous, Tongue open
Setae type	Lumbricine	Lumbricine	Lumbricine	Lumbricine	Perichaetine	Lumbricine
Spermathecal pores	Paired, small transverse slits in 7- 8	Slit like, one pair at Inters -egmental furrow 7/8	Three pairs, In 7-9	Single lateral pair in 14-17	Small slit like in 23	Paired 9/10 and 10/11
Clitellum type & position	Annular In 10-13	Annular In 9-14	Saddle shape, In 15– 22	Saddle shaped, interrupted ventrally at 14-18	Annular In 13–16	Saddle shape, In 09 - 11
Male genital pore (Paired)	In inters -egmental furrow 10- 11	At interse -gmental furrow 10/11	Minute in 17	17 With penial Setae	27 With penial Setae	Equatorial slits in 15th segment
Female genital pore	Female pores at 11/12	A paired, at or posterior to interse -gment furrow 11/12	A pair in 14	Combined with spermathecal pores, in 14	A pair Minute in 24	A pair Minute in 14

First dorsal pore	Absent	Absent	Absent	Absent	In 11/12	In 11
Gizzards	03-Apr	02-Apr	07-Aug	Large, single in 5	Large, single in 8	Large, in 17-18
Prostates	Prostate in 10	Glandular, tubular, usually in a u-shaped loop	None	Large pair of digitiform prostates	None	None
Calciferous glands	-	Present	Three pairs in 7-9	10-11	-	Present
Last pair of heart Segm -ent No.	13	13	11	11	13	11
Typhlosole	-	-	-	Absent	Present At 28	In 20-23 to 78-86

Table 2b: Taxonomic characters of the Earthworm species from Pandavapura taluk of Mandya district, Karnataka

Characters	***Perionyx excavatus***	***Metaphire anomala***	***Metaphire posthuma***	***Lampito mauritii***	***Amynthas alexandri***
Colour	Bluish red to brown	Creamy grey	Grey black with pink anterior	Greyish black brown	Dark red
Length (mm)	40-62	134-154	120-200	47-82	130-175
Width (mm)	01-Feb	4.5-6	4.5 - 5	02-Mar	04-Jun
No. Of segments	124-130	116-126	130-257	142-160	115 – 137
Prostomium	Epilobous, Tongue open	Epilobous	Prolobous	Epilobous, Tongue open	Rudimentary
Setae type	Perichaetine	Perichaetine	Perichaetine	Perichaetine	Perichaetine
Spermathecal pores	In 7/8/9, paired, near to the mid-ventral line	3 pairs at5/6-7/8 slit like	Paired in 5/6/7/s/9	3 pairs in 6/7/ 8/9 inter-segments	4 pairs in in intersegmental furrows 5/6/ 7/8/9
Clitellum type & position	Annular In 14–17	Annular In 14–16	Annular In 14–16	Annular In 13-17	Annular In 14-16
Male genital pore (Paired)	18 With penial Setae	20 with copulatory pouches	18 with up to ten setae	18 with penial setae	18 with setae
Female genital pore	A pair in 14	Single in 14	A pair in 14	A pair in 14	Single in 14
First dorsal pore	02-Mar	Dec-13	Absent	Absent	Intersegmental furrow 12-13
Gizzards	Large, single in 5	Single in 8-9	In 8-9	Large, single in 5-6	Single in 7-8
Prostates	Recemose Type	Racemose, paired, in	A pair of glands extends on 17	Large recemose in 18-19 with	Racemose, paired, in

	In 18	segment 20	-20 segments	muscular duct	segment 18
Calciferous glands	Present	Present	Present	In 10-13	Present
Last pair of heart (Segment)	13	13	13	13	13
Typhlosole	In 15 Simple, lamelliform.	Present Lamelliform	26-28 Lamelliform	Absent	Lamelliform, ending in 90

Fig. 2: Photographs of collected earthworm species from Pandavapura taluk Mandya district of Karnataka, India.

Table 3: Occurrence of collected earthworm species in the study area

Earthworm species	Agricultural	Residential	Industrial
Drawida modesta Rao,1921	-	++	+
Drawida nepalensis Michaelsen, 1907	+	+	-
Pontoscolex corethrurus (Muller,1856)	++	-	+
Eudrilus eugeniae (Kinberg, 1867)	+	++	-
Eutyphoeus orientalis (Beddard, 1833)	+	-	-
Eisenia fetida (Savigny, 1826)	++	+	+
Perionyx excavates Perrier, 1872	++	++	+
Metaphire anomala (Michaelsen, 1907)	-	+	+
Metaphire posthuma (Vaillant, 1868)	+	-	+
Lampito mauritii Kinberg, 1866	-	++	+
Amynthas alexandri (Beddard, 1900)	-	+	-

(-) = Absent; (++) = High Population (20-40 Worms/Unit area); (+) = Low population (10-20) Worms/Unit area.

While the Indian earthworm fauna's high endemism-represents, roughly 89% of species and 71% of genera.[40] However, in the current study exotic peregrine species predominate over native species. Among the recorded earthworm species, 04 are native peregrine, 06 exotic peregrine, 01 Subendemic. Further, the species identified in this study were belong to endogeic and epigenic ecological category (Table. 4). which have a very important role in soil nutrient dynamics.[41] Metaphire anomala, Metaphire posthuma and Amynthas alexandri are Exotic peregrine. Generally, Eisenia fetida and Perionyx excavates were the most eurytopic species occurring in present study. Among lesser eurytopic species, Eutyphoeus orientalis in agricultural area and Amynthas alexandri was found in Residential area; Drawida modesta, Metaphire anomala and Lampito mauritii was recorded from residential and industrial habitats; Drawida nepalensis and Eudrilus eugeniae occurred in agricultural and residential fields. Metaphire posthuma are restricted to residential area. Pontoscolex corethrurus is present in agricultural and industrial habitats (Table 3). In existing study exotic peregrine species were widespread in agricultural and residential area whereas native species were restricted to residential and industrial area. These native peregrine species are possibly transported to this area through the soil around roots of exotic plants and other means.[41] The altering of habitat and available resources and biological invasion competes or replace the native species.[42] Though, the current research is pioneer work from Pandavapura taluk of Mandya district, Karnataka. Recently, similar results have been reported in different parts of India and Karnataka.[43]

Ecological diversity indices were calculated using PAST software version 4.03. for the observed species of earthworm. Species richness, evenness and dominance were analysed using Shanon-Shimpson diversity index (Shannon H' Log Base 10), Simpson diversity index (1/D) and Berger-Parker Dominance (d) index, (Table 5). The Shannon diversity index and Simpson's diversity index values shows the highest abundance and diversity of earthworms in the Agricultural areas (2.217) than in industrial sites with lowest value (1.993). Generally, high moisture content in the soil favours the growth and abundance of earthworms. In the present investigation, the agricultural area has more moisture content than the industrial area, because the agriculture area in Pandavapura is situated near to the Cauvery River basin, Visveswaraya canal, Lakes, Ponds and Bore wells might be the reason for highest abundance and diversity of earthworms. Similarly, Margaleff M Base 10 index depicts the highest diversity values (1.679) in Agricultural area and lowest (1.534) in industrial area. Further, in the present investigation, more common and abundant species of earthworms are documented in the agricultural habitat followed by the residential and industrial habitats.

Table 4: List of Ecological group and Zoogeographical distribution of Earthworm Species collected Study area

Earthworm species	Ecological group	Zoogeographical distribution
Drawida modesta Rao,1921	Endogeic	Native peregrine
Drawida nepalensis Michaelsen, 1907	Endogeic	Native peregrine
Pontoscolex corethrurus (Muller,1856)	Endogeic	Exotic peregrine
Eudrilus eugeniae (Kinberg, 1867)	Epigeic	Exotic peregrine
Eutyphoeus orientalis (Beddard, 1833)	Endogeic	Subendemic species
Eisenia fetida (Savigny, 1826)	Epigeic	Exotic peregrine
Perionyx excavates Perrier, 1872	Epigeic	Native peregrine
Metaphire anomala (Michaelsen, 1907)	Endogeic	Exotic peregrine
Metaphire posthuma (Vaillant, 1868)	Endogeic	Exotic peregrine
Lampito mauritii Kinberg, 1866	Aneceic	Native peregrine
Amynthas alexandri (Beddard, 1900)	Epi-endogeic	Exotic peregrine

Table 5: Diversity Indices of Earthworm species recorded at Pandavapura taluk, Mandya district, Karnataka

Indices	Agricultural	Residential	Industrial
Dominance_D	0.117	0.1273	0.1458
Simpson_1-D	0.883	0.8727	0.8542
Shannon_H	2.217	2.168	1.993
Evenness_e^H/S	0.9176	0.8739	0.917
Brillouin	2.121	2.068	1.849
Menhinick	0.6852	0.7071	0.8165
Margalef	1.679	1.699	1.534
Equitability_J	0.9627	0.9415	0.9583
Fisher_alpha	2.177	2.215	2.075
Berger-Parker	0.169	0.19	0.1979

Furthermore, we strongly suggest undertaking long-term studies on earthworm diversity in order to discover their spatiotemporal distribution and the effects of various land use systems, based on the results of this current research. The significance of different land use systems within the region is highlighted by the variety of earthworm species found in Pandavapura Taluk. The aforementioned results illuminate the need for land use specific approaches to strengthen soil health and sustainable utilise of earthworms, which has implications for land management practices.

Conclusion

Earthworm diversity and abundance were evaluated in three different land use systems of Pandavapura taluk of Mandya District. Totally eleven earthworm species belonging to six families were recorded. *Eudrilus eugeniae, Eisenia fetida* and *Perionyx excavates* are the earthworm species which is suggested as the best one for agriculture and vermicompost purpose. The local earthworm species composition may be explained by ecological factors, species-specific dispersal patterns, and dietary preferences. Certain species high abundances

can be used as indicators species. In this current investigation the greatest diversity of earthworms is recorded in agricultural area as compared to other land use types. So that, it is important to assess their diversity in order to make informed decisions about environmental management and conservation of sensitive and sentinel earthworm species.

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Ethical approval statement
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Authors' Contribution
Shashank K R: Writing- Original draft; Conducted experiments; Methodology; Designed the study; Investigation; Data curation; Analysed data. M. Mahadevaswamy: Formal analysis; Conceptualization; Review and editing; Supervision and Validation. Both authors read and approved the final manuscript.

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