

RESEARCH REVIEW



Current status of the earthworm genus *Eutyphoeus* (Clitellata: Acanthodrilidae) in Mizoram, North-East India: A review

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The genus *Eutyphoeus* Michaelsen (1900), represents an important component of the earthworm fauna of northeast India, with Mizoram contributing a notable number of species records. The state has a diverse landscape characterized by mountainous terrain, forested habitats and high rainfall providing suitable conditions for earthworm diversity. Knowledge of *Eutyphoeus* in Mizoram has developed through successive taxonomic and ecological studies, resulting in the description and documentation of several species from different parts of the state. Recent studies have also incorporated molecular approaches, particularly mitochondrial cytochrome c oxidase subunit I (COI) sequencing to support species identification, delimitation and assessment of genetic variation. This review brings together the published information on *Eutyphoeus* in Mizoram, with emphasis on its taxonomic history, species diversity, distribution and molecular studies. The present study records 12 species of *Eutyphoeus* earthworms in Mizoram, Northeast India. The available literature indicates that the known diversity of the genus has increased through continued field investigations and the application of molecular tools. However, distributional and molecular information remains uneven among species and localities. Further field surveys, particularly in less explored areas, along with expanded molecular sampling will help improve the understanding of the diversity, distribution and genetic variation of *Eutyphoeus* in Mizoram. This review provides a concise account of the current knowledge of the genus and identifies areas where further research can contribute to its study in the state.

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Introduction

Mizoram is a mountainous state in northeastern India, characterized by having rugged terrain, deep valleys, extensive forest cover and high annual rainfall. The state is located within the Indo-Burma biodiversity hotspot and contains tropical and subtropical forests with considerable variation in elevation and environmental conditions.^{1,2,3} These characteristics provide diverse habitats for soil organisms, including earthworms. Earthworm studies in Mizoram have also shown the importance of rainfall and soil conditions in determining the population dynamics while

earthworm activity and cast production have also been found to be closely associated with the rainy season.^{1,2,3,4,5}

The earthworm fauna of northeastern India has been documented through a number of taxonomic and ecological studies. Tiwari et al.³ compiled a regional checklist that included 128 species and subspecies belonging to 26 genera and nine families across North Eastern Region (NER) of India³. The genus *Eutyphoeus* currently comprises of 53 recognized species worldwide.^{7,8,9,10,11,12,13} India has been reported to harbour 29 species,

with recent taxonomic studies further expanding the known diversity.^{3,7,8,9,12,13,16,17} Ten new species were described from Manipur by Tiwari et al.¹³, while another new species was described from Sikkim in 2026.¹⁷ These recent additions bring the number of *Eutyphoeus* species reported from India to 40, highlighting the continuing expansion of knowledge of the genus in the country.

The genus *Eutyphoeus* has received increasing attention in Mizoram during the past two decades. Several species have been described and recorded from the state through various taxonomic and ecological studies (see Table 1). This review summarizes the published status of *Eutyphoeus* in Mizoram, with emphasis on its diversity, distribution and molecular developments.

Taxonomic status and diversity of *Eutyphoeus* in Mizoram

Systematic position of *Eutyphoeus*

Class Clitellata Michaelsen, 1919

Subclass Oligochaeta Grube, 1850

Order Crassicitellata Jamieson, 1988

Family Acanthodrilidae Claus, 1880

Genus *Eutyphoeus* Michaelsen, 1900

The documented history of *Eutyphoeus* in Mizoram begins with records of *Eutyphoeus gigas*,

Eutyphoeus gammiei and *Eutyphoeus assamensis* followed by the description of *Eutyphoeus mizoramensis*.^{12,15,16,19,21,22} The checklist by Tiwari et al.²³ confirmed these four species as the *Eutyphoeus* fauna known from Mizoram at the time.³ *E. assamensis* was recorded from unspecified location, *E. gammiei* *E. gigas* from Bungtlang and other unspecified localities and *E. mizoramensis* from Sairang and subsequently other localities in the state.²³ A major increase in known diversity occurred with Tiwari et al.²⁴ who described three new species namely *E. phawngpuiensis*, *E. serei* and *E. tawi* from protected forests of Mizoram.¹⁵ The specimens were collected from Phawngpui National Park, Dampa Tiger Reserve, Tawi Wildlife Sanctuary. Along with the three new species, *E. mizoramensis* was collected from Aizawl to Dampa Tiger Reserve.¹⁵ Their study was also first dedicated investigated of endemic *Eutyphoeus* from Mizoram using an integrated taxonomic approach. Rodingpuia et al.²⁵ subsequently described *E. rihnimensis* from Khawrihim in Mamit district with additional specimens collected from Mamit and Dampui. The species was supported by both morphological and COI gene.²⁴

The most recent addition came from Lone et al.²⁶. Their study identified six *Eutyphoeus* species from Mizoram namely *E. comillahnus*, *E. festivus*, *E. gigas*, *E. mizoramensis*, *E. pharppingianus* and *E. scutarius*. Four of these species, namely *E. comillahnus*, *E. festivus*, *E. scutarius* and *E. pharppingianus* were recorded as new records for Mizoram. In addition, *E. pharppingianus* was reported for the first time from the entire Northeast Region.²⁶

At present, 12 species of *Eutyphoeus* are known from Mizoram (Table 1).^{12,15,16,19,21,22,24,27,28}

Table 1. List of known species of *Eutyphoeus* from Mizoram

Sl. No.	Species	Reference(s)
1.	<i>Eutyphoeus assamensis</i>	Gates ¹¹
2.	<i>Eutyphoeus gammiei</i>	Beddard ²⁷
3.	<i>Eutyphoeus gigas</i>	Stephenson ²⁹
4.	<i>Eutyphoeus mizoramensis</i>	Julka et al. ¹²
5.	<i>Eutyphoeus phawngpuiensis</i>	Tiwari et al. ²⁴
6.	<i>Eutyphoeus serei</i>	Tiwari et al. ²⁴
7.	<i>Eutyphoeus tawi</i>	Tiwari et al. ²⁴
8.	<i>Eutyphoeus rihnimensis</i>	Rodingpuia et al. ²⁵
9.	<i>Eutyphoeus comillahnus</i>	Michaelsen ¹⁹
10.	<i>Eutyphoeus festivus</i>	Gates ²⁰
11.	<i>Eutyphoeus pharppingianus</i>	Michaelsen ¹⁹
12.	<i>Eutyphoeus scutarius</i>	Michaelsen ¹⁹

Molecular advances in *Eutyphoeus* research

Molecular studies of *Eutyphoeus* in northeastern India are relatively recent and mitochondrial COI gene has been the principal marker used in the available investigations. Thakur et al.¹⁸ investigated *Eutyphoeus* from Garo Hills of Meghalaya using COI barcoding and examined genetic distances and phylogenetic relationships³¹. Their study provided an early molecular reference for the genus in the Northeast region.

Tiwari et al.²⁴ incorporated COI data into the description of the three new Mizoram species. Forty-nine samples from the study were sequenced and additional sequences were retrieved from BOLD for phylogenetic comparison. Three new species formed distinct molecular groupings, and ABGD analysis supported their separation. The maximum intraspecific distances and near-neighbour distances were 3.5% and 9.37% for *E. phawngpuensis*, 2.35% and 14.83% for *E. serei* and 2.28% for *E. tawi*. The study also reported barcode gaps of 5.89–12.66% for the three new species.¹⁷

Rodingpuia et al.²⁵ further applied COI sequencing in the description of *E. rihnimensis*. Sequences from the new species were compared with available *Eutyphoeus* sequences from BOLD and both Maximum Likelihood and Bayesian analysis were used to assess its phylogenetic position.²⁴

Lone et al.²⁶ provided the most extensive molecular assessment of *Eutyphoeus* from Mizoram so far. Their study combined morphological identification with COI sequencing and examined six species from the state. The authors generated 42 COI barcodes and combined them with 81 *Eutyphoeus* sequences retrieved from BOLD producing a dataset of 123 sequences.²⁵ The study reported a mean K2P intraspecific distance of 3.08% and a minimum interspecific distance of 12.35%. ABGD and barcode gap analysis indicated a barcode gap of approximately 7–10%. The COI dataset produced 64 haplotypes and provided information on haplotype and nucleotide diversity for individual species. However, the study also showed that COI data does not resolve every taxonomic problem equally well. *E. callosus* showed comparatively high intraspecific divergence and lacked a clear barcode gap. The authors suggested that this pattern may indicate a cryptic species or species complex, while also noting that limited sampling could contribute to the result.²⁵ They recommended broader sampling and multilocus analysis for better resolution.

Overall, molecular research has progressed from the initial application of COI to a few *Eutyphoeus* species to broader datasets incorporating multiple species, phylogenetic analysis and population level genetic information.

Current knowledge and research gap

The published record demonstrates a clear increase in the known *Eutyphoeus* diversity of Mizoram. Nevertheless, the distribution of the genus is still incompletely documented. The studies available so far have focused on particular localities, protected areas or accessible sites, while many forested and mountainous areas remain insufficiently explored. Lone et al.²⁶ themselves notes that the steep terrain and difficult access to natural forests present challenges for earthworm surveys.

The molecular dataset is also uneven among species. Some species now have multiple COI sequences whereas others remain represented by few or no sequences. This limits comparisons of intraspecific variation and make it difficult to assess geographic population structure across Mizoram.

Another important gap is the need to combine wider geographic sampling with molecular data. COI has proved useful for distinguishing many *Eutyphoeus* species, but the results for *E. callosus* also demonstrate that single-locus data may not always provide a complete picture. Broader sampling and additional genetic markers could help clarify closely related or highly variable lineages.²⁵

Future studies should therefore prioritize unexplored parts of Mizoram and generate molecular data from accurately identified and geographically documented specimens. A comprehensive COI reference library, supported where necessary by multilocus data, would provide a stronger basis for species identification phylogenetic studies and assessment of genetic variation within the genus.

Conclusion

Knowledge of *Eutyphoeus* in Mizoram has developed through a series of taxonomic and ecological studies. Earlier investigations documented several species from the state while subsequent studies added newly described species and new distributional records. Molecular approaches have also been incorporated into recent studies, particularly the use of mitochondrial COI sequences for species identification, delimitation and phylogenetic analysis. Despite these advances, information on the distribution and molecular characteristics of *Eutyphoeus* in Mizoram remains limited for some species. Additional studies, particularly from less explored areas, may provide additional information on the diversity, distribution and genetic variation of the genus in the state.

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