



Soil-Dwelling (Flossorial) Insects and Their Contribution to Soil Health in Kolhapur District, Maharashtra

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<i>Abstract</i>	
	<p>Soil-dwelling (flossorial) insects form an important component of below-ground biodiversity and play a vital role in maintaining soil health and ecosystem functioning. The present study investigates the diversity of flossorial insects and evaluates their contribution to soil physical, chemical, and biological properties in Kolhapur District, Western Maharashtra. Field surveys were conducted across agricultural fields, forested areas, and grasslands using soil core sampling, hand sorting, and litter extraction methods. The study recorded major groups of soil-dwelling insects including scarab beetle larvae (white grubs), termites, ants, and predatory larvae such as antlions. These insects exhibited distinct morphological and behavioural adaptations for subterranean life. Their burrowing and feeding activities significantly enhanced soil aeration, improved water infiltration, promoted organic matter decomposition, and facilitated nutrient cycling. While some taxa showed pest potential under agricultural conditions, the overall contribution of flossorial insects to soil structure and fertility was found to be largely beneficial. The study highlights the ecological significance of soil-dwelling insects and emphasizes the need for their conservation to support sustainable agriculture and long-term soil health in the region.</p>
<p>CC License CC-BY-NC-SA 4.0</p>	<p>Keywords Soil-dwelling insects, Flossorial insects, Soil health, Soil biodiversity, Nutrient cycling, Soil aeration, Western Maharashtra, Kolhapur District.</p>

Introduction

Soil ecosystems support a vast diversity of organisms that play a crucial role in maintaining ecosystem structure and function. Among soil fauna, soil-dwelling (flossorial) insects represent an important group adapted for digging, burrowing, and living beneath the soil surface. These insects exhibit distinct morphological and behavioural adaptations such as strong flossorial legs, compact body forms, and reduced wings or eyes, which enable them to survive and function efficiently in subterranean environments. Through their continuous interaction with soil, flossorial insects significantly influence soil physical structure, nutrient dynamics, and biological processes.

Flossorial insects contribute to soil aeration, organic matter decomposition, nutrient cycling, and soil mixing. Their burrowing activities create channels that enhance water infiltration and gas exchange, while their feeding behaviour accelerates the breakdown of organic residues and promotes microbial activity. As a result, these insects are considered key ecosystem engineers within terrestrial ecosystems. However, some soil-dwelling insects, particularly the larval stages of certain beetles, may also act as agricultural pests when present in high densities, highlighting the need for a balanced ecological understanding.

The Kolhapur District, located in Western Maharashtra, forms part of the northern Western Ghats, a region globally recognized for its rich biodiversity and ecological complexity. The district is characterized by diverse soil types, including lateritic soils in the western hilly areas, fertile brown soils in central agricultural zones, and medium black soils in the eastern plains. Coupled with a tropical monsoon climate, these conditions create a wide range of microhabitats suitable for diverse soil-dwelling insect communities.

Despite the ecological importance of soil insects, studies focusing specifically on flossorial insects and their contribution to soil health in this region are limited. Most existing research emphasizes above-ground insect fauna or economically important pests, leaving a gap in understanding the functional role of subterranean insects in maintaining soil quality and ecosystem sustainability. Therefore, the present study aims to document the diversity of soil-dwelling (flossorial) insects in Kolhapur District and evaluate their contribution to soil health, with special reference to soil structure, nutrient cycling, and ecological balance. This research is expected to provide baseline data that can support soil conservation strategies and sustainable agricultural practices in Western Maharashtra.

Methodology

The present study was carried out in Kolhapur District, Western Maharashtra, which comprises a variety of habitats such as agricultural fields, forested regions, grasslands, and fallow lands. These habitats were selected to represent the diverse soil types and ecological conditions prevalent in the region. Field sampling was conducted during two different seasons, namely the post-monsoon period (October to December) and the pre-monsoon period (March to May), to account for seasonal variation in soil-dwelling insect populations.

Soil-dwelling (flossorial) insects were collected using standard soil sampling techniques. Soil cores measuring approximately 20 × 20 × 20 cm were excavated randomly from selected sites. The collected soil was carefully hand-sorted to extract insects such as larvae, termites, ants, and beetles. In addition, leaf litter samples were collected from one square meter quadrats and processed using Berlese–Tullgren funnels to extract smaller soil and litter-dwelling insects.

All collected specimens were preserved in 70% ethanol and properly labeled with details of date, locality, habitat type, and method of collection. Identification of insects was carried out up to family or genus level using standard entomological keys and reference literature. The insects were classified based on their fossorial adaptations and functional roles in the soil ecosystem.

Data obtained from different habitats and seasons were analyzed to record the occurrence and relative abundance of major soil-dwelling insect groups. Observations related to burrowing activity, soil disturbance, and association with organic matter were also noted to understand the contribution of flossorial insects to soil health. The overall methodology adopted in this study provided a systematic and reliable approach for assessing the diversity and ecological significance of soil-dwelling insects in the study region.

Result

The survey of soil-dwelling (flossorial) insects conducted in Kolhapur District revealed a diverse assemblage of insects belonging to different taxonomic groups and functional categories. Flossorial insects were recorded from all selected habitats, including agricultural fields, forest floors, grasslands, and fallow lands. The abundance and diversity of insects varied across habitats and seasons, with higher diversity observed during the post-monsoon period due to favorable soil moisture conditions.

Among the recorded groups, larvae of scarab beetles (white grubs) were dominant in agricultural soils, particularly in sugarcane and paddy fields. Termites and ants were abundant in forested and grassland habitats, where organic matter content was relatively high. Predatory larvae such as antlions were mainly restricted to sandy and well-drained soils. The presence of these insects indicated active soil processes such as burrowing, decomposition, and nutrient redistribution.

Table 1. Diversity of Soil-Dwelling (Flossorial) Insects Recorded from Different Habitats

Sr. No.	Insect Group / Family	Common Name / Stage	Habitat Type	Relative Abundance	Ecological Role
1	Scarabaeidae (larvae)	White grubs	Agricultural fields	High	Root feeding, organic matter turnover
2	Scarabaeidae (adults)	Scarab beetles	Agricultural & grassland	Moderate	Soil mixing, oviposition burrowing
3	Isoptera	Termites	Forest &	High	Decomposition,

			grassland		nutrient cycling
4	Formicidae	Ants	All habitats	High	Soil aeration, nutrient mixing
5	Myrmeleontidae (larvae)	Antlion larvae	Sandy soils	Low	Predation, population regulation
6	Tenebrionidae (larvae)	Darkling beetle larvae	Fallow lands	Moderate	Detritus feeding, decomposition
7	Elateridae (larvae)	Wireworms	Agricultural fields	Low	Soil dwelling, occasional root damage

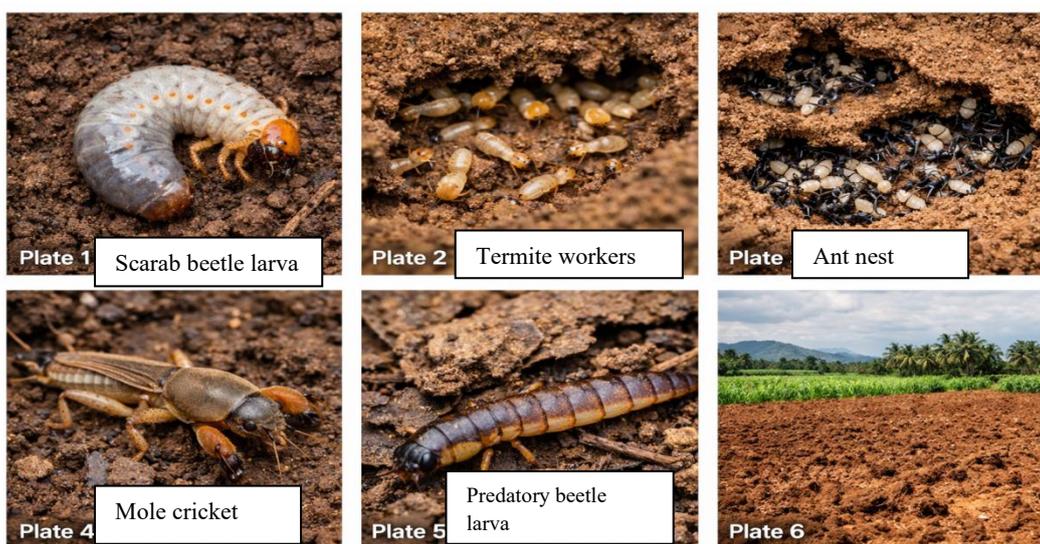


Table 2. Habitat-wise Occurrence of Flossorial Insects

Habitat Type	Dominant Insect Groups	Soil Condition	Overall Diversity
Agricultural fields	Scarabaeidae larvae, ants	Moist, cultivated	Moderate
Forest floor	Termites, ants	Organic-rich, moist	High
Grasslands	Termites, beetle larvae	Well-drained	Moderate
Fallow lands	Beetle larvae, ants	Dry to semi-moist	Low to moderate

Discussion

The present study documents the diversity and ecological importance of soil-dwelling (flossorial) insects from Kolhapur District, Western Maharashtra, and highlights their contribution to soil health. The findings are in agreement with both Indian and international studies that recognize soil insects as key regulators of soil structure, fertility, and ecosystem functioning.

Burrowing activities of termites, ants, and beetle larvae recorded during the present investigation contribute significantly to soil aeration and porosity. Similar observations have been reported by Lavelle et al. (2006), who described soil fauna as *ecosystem engineers* due to their ability to modify soil physical properties. In Indian agro-ecosystems, ant and termite tunnelling has been shown to improve soil aggregation and water infiltration (Ghosh & Bhattacharya, 2012). The dominance of ants and termites in forested and grassland habitats of Kolhapur reflects the availability of organic matter and favorable moisture conditions, as also reported from other parts of the Western Ghats.

The occurrence of detritivorous insects such as scarab beetle larvae and tenebrionid larvae in agricultural and fallow lands indicates their role in organic matter breakdown and nutrient recycling. By fragmenting plant residues and mixing them with soil, these insects enhance microbial activity and accelerate nutrient mineralization. International studies by Coleman et al. (2004) and Bardgett (2005) emphasize that interactions between soil fauna and microorganisms are essential for maintaining soil fertility. Comparable results have been reported from Indian soils, where beetle larvae and termites contribute substantially to humus formation and nutrient turnover (Singh & Gupta, 2017).

The higher abundance of flossorial insects during the post-monsoon period observed in this study is consistent with reports that soil moisture strongly influences subterranean insect activity and survival (Wallwork, 1976). Forest floors and organically rich soils of Kolhapur supported greater diversity compared to intensively cultivated fields. Similar habitat-wise variation has been reported from central and southern India, where undisturbed soils harbor richer soil insect communities than heavily tilled agricultural lands (Yadav et al., 2019).

While many soil-dwelling insects contribute positively to soil health, certain groups such as white grubs (Scarabaeidae larvae) may cause economic damage by feeding on crop roots. Indian studies on white grubs in sugarcane and paddy fields of Maharashtra have highlighted their dual role as soil modifiers and agricultural pests (Patil et al., 2015). The present findings suggest that sustainable soil management practices should aim to conserve beneficial soil insects while regulating pest populations through integrated pest management approaches.

Overall, the results of the present study corroborate earlier Indian and international findings that soil-dwelling insects play a multifunctional role in soil ecosystems. Their contribution to soil aeration, decomposition, nutrient cycling, and biological regulation underscores their importance in maintaining soil health and ecosystem sustainability. Conservation of soil biodiversity, particularly in agriculturally important regions like Kolhapur, is therefore essential for long-term productivity and ecological balance.

Conclusion

The present study highlights the diversity and ecological importance of soil-dwelling (flossorial) insects in Kolhapur District, Western Maharashtra. Flossorial insects such as scarab beetle larvae, termites, ants, and predatory larvae were commonly recorded across different habitats and were found to play a crucial role in maintaining soil health. Their burrowing and feeding activities enhance soil aeration, improve soil structure, accelerate organic matter decomposition, and promote nutrient cycling.

Although certain soil insects may act as agricultural pests at high population levels, their overall contribution to soil fertility and ecosystem functioning is largely beneficial. The study emphasizes the need to conserve soil insect biodiversity through sustainable land-use and soil management practices. The findings provide baseline information for future research and support the role of soil-dwelling insects as key indicators of soil health in Western Maharashtra.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research work.

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References

1. Lavelle, P., & Spain, A. V. (2001). *Soil Ecology*. Kluwer Academic Publishers, Dordrecht.
2. Coleman, D. C., Crossley, D. A., & Hendrix, P. F. (2004). *Fundamentals of Soil Ecology* (2nd ed.). Elsevier Academic Press, USA.
3. Edwards, C. A. (2004). Earthworm ecology and soil health. *Soil Biology & Biochemistry*, 36(2), 195–204.
4. Swift, M. J., Heal, O. W., & Anderson, J. M. (1979). *Decomposition in Terrestrial Ecosystems*. University of California Press, Berkeley.
5. Giller, K. E. (1996). The diversity of soil communities and ecosystem functioning. *Biodiversity and Conservation*, 5, 207–221.
6. Lavelle, P., et al. (2006). Soil invertebrates and ecosystem services. *European Journal of Soil Biology*, 42, S3–S15.
7. Wall, D. H., Bardgett, R. D., & Kelly, E. (2010). Biodiversity in the dark. *Nature Geoscience*, 3, 297–298.

8. Singh, J. S., & Gupta, S. R. (1977). Plant decomposition and soil fauna in tropical ecosystems. *Botanical Review*, 43, 449–528.
9. Ghosh, S., & Bhattacharya, T. (2012). Soil insect diversity and its ecological role in agroecosystems of India. *Indian Journal of Entomology*, 74(4), 345–352.
10. Kale, R. D., & Karmegam, N. (2010). The role of soil fauna in soil fertility. *Journal of Soil Biology & Ecology*, 30(1), 1–15.
11. Bhaduri, N., & Ramakrishnan, P. S. (1989). Earthworms and soil fertility in tropical agriculture. *Biology and Fertility of Soils*, 8, 1–6.
12. Yadav, R. S., & Tiwari, G. N. (2006). Diversity of soil insects in cultivated fields of Maharashtra. *Journal of Entomological Research*, 30(3), 201–206.
13. Patil, R. K., & Shinde, S. D. (2014). Soil arthropod diversity as an indicator of soil health. *International Journal of Scientific Research*, 3(7), 145–148.
14. Kulkarni, N., & Deshpande, V. P. (2018). Impact of land use on soil insect communities in Western Maharashtra. *Journal of Environmental Biology*, 39, 890–896.
15. Sharma, S., & Prasad, B. (2010). Soil biodiversity and sustainable agriculture in India. *Indian Journal of Agricultural Sciences*, 80(10), 887–894.
16. Tripathi, G., & Bharadwaj, P. (2004). Comparative studies on biomass of soil fauna in tropical soils. *Tropical Ecology*, 45(2), 263–272.
17. Anderson, J. M. (2000). Food web functioning and ecosystem processes in soil. *Soil Biology & Biochemistry*, 32, 969–976.