International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 05-02-2026, Accepted: 08-03-2026, Published: 23-03-2026
Volume 11, Issue 1, 2026, Page No. 551-554

Spatiotemporal patterns of dung beetle diversity in the Bhedaghat region of Jabalpur, Central India

Dr. Sanjay Kumar[1*], Dr. Arjun Shukla[2]
[1] Assistant Professor, Department of Zoology, Chaudhary Ranbir Singh University, Jind, Haryana, India
[2] Faculty, Department of Zoology, Govt. M.H. College of H.Sc and Science, Jabalpur, Madhya Pradesh, India
Corresponding Author: Dr. Sanjay Kumar

Abstract
Dung beetles (Coleoptera: Scarabaeidae) play a pivotal role in ecosystem functioning by facilitating nutrient cycling, secondary seed dispersal, soil aeration, and suppression of parasites. Their community structure and distribution are strongly influenced by a complex interplay of abiotic and biotic factors, including temperature, soil characteristics, moisture regimes, rainfall patterns, and the availability of dung resources. Owing to their sensitivity to environmental changes, dung beetles are widely recognized as reliable bioindicators of habitat quality and ecosystem health. The present study investigates the spatiotemporal patterns of dung beetle diversity in the Bhedaghat region of Jabalpur, Central India, a unique rocky riverine landscape associated with the Narmada basin. Systematic faunistic surveys were conducted from July 2017 to October 2018 using manual collection and baited pitfall trapping techniques across multiple habitats. A total of 824 individuals representing 16 species, 10 genera, and three subfamilies were documented. The assemblage was dominated by the subfamily Scarabaeinae, indicating its ecological adaptability and functional significance in the region. Species distribution exhibited notable spatial heterogeneity and temporal variation, likely driven by seasonal climatic factors and resource availability. The findings highlight the ecological importance of dung beetle communities in maintaining ecosystem processes and underscore their potential as indicators for monitoring biodiversity loss and environmental degradation in central Indian landscapes.

Keywords: Dung beetles, scarabaeidae, spatiotemporal distribution, biodiversity, bhedaghat, central india, bioindicators, ecosystem functioning, faunal diversity, narmada basin

Introduction

Dung beetles (Coleoptera: Scarabaeidae) represent one of the most ecologically significant and taxonomically diverse groups of insects, exhibiting a widespread global distribution with peak diversity in tropical forests and savanna ecosystems (Hanski & Cambefort, 1991) [8]. With over 7,000 described species worldwide, they constitute a major component of terrestrial biodiversity within the order Coleoptera. These beetles primarily exploit the microorganism-rich liquid fraction of mammalian dung as a food resource, while the fibrous component is utilized for brood provisioning and larval development (Halffter & Matthews, 1966; Halffter & Edmonds, 1982) [5, 6]. Dung beetles are functionally classified into three principal guilds based on their nesting and resource utilization strategies: rollers (telecoprids), tunnelers (paracoprids), and dwellers (endocoprids). Rollers detach and transport dung balls away from the source for burial and reproduction, whereas tunnelers construct subterranean galleries beneath or near dung pats. In contrast, dwellers complete their life cycle within the dung itself. These functional groups reflect diverse evolutionary adaptations and play distinct roles in ecosystem processes. Taxonomically, most members of the subfamily Scarabaeinae—including tribes such as Dichotomiini, Coprini, Onitini, and Onthophagini—are predominantly tunnelers, while tribes such as Scarabaeini, Gymnopleurini, and Sisyphini are primarily rollers. Certain taxa within Oniticellini and Aphodiinae exhibit dwelling behavior, and some groups demonstrate kleptoparasitic tendencies, further highlighting the ecological complexity of dung beetle assemblages. Ecologically, dung beetles are key contributors to multiple ecosystem functions, including nutrient recycling, soil aeration (bioturbation), suppression of parasites, and secondary seed dispersal. These processes enhance soil fertility, promote plant regeneration, and maintain ecosystem stability (Andresen, 2002, 2003; Nichols *et al*., 2008) [1, 2, 12]. Due to their high sensitivity to environmental changes and habitat disturbances, dung beetles are widely regarded as effective bioindicators for assessing ecosystem health and biodiversity loss (Stokstad, 2004; Waterhouse, 1974) [13, 14]. Despite their ecological importance, studies on dung beetle diversity and distribution in central Indian landscapes, particularly in unique riverine and rocky habitats such as the Bhedaghat region of Jabalpur, remain limited. Therefore, the present study aims to investigate the spatiotemporal patterns, community composition, and ecological significance of dung beetle assemblages in this region, providing baseline data for future biodiversity monitoring and conservation strategies.

Materials and methods

Study Area

The present study was conducted in the Bhedaghat region of Jabalpur district, located in the central part of Madhya Pradesh, India. Jabalpur lies between 23°10′ N latitude and 79°59′ E longitude and is bordered by Mandla, Seoni, Narsimhapur, Damoh, Katni, and Dindori districts. The region represents a transitional landscape of central India with heterogeneous habitats supporting diverse faunal assemblages. Bhedaghat, situated approximately 20 km from Jabalpur city along the Narmada River, is geographically positioned at 23°07′55.20″ N latitude and 79°48′03.60″ E longitude, with an average elevation of 353 m above mean sea level. The study area is characterized by

a rocky terrain, predominantly composed of marble and calcareous substrata, interspersed with sparse vegetation and patches of grassland. The climatic conditions are typically tropical, with distinct seasonal variations influencing the availability of dung resources and beetle activity patterns.

Sampling Design and Collection Methods

Field surveys were carried out over a period of 16 months, from July 2017 to October 2018, covering monsoon and post-monsoon seasons to capture temporal variations in dung beetle assemblages. Multiple sampling sites were selected across different microhabitats within and around the Bhedaghat region to ensure comprehensive spatial coverage. Dung beetles were collected using a combination of standard entomological techniques, including:

Baited pitfall traps: Fresh mammalian dung was used as bait to attract coprophagous beetles. Traps were installed at ground level and monitored at regular intervals.

Manual collection: Beetles were directly collected from dung pats and surrounding substrates using forceps and hand picking.

Light trapping: Occasional light traps were employed to capture nocturnal species. All collected specimens were preserved and transported to the laboratory for further analysis.

Specimen Processing and Identification

Collected specimens were cleaned, sorted, and preserved following standard entomological protocols. Identification was carried out using morphological characters with the help of established taxonomic keys and literature, including Arrow (1931) [3], Mittal (1975, 1981a, 1993) [9, 10, 11], and Gupta (1992) [4]. Identification was performed up to species level wherever possible.

Data Analysis

The collected data were analyzed to determine species richness, relative abundance, and distribution patterns across different sampling sites and time periods. Species composition was assessed at the levels of subfamily, genus, and species. Spatiotemporal variations in dung beetle assemblages were interpreted in relation to habitat characteristics and seasonal changes.

Results and discussion

Extensive field surveys conducted across diverse habitats of the Bhedaghat region and adjoining areas of Jabalpur over a period of July 2017 to October 2018 resulted in the collection of a substantial number of dung beetles using standardized sampling techniques, including baited pitfall traps, manual collection, and light trapping. The study area encompassed a wide geographical range of over 650 km², covering heterogeneous habitats such as rocky riverine zones, grasslands, and semi-natural landscapes, thereby enabling a comprehensive assessment of dung beetle diversity and distribution. A total of 824 individuals were recorded during the entire sampling period, representing 16 species, 10 genera, and three subfamilies of Scarabaeidae. The assemblage was predominantly composed of members of the subfamily Scarabaeinae, which contributed the highest species richness and abundance, followed by Aphodiinae and Hybosorinae. This dominance of Scarabaeinae is consistent with previous studies, reflecting their ecological adaptability and functional significance in tropical and subtropical ecosystems. Among the recorded genera, eight genera—Gymnopleurus, Onthophagus, Onitis, Oniticellus, Tiniocellus, Copris, Catharsius, and Sisyphus—belonged to Scarabaeinae, while Aphodius and Hybosorus represented Aphodiinae and Hybosorinae, respectively. Genus-level representation indicated that Onitis exhibited the highest species richness (three species), followed by Oniticellus, Copris, Catharsius, and Hybosorus (two species each), whereas the remaining genera were represented by a single species. Species-wise abundance revealed a highly uneven distribution pattern within the assemblage. Dominant species included Copris caninicus (162 individuals), Onitis virens (124 individuals), Copris signatus (115 individuals), Catharsius sagax (91 individuals), and Aphodius campestris (77 individuals). These species collectively accounted for a major proportion of the total abundance, indicating their ecological success and adaptability to local environmental conditions. In contrast, several species such as Gymnopleurus parvus (2 individuals), Onthophagus catta (7 individuals), Oniticellus spinipes (7 individuals), and Tiniocellus spinipes (8 individuals) were represented by very low abundance, suggesting either habitat specificity, seasonal occurrence, or limited resource utilization. Temporal analysis revealed variation in species composition and abundance across the study period. During the first year, a total of 419 individuals belonging to 14 species and 8 genera were recorded, whereas the second year yielded 405 individuals representing 13 species and 7 genera. Although the overall abundance remained relatively consistent, a slight decline in species richness was observed in the second year. This variation may be attributed to fluctuations in climatic conditions, particularly rainfall and temperature, as well as changes in dung availability and habitat disturbances. The observed spatiotemporal heterogeneity in dung beetle assemblages highlights the influence of environmental gradients and resource dynamics on community structure. The dominance of tunneling and dwelling species further indicates their adaptive advantage in rocky and resource-variable habitats such as Bhedaghat. Moreover, the presence of both dominant and rare species suggests a structurally complex community with varying ecological niches. From an ecological perspective, the recorded dung beetle diversity underscores their critical role in ecosystem functioning, particularly in nutrient cycling, soil aeration, and organic matter decomposition. The sensitivity of several species to environmental changes further reinforces their utility as bioindicators for monitoring habitat quality and ecological integrity in central Indian landscapes. Overall, the present study provides baseline data on dung beetle diversity and distribution in a relatively underexplored region and contributes to the growing body of knowledge on insect biodiversity and ecosystem functioning in tropical ecosystems.

Table 1: Weekly abundance and distribution of dung beetle species in the Bhedaghat region (July–October, 2017–2018)

Species	Jl1	Jl2	Jl3	Ag1	Ag2	Ag3	Sp1	Sp2	Sp3	Oc1	Oc2	Oc3	Total
Gymnopleurus parvus	0	0	0	0	0	0	0	0	0	0	0	0	2
Onthophagus catta	0	0	0	0	0	0	0	0	0	0	0	0	7
Onitis virens	12	2	10	0	3	0	2	2	0	3	3	0	124
Onitis subopacus	3	11	2	1	3	2	0	0	2	0	0	0	78
Onitis philemon	4	2	3	2	0	4	9	1	4	2	0	1	54
Oniticellus cinctus	4	0	2	2	0	2	4	5	1	2	0	0	50
Oniticellus spinipes	0	0	0	0	0	0	0	0	0	0	0	0	7
Tiniocellus spinipes	0	2	1	3	0	2	0	0	0	0	0	0	8
Copris caninicus	14	0	0	5	1	0	0	0	1	0	1	0	162
Copris signatus	8	8	4	0	4	0	4	0	5	1	0	0	115
Sisyphus neglectus	0	0	0	0	0	0	0	0	0	0	0	0	3
Catharsius molossus	0	0	1	1	1	0	0	2	0	0	0	1	12
Catharsius sagax	8	2	2	4	17	13	4	0	0	1	1	0	91
Aphodius campestris	9	2	1	0	0	0	3	0	5	0	0	1	77
Hybosorus illigeri	0	0	2	0	0	3	0	2	0	0	0	0	19
Hybosorus orientalis	0	0	3	0	2	0	4	0	0	0	0	0	15
Total	62	29	31	18	31	26	30	12	18	9	5	3	824

The weekly distribution of dung beetle species revealed distinct temporal fluctuations in abundance across the sampling period (July–October). Peak abundance was recorded during the early monsoon phase (July), particularly in the first week (Jl1 = 62 individuals), indicating favorable environmental conditions such as higher moisture and dung availability. A gradual decline in abundance was observed towards October (Oc3 = 3 individuals), suggesting seasonal reduction in resource availability and beetle activity. Among all species, Copris caninicus (162 individuals), Onitis virens (124 individuals), and Copris signatus (115 individuals) exhibited the highest dominance, contributing significantly to overall abundance. Mid-monsoon periods (August) showed species-specific peaks, particularly for Catharsius sagax (Ag2 = 17 individuals), indicating temporal niche specialization. Conversely, several species exhibited very low or sporadic occurrence, reflecting either habitat specificity or seasonal constraints. Overall, the data demonstrate a clear spatiotemporal pattern, with maximum diversity and abundance during monsoon periods, emphasizing the role of climatic factors and resource dynamics in structuring dung beetle communities.

Conclusion

The present study provides a comprehensive assessment of the diversity, composition, abundance, and spatiotemporal dynamics of dung beetle assemblages in the Bhedaghat region of Central India. A total of 16 species belonging to 10 genera and three subfamilies were documented, highlighting the ecological richness of this relatively understudied landscape. The dominance of Scarabaeinae and the presence of both abundant and rare species indicate a structurally complex and functionally significant community. The observed temporal variation, with peak abundance during the monsoon season, underscores the strong influence of climatic factors and resource availability on dung beetle activity and distribution. Such seasonal patterns reflect the ecological sensitivity of these insects to environmental conditions and habitat characteristics. However, the study also indicates a potential decline in dung beetle diversity, which may be attributed to increasing anthropogenic pressures, including habitat degradation, land-use changes, and alteration of natural ecosystems. Notably, the use of veterinary pharmaceuticals, particularly steroidal and antiparasitic compounds administered to livestock, can adversely affect dung beetle populations by altering dung quality and toxicity. These substances may directly or indirectly disrupt beetle survival, reproduction, and ecological functioning.

Given their crucial role in nutrient cycling, soil aeration, parasite suppression, and secondary seed dispersal, any decline in dung beetle populations can have cascading effects on ecosystem health and productivity. Therefore, conservation of dung beetle diversity is of paramount importance for maintaining ecological balance and sustaining ecosystem services. The findings of this study establish baseline data for the region and emphasize the need for long-term monitoring, sustainable livestock management practices, and habitat conservation strategies. Integrating dung beetle conservation into broader biodiversity management frameworks will be essential for safeguarding ecosystem integrity in central Indian landscapes.

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