

Habitat-Associated Variations of Scarab Beetles in Semi-Arid Eastern Plain of Rajasthan, India

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ABSTRACT

The present study provides a habitat-specific assessment of the diversity and distribution of scarab beetle species in four different habitat types in semi-arid region of Rajasthan. Scarab beetle specimens were collected from four representative habitat types viz. agricultural lands, grasslands, open forests, and rocky terrains using systematically placed sampling plots with various standardized collection methods. A total of 1044 individuals of scarab beetles, representing 25 species and 18 genera belonging to the family Scarabaeidae, were collected. Scarabaeinae was recorded as the largest subfamily with 12 species, followed by Melolonthinae (5), Dynastinae (2), Cetoniinae (3), Aphodiinae (2), and Rutelinae (1). Across the all habitats, the species composition of scarab beetles in agricultural ecosystems exhibited the highest

richness, comprising 40.61% of the total population with 25 species, followed by grasslands (34.20%, 23 species), open forest (18.8%, 19 species), and rocky habitat with the lowest species richness (6.61%, 10 species). Based on presence-absence of scarab beetles across different habitats, 7 species (38.54%) were reported very common, 6 species (37.5%) common, 9 species (16.67%) moderate, and 3 species (2.08%) were found least common. *D. gazella*, *C. molossus*, *E. pallipes*, *O. taurus*, *O. philemon*, *A. crenatus*, *H. serrata* and *O. rhinoceros*, were widely distributed species over surveyed habitat types. Alpha diversity of scarab beetles varied significantly across the habitats, with ranges of diversity index viz., Shannon ($H' = 2.077-3.11$), dominance ($D = 0.04889-0.1397$), and evenness ($E = 0.7978-0.8972$). This study was a magnificent record of scarab beetles abundance and diversity in various habitats throughout the semi-arid region of Rajasthan.

Keywords Abundance, Diversity, Habitats, Scarabaeidae, Scarab beetle.

INTRODUCTION

Insects exhibit remarkable diversity, representing approximately two-thirds of all identified species globally. Scarab beetles are a group of polyphagous and holometabolous insects belonging to the order Coleoptera and family Scarabaeidae, accounting for nearly 10% of all beetle species with distinguished ecological importance (Piñero and Dudenhoefter 2018). The high species richness and diversity of

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scarab beetles across various habitats render them excellent biological indicators of ecosystem health and habitat quality. Scarab beetles primarily fulfill various ecological functions, such as scavenging, consuming plant material, aerating soil, suppressing dung flies and livestock parasites, controlling pests, providing trophic resources for insectivorous animals, and facilitating seed dispersal (Nichols *et al.* 2008; Young 2015). Nevertheless, despite their ecological significance, numerous species also pose considerable threats to agriculture, inflicting damage on crops during both their adult and larval phases (Aparna *et al.* 2018). Consequently, scarab beetles are recognized as both important providers of ecosystem services and potential agricultural pests, highlighting their dual ecological and economic importance (Fincher *et al.* 1981; Sewak 2006; Li *et al.* 2010; Henschel 2021). They play an active role in the decomposition of organic materials, such as dung and deceased organisms, thereby promoting nutrient cycling and enhancing soil health (Li *et al.* 2010; Nichols *et al.* 2008). By integrating organic matter into the soil, they improve soil structure, aeration, and the capacity to retain water. Additionally, these beetles assist in controlling parasites that lay eggs in dung and serve as significant agents in the dispersal of seeds that are excreted by frugivorous vertebrates (Andresen 2003).

Scarab beetles can be classified into two main lineages: Pleurosticti and Laprosticti, based on their feeding habits (Smith *et al.* 2006; Tarasov and Génier 2015). Pleurosticti are phytophagous comprising Melolonthinae, Rutelinae, Dynastinae, and Cetoniinae subfamilies. Some of the Dynastinae species exhibit phytophagous behavior at both the larval and adult stages. Adult beetles in some Dynastinae and Cetoniinae species are plant pests, whereas their larvae feed on soil organic matter or humus, exhibiting detritivorous behavior (Smith 2008, Sreedevi *et al.* 2022, Jiang *et al.* 2026). Laprosticti are coprophagous, comprises dung beetles and include the Scarabaeinae and Aphodiinae subfamilies (Halffter and Matthews 1966; Hanski and Cambefort 1991, Barlow *et al.* 2010, Culot *et al.* 2013). Dung beetles are detritivores that consume carcasses, decomposing fruit, and mammalian excrement for sustenance and nest construction. These beetles play significant

ecological roles, including seed dispersal (Braga *et al.* 2013), the removal of waste (Horgan 2005; Kenyon *et al.* 2016), nutrient cycling, enhancement of plant growth, bioturbation, elimination of parasites, and controller of fly populations (Nichols *et al.* 2008, Sreedevi *et al.* 2022). Such ecological services arise from their nesting and feeding behaviors (Hanski and Cambefort 1991). The community of dung beetles is divided into three functional groups according to their approaches to managing fecal matter: Telecoprids form a fecal ball and roll it away from the origin for burial or surface placement; endocoprids feed on material found within or under fresh feces without moving it; and paracoprids dig tunnels beneath or adjacent to feces to bury a fecal mass (Halffter and Edmonds 1982).

Globally, there are approximately 36,448 recognized species of scarab beetles, categorized into 19 subfamilies (GBIF.org, 7 July 2024). The diversity of scarab beetles across various Indian regions has been documented by several researchers, including Sabatinelli (1992), Sabu *et al.* (2006), Chandra and Ahirwar (2007), Ahrens and Fabrizi (2011), Bhawane *et al.* (2012), Chandra *et al.* (2015), Sreedevi *et al.* (2018), Kalawate (2018), and Sharma *et al.* (2019). In India 6,598 species were reported across the subfamilies Aphodiinae, Cetoninae, Dynastinae, Melolonthinae, Rutelinae, Scarabaeinae, and Orphinae (GBIF.org, 7 July 2024). Scarab beetles are highly ecologically adaptable and are frequently found in a wide range of habitat types in India, including agricultural lands, grasslands, tropical forests, and arid zones. They are widely adapted to most terrestrial habitats comprising of phytophages, fungivores, herbivores, necrophages, coprophages and saprophages and are ubiquitous. Their abundance and composition are affected by habitat-specific factors such as organic matter availability, soil moisture, vegetation structure, and the presence of mammalian herbivores. Forest ecosystems, with dense vegetation and decomposing organic matter, support a high species diversity, whereas agricultural fields and grasslands provide ideal conditions for coprophagous and saprophagous species (Shah and Shah 2022). The degradation of natural habitats and changes in the land use patterns are posing threat to biodiversity worldwide (Newbold *et al.* 2015).

The state Rajasthan which is regarded as a semi-arid agro climatic zone is located in the west part of India. The state stands out for its rich biological diversity, attributed to its distinctive biogeographic position, diverse climatic conditions, and significant ecological and geological variability. Some of the studies on the diversity of beetles in the Thar Desert, southern and shekhawati region of Rajasthan, have been conducted by Kazmi and Ramamurthy (2004), Sewak (2005), Parvez and Srivastava (2010), Kumar *et al.* (2017), Chaudhary (2019), Jakhar *et al.* (2021), and Prajapat *et al.* (2025). But, little is known about the species diversity and community structures of scarab beetles in the Jaipur region due to a lack of scientific research. Thus, there is a need for comprehensive data recording and analysis on scarab beetles to monitor the health of the ecosystem and inform conservation policy and action. Therefore, the present research work was aimed to establish foundational information regarding the occurrences of scarab beetle species and spatial patterns across different habitat types within the Jaipur region of Rajasthan. It was further evaluated whether species composition and diversity, richness, and population abundance significantly differ among the surveyed habitats. The outcomes of this investigation are expected to play a foundational role in using scarab beetles as bio-indicators for evaluating and monitoring the ecological integrity and recovery status of restored habitats in and around Jaipur.

MATERIALS AND METHODS

Study area

The study of scarab beetles was carried out in the Jaipur region a semi-arid eastern region of Rajasthan (Fig. 1). This area is geographically situated between latitudes 26°23' and 27°51' N, and longitudes 74°55'

and 76°50' E, with an elevation of 431 meters. The total expanse of Jaipur district encompasses 11,152 square kilometers. The topography of the Jaipur region is remarkably varied, characterized by rugged hills, undulating plains, and isolated hillocks, predominantly influenced by the Aravalli hill range. These ancient mountains, composed of quartzite and schist, stretch in a Northeast-Southwest orientation, creating prominent ridges and valleys. Also, the landscape is dominated by large flat areas and alluvial plains with sandy and loamy soils. The semi-arid climate of the region, coupled with structural faults and lineaments, significantly affects soil erosion, vegetation distribution, and urban development, rendering its topographical characteristics crucial for regional planning and resource management. The summer temperatures in Jaipur reach extreme levels, ranging from 40°C to 47°C, while the winters are mainly frigid, with temperatures between 4°C and 9°C, occasionally dropping below 0°C. The monsoon season, occurring from July to September, averages yearly precipitation of 633 mm in Jaipur.

The study area was categorized into four distinct sites: Chomu, Viratnagar, Amer, and Bassi (Table 1, Fig. 1). The selection of the sampling sites was based on different habitat characteristics who had an extensive understanding of the soil types, vegetation types, and land use systems occurring in the study area. These sites represent a variety of ecoregions, including agricultural land, grasslands, open forests, and rocky terrains. The agricultural zones are primarily characterized by food crops, including wheat, mustard, various vegetables, and bajra, alongside agroforestry species like neem and khejri. The grasslands are predominantly populated by resilient grasses, as well as an assortment of shrubs and herbs. In the open forests and scrublands, one can find dry deciduous and thorny trees, such as Dhak (*Butea*

Table 1. Study sites of the study area with habitat characteristics.

Sl. No.	Study sites	GPS Coordinates	Habitats
1.	Chomu	27.1656° N latitude; 76.0521° E longitude	Agricultural, grassland, open forest, rocky areas
2.	Viratnagar	27.4316° N latitude; 76.1794° E longitude	Grassland, rocky areas
3.	Amer	26.9880° N latitude; 75.8610° E longitude	Open forest, rocky areas
4.	Bassi	26.8419° N latitude; 76.0521° E longitude	Agricultural, grassland areas

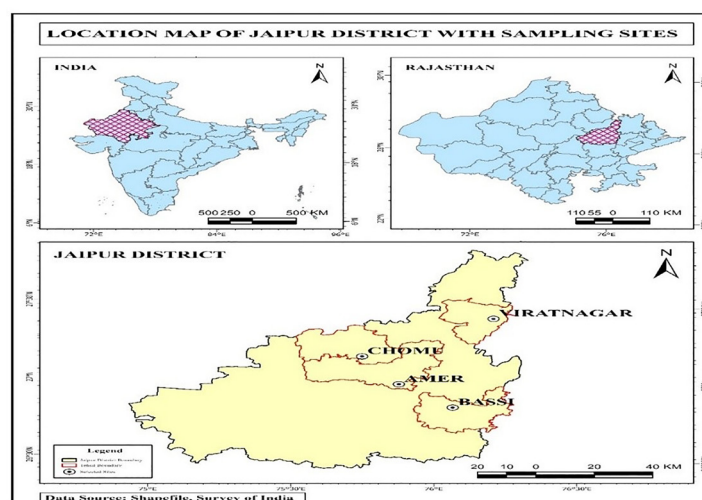


Fig. 1. Map showing the location of four study sites in Jaipur region, Rajasthan (Source, QGIS 3.40.2).

monosperma), Babul (*Acacia nilotica*), and Rohida (*Tecomella undulata*), in addition to a variety of wild and medicinal plants. The rocky terrains support hardy vegetation, including jujube (*Ziziphus mauritiana*), various Euphorbia species, and cacti, which thrive in the challenging, arid soils. Overall, the diverse flora of the Jaipur region illustrates a harmonious interplay between cultivated agricultural areas, natural ecosystems, and resilient species that not only withstand the harsh climate but also sustain both wildlife and human communities.

Study design and data collection

Survey and sampling of scarab beetles was done throughout the study period from March 2023 to February 2024 in different habitats of study sites in Jaipur region. The assessment was carried out of beetle abundance and diversity biweekly employing different sampling methods according to the surveyed habitats. Firstly, the line transect method is a walk along a predetermined path (transect line) of 50–100 m and record the beetles observed within a certain distance from the line. It is particularly useful in open habitats where beetles can be easily seen and counted (Magurran 2004). We used this method in grassland, open forest, and agricultural regions. Secondly, the quadrat sampling method divides the habitat into small and equal quadrates (20 m²) to survey insects and provide data on species distribution and density

(Southwood and Henderson 2000). This method was applied in agricultural and grassland regions. Lastly, the visual survey method is a method where observers actively search for beetles in a specified area, often using sight. It is effective in areas with diverse vegetation, where insects might be easily seen. This method was applied across all habitats, including grassland, agricultural, open forest, and rocky regions. The collection of beetles was carried out in the early morning (7 AM to 11 AM), when the frequency of beetles is high due to low flight activity and they can be easily collected. The specimens were collected systematically from different habitats of the study area. The nocturnal beetles were collected by the light trap method, while the diurnal beetles were collected by handpicking, pitfall traps, sweep netting.

Preservation and identification

Sampled beetles were brought to the entomology laboratory at the Department of Zoology, University of Rajasthan, Jaipur to be processed for pinning, stretching, and drying and then preserved in wooden boxes with para dichlorobenzene for further study. The specimens were sorted according to different functional guilds; dwellers (endocoprids), rollers (telecoprids) and tunnelers (paracoprids) and phytophagous following Hanski and Cambefort (1991). These specimens were identified using a stereoscopic binocular microscope (Cilika) and standard identi-

fication keys via Arrow (1931), Balthasar (1963a), Balthasar (1963b), Vaz de Mello *et al.* (2011), Chandra and Gupta (2013), Nemes and Price (2015), and Kharel *et al.* (2020), as well as by comparing them to confirmed specimens in the insect museum at the University of Rajasthan's Department of Zoology.

Data analysis

Diversity indices, such as Shannon-Wiener (H'), Simpson (D_x), Dominance (D), Evenness (E), and Margalef richness (M_x), were calculated using species abundance data (Magurran 1988). Species were classified into four categories based on occurrence frequency: Very common (90-70 sightings), common (70-50), moderate (50-30), and rare (30-10). Bray-Curtis cluster analysis (with single linkage) was used to assess habitat similarity and species composition using Paleontological Statistical Software, version 4.03 (McCune and Mefford 1999). Species richness was estimated using rarefaction curves, and multivariate patterns were studied using Principal Component Analysis (PCA) and chord diagrams (using OriginPro 2026). Pearson's chi-square test was used to assess significant differences in beetle assemblages across habitats.

RESULTS

Scarab beetle species composition

A total of 1044 individuals of 25 scarab beetle species belonging to the Scarabaeidae family, encompassing

6 subfamilies and 18 genera, were collected across the four habitats surveyed in the Jaipur region (Table 2). The study area showed numerical variations of scarab beetle's species belonging to each subfamily. The subfamily Scarabaeinae was reported as the most dominant, with 12 species grouped under 8 genera, which accounted for 43.97% of the total collected species, followed by Melolonthinae (5 species and 4 genera, 21.26%), Cetoniinae (3 species, 3 genera, 12.93%), Dynastinae (2 species, 2 genera, 7.38%), Aphodiinae (2 species, 1 genera, 8.62%), while subfamilies Rutelinae had the least with 1 species under 1 genus each, which contributed 5.84% of total recorded species (Fig. 2, Fig. 3). On the basis of presence-absence of scarab beetles at different habitats, 7 species constituted of 38.54% relative abundance were reported very common, 6 species (37.5%) were common, 9 species (16.67%) were moderate, and 3 species (2.08%) were recorded least common (Table 2).

Patterns of beetle species richness, diversity, and abundance in four habitat types in the Jaipur region

The scarab beetle's distribution and abundance were observed across different habitats, viz., agriculture, grassland, open forest, and rocky regions of the study area. The highest species richness of scarab beetles was observed in agricultural areas, accounting for 40.6% individuals comprising 25 species of the total population. Grasslands followed with 34.2% individuals (23 species), showing a significant presence of

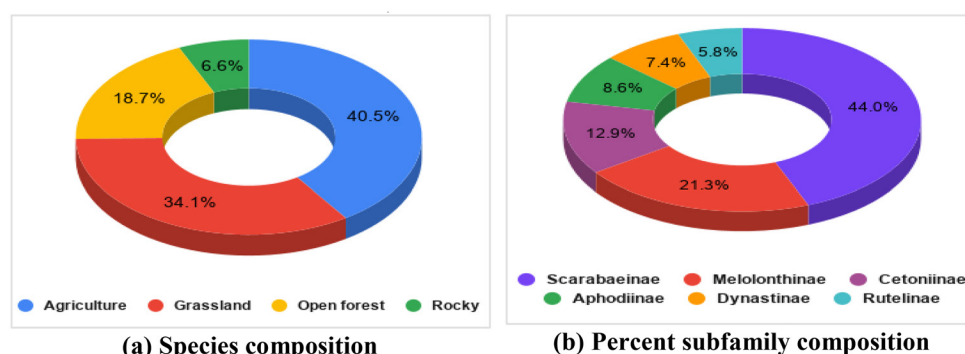


Fig. 2 (a) Species composition and (b) Percent subfamily composition of scarab beetles recorded in different habitats of Jaipur region, Rajasthan.

Table 2. Distribution and abundance of scarab beetles across the different habitat types in Jaipur region.

Subfamily	Species	Agricul- tural	Grass- land	Open forest	Rocky	Observation frequency (%)	Relative abundance (%)	Functional guild	Status
Scarabaeinae	<i>Helicopriss bucephalus</i> (Fabricius 1775)	+	+	+	–	75%	3.93	Tunneller (paracoprid)	C
	<i>Euoniticellus pallipes</i> (Fabricius 1781)	+	+	+	+	100%	1.92	Tunneller (paracoprid)	M
	<i>Gymnopleurus miliaris</i> (Fabricius 1775)	+	+	+	–	75%	1.53	Roller (telecoprid)	LC
	<i>Catharsius molossus</i> (Linnaeus 1758)	+	+	+	+	100%	4.98	Tunneller (paracoprid)	C
	<i>Catharsius pithecius</i> (Fabricius 1775)	+	–	+	+	75%	4.31	Tunneller (paracoprid)	C
	<i>Catharsius sagax</i> (Quensel 1806)	+	+	–	–	50%	1.72	Tunneller (paracoprid)	LC
	<i>Onthophagus sp.</i> (Latreille 1802)	+	+	–	–	50%	2.01	Tunneller (paracoprid)	M
	<i>Digitonthophagus gazella</i> (Fabricius 1787)	+	+	+	+	100%	8.52	Tunneller (paracoprid)	VC
	<i>Onthophagus taurus</i> (Schreber 1759)	+	+	+	+	100%	6.23	Tunneller (paracoprid)	VC
	<i>Onthophagus tarandus</i> (Fabricius 1792)	+	+	–	–	50%	1.63	Tunneller (paracoprid)	LC
	<i>Onitis philemon</i> (Fabricius 1801)	+	+	+	+	100%	4.69	Tunneller (paracoprid)	C
	<i>Cheironitis sp.</i> (Lansberge 1875)	+	+	+	–	75%	2.49	Tunneller (paracoprid)	M
Aphodiinae	<i>Aphodius moestus</i> (Fabricius 1801)	+	+	–	–	50%	5.17	Dweller (endocoprid)	C
	<i>Aphodius crenatus</i> (Harold 1862)	+	+	+	+	100%	3.45	Dweller (endocoprid)	M
Melolonthinae	<i>Holotrichia serrata</i> (Fabricius 1781)	+	+	+	+	100%	5.94	Phytophagous	VC
	<i>Anoxia villosa</i> (Fabricius 1781)	+	+	+	–	75%	2.59	Phytophagous	M
	<i>Maladera castanea</i> (Arrow 1911)	+	+	+	–	75%	6.80	Phytophagous	VC
	<i>Holotrichia sp.</i> (Hope 1837)	+	+	+	+	100%	3.07	Phytophagous	M
	<i>Serica brunnea</i> (Linnaeus 1758)	+	+	+	–	75%	2.87	Phytophagous	M
	<i>Oryctes rhinoceros</i> (Linnaeus 1758)	+	+	+	–	100%	5.27	Phytophagous	VC
Dynastinae	<i>Heteronychus arator</i> (Fabricius 1775)	+	+	–	–	50%	2.11	Phytophagous	M
Cetoniinae	<i>Protactia alboguttata</i> (Vigors 1826)	+	+	+	–	75%	5.94	Phytophagous	VC
	<i>Protactia aurichalcea</i> (Fabricius 1775)	+	–	+	–	50%	4.69	Phytophagous	C
	<i>Chiloloba acuta</i> (Wiedemann 1823)	+	+	–	–	50%	2.30	Phytophagous	M
Rutelinae	<i>Anomala sp.</i> (Samouelle 1819)	+	+	+	–	75%	5.84	Phytophagous	VC

VC (very common), C (common), M (moderate), R (rare).

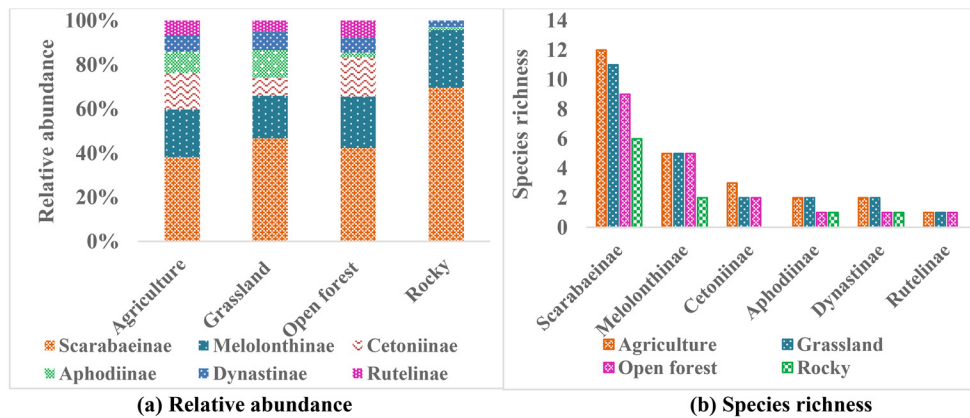


Fig. 3. Habitats in the study area showing (a) relative abundance and (b) species richness of scarab beetle subfamilies.

beetles. Open forests contributed 18.8% abundance (19 species), indicating a moderate distribution, while rocky habitats supported the lowest proportion at only 6.7% individuals (10 species) (Fig. 3). The mean box whisker plots explained that agricultural areas had highest median abundance, indicating presence of more beetles than other habitats. Grasslands followed, with a wide range of values and some extreme outliers, indicating environmental heterogeneity. Open forests showed moderate beetle abundance with narrower range, whereas rocky habitats showed the lowest median and range, indicating scarab beetles' suitability was limited. These findings suggest that

habitat types had a strong influence on beetle abundance, most likely due to differences in vegetation cover, soil conditions, and resource availability (Fig. 4).

The rarefaction curve findings showed variation in abundance of beetles in habitats; where a steep curve indicated high diversity and shallow curve indicated low diversity. Likewise, the agricultural regions exhibited the highest species diversity, followed by grasslands, while open forests maintained a moderate level of species. In contrast, rocky habitats demonstrated the lowest species richness, likely due

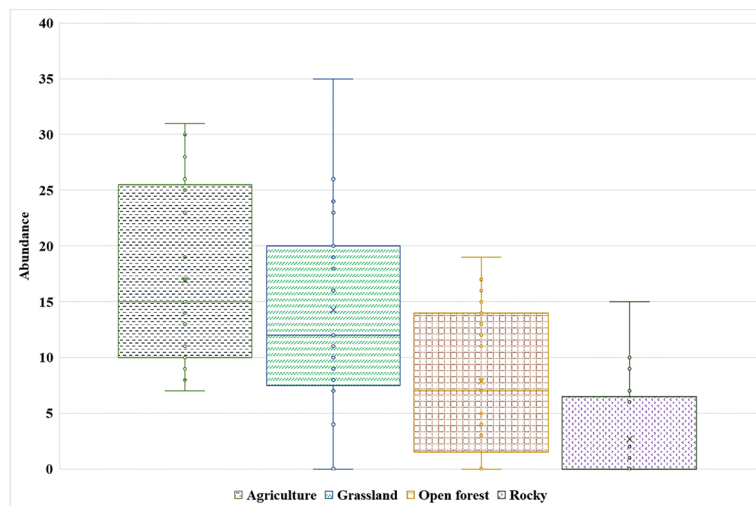


Fig. 4. Mean box whisker plot of relative abundance of scarab beetles in different habitats.

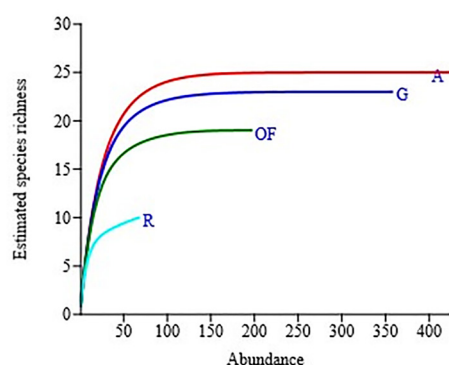


Fig. 5. Rarefaction curves of estimated species richness in four habitat types. A (Agriculture); G (Grassland); OF (Open Forest); R (Rocky)

to harsher environmental conditions and limited resources. These findings underscored the impact of habitat type on biodiversity, revealing the differing levels of species diversity present in various ecosystems (Fig. 5). The chord diagram illustrates the distribution and relative abundance of scarab beetle species across four different habitat types, where the width of the connecting arcs signifies the strength of species habitat associations. Certain species, including *Onthophagus* sp., *C. molossus*, and *D. gazella*, display broader connections across various habitats, suggesting a higher abundance and generalist behavior. Conversely, some species demonstrate stronger associations with particular habitats, indicating habitat preference and specialization, especially in

rocky and agricultural environments. The variation in the thickness of the arcs emphasizes the differences in species dominance among the habitats. So, the diagram reveals that scarab beetle communities are organized by habitat type, with both generalist and specialist species playing a role in diversity and ecosystem functioning (Fig. 6).

Further, the distribution of beetle subfamilies across four habitats was compared using the Pearson's chi-square test, and the results revealed a statistically significant relationship between numerical assemblage of beetle subfamilies and habitat types ($\chi^2 = 61.01$, $df=15$, $p\text{-value} < 0.0001$).

The Scarabaeinae subfamily was recorded with highest species richness in agriculture and grassland respectively 12 species and 11 species. The study findings indicated that *C. molossus*, *D. gazella*, *E. pallipes*, *O. taurus*, *O. philemon*, *A. crenatus*, *H. serrata* and *O. rhinoceros* were quite commonly present species across all four habitat types surveyed. *D. gazella* was the most abundant species, with a total of 89 individuals, accounting for 8.52% of the overall population. *O. taurus* and *H. serrata* were the second most abundant species, each with 65 (6.23%) and 62 (5.94) individuals. Three species, *G. miliaris* (16 individuals), *O. tarandus* (17 individuals), and *C. sagax* (18 individuals), were the least abundant (Table 2). In the context of abundance, *M. castanea* ($n=31$) was recorded highest abundant in agricultural habi-

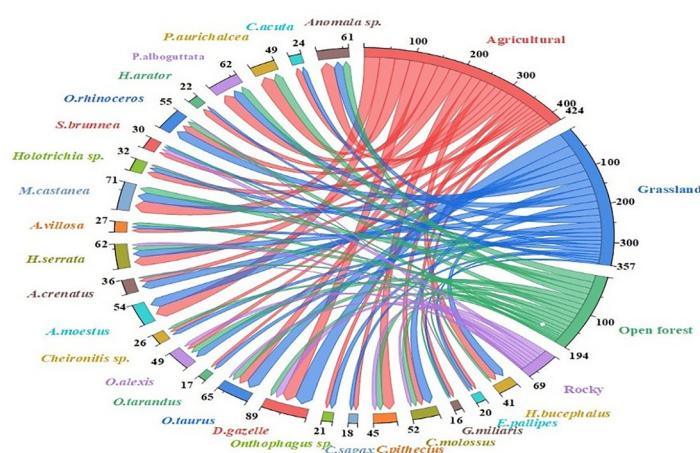


Fig. 6. Chord diagram showing the distribution and relative abundance of scarab beetle species across four habitat types.

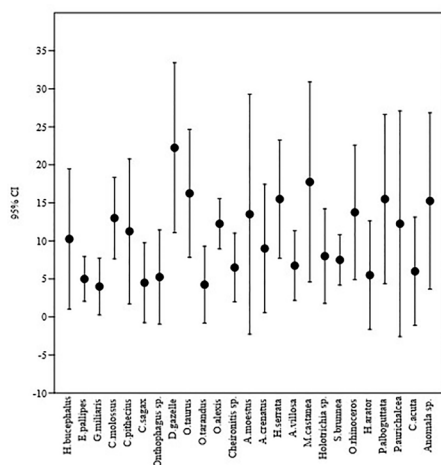


Fig. 7. Mean abundance of scarab beetles species at 95% confidence interval (CI).

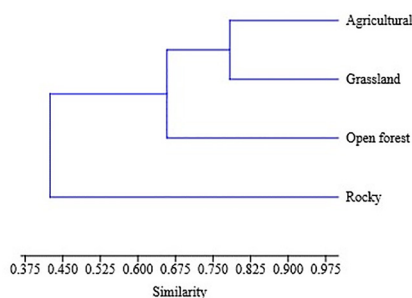


Fig. 8. Bray-Curtis cluster analysis dendrogram showing the distance relationship between habitats.

tats, while *O. tarandus* ($n=7$) was observed lowest. In grassland habitats, *D. gazella* ($n=35$) exhibited the

highest abundance, whereas *E. pallipes* ($n=7$) and *S. brunnea* ($n=7$) were found the least abundant. In open forests, *P. aurichalcea* ($n=19$) was the most abundant species, while *E. pallipes* ($n=3$) and *G. miliaris* ($n=3$) showed the lowest abundance. In rocky habitats, *D. gazella* ($n=15$) again exhibited the highest abundance, whereas *A. crenatus* ($n=1$) and *E. pallipes* ($n=1$) were the least abundant (Table 2). An average abundance of various scarab beetle species was analyzed accompanied by their 95% confidence intervals (CI). Each species was represented by a mean abundance value, with vertical error bars denoting the range of uncertainty at a 95% confidence level. Species such as *D. gazella* and *M. castanea* exhibit greater variability, as evidenced by their extended error bars, whereas species like *G. miliaris* and *O. tarandus* displayed shorter bars, indicating more stable population estimates. This variability underscores the differences in species distribution and stability across various habitats, offering insights into which species maintain consistent populations and which demonstrate fluctuating abundance levels (Fig. 7).

The analysis of the similarity within the scarab beetle community across different habitats, using the Bray-Curtis index, revealed that the species composition in grassland and agriculture formed the most closely related group, demonstrating the highest level of similarity. Open forest showed some degree of similarity to these habitats but remained distinct. In contrast, the rocky habitat was remarkably different from the others, suggesting a unique composition of beetle species. This pattern underscores the significant

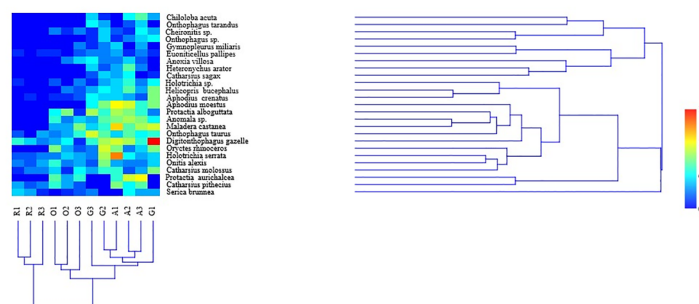


Fig. 9. Two-way clustered heat map based on Bray-Curtis clustering method, illustrating the relative abundance of scarab beetles species across four habitat-season groups: A= agricultural, G= grassland, O= open forest, and R= rocky. Color intensity reflects relative abundance (red = high, blue = low). Clustering was performed using Bray-Curtis clustering method on Euclidean distances. The dendrogram showing the distance relationship between species composition in different habitats.

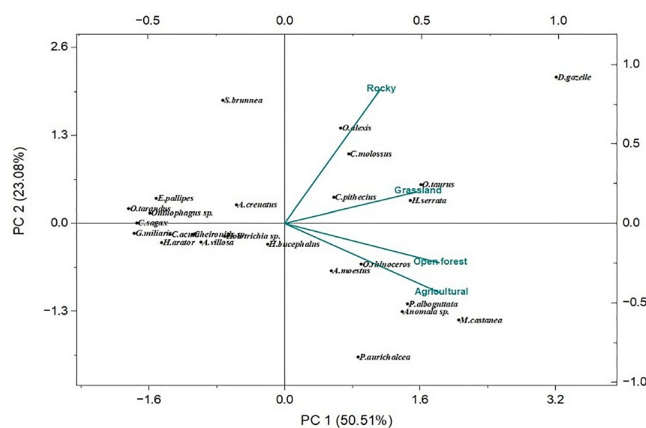


Fig. 10. Principal Component Analysis (PCA) ordination showing the relationship between scarab beetle species abundance and four habitat types in the study area. The first two principal components (PC1: 50.51%, PC2: 23.08%) explain the major variation in species distribution across habitats.

influence of habitat type on beetle distribution, with environments that are more closely related supporting

similar beetle communities (Fig. 8). Furthermore, the two-way clustered heat map reveals clear and

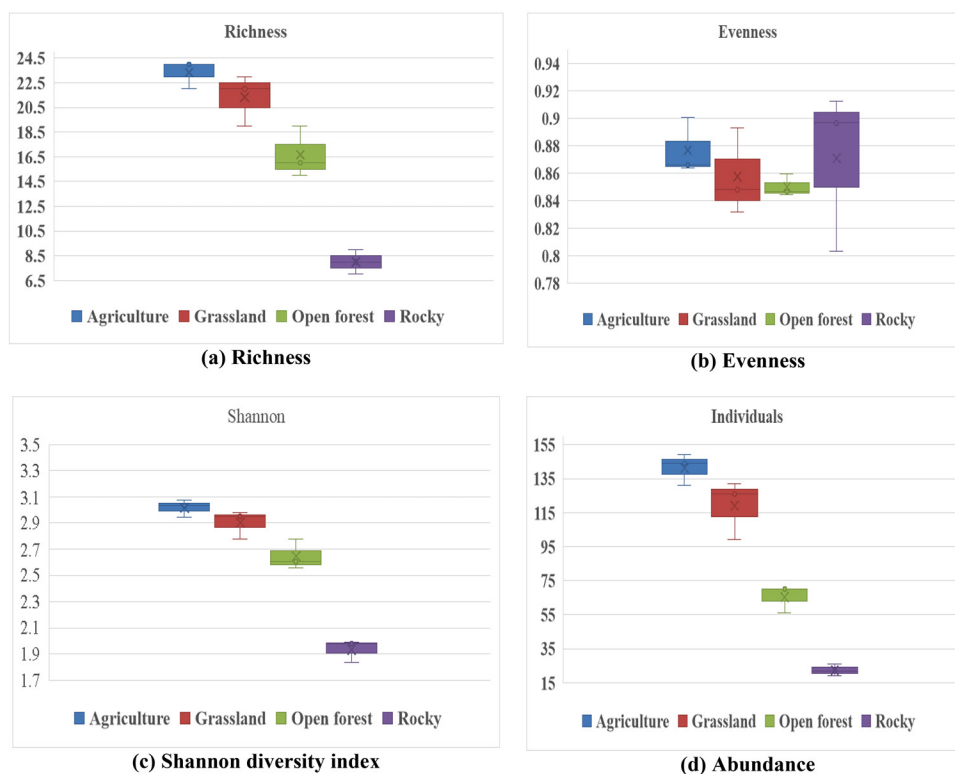


Fig. 11. Pattern of Scarab beetles (a) Richness, (b) Evenness, (c) Shannon diversity index, and (d) abundance across the four habitat types in Jaipur.

Table 3. Eigenvalues and percentage of variance explained by principal components.

Principal components	Eigenvalue	Percentage of variance	Cumulative % of variance
PC1	2.02055	50.51%	50.51%
PC2	0.92308	23.08%	73.59%
PC3	0.71091	17.77%	91.36%
PC4	0.34546	8.64%	100.00%

distinct patterns in the distribution of scarab beetle species across the four habitats. Species are grouped into specific clusters based on similarities in their relative abundance, indicating that several beetle species show a strong preference for particular habitats, while others occur across multiple habitats but with comparatively lower abundance. Along the habitat axis, agricultural and grassland sites cluster closely together, suggesting a broadly similar scarab beetle community composition in these habitats. In contrast, open forest and rocky habitats form separate clusters, reflecting the presence of distinct and unique beetle assemblages associated with these environments. Warmer color intensities (yellow to red) highlight species that are highly abundant within specific habitats, whereas cooler colors (blue) indicate species that are rare or absent (Fig. 9).

The PCA biplot shows distinct habitat-driven variation in scarab beetle assemblages, with PC1 (50.51%) and PC2 (23.08%) contributing to 73.59% of the total variance. Species on the positive side of PC1 are strongly associated with open forest, agricultural, and grassland habitats, whereas those closer to the origin have generalist behavior despite low habitat specificity. Overall, the ordination shows that habitat type significantly influences scarab beetle communities, with distinct species assemblages corresponding to specific environmental conditions (Fig. 10, Table 3).

The values of alpha diversity indices, viz., Shannon Diversity index, ranged from 2.077 to 3.11 and were recorded highest at agriculture ($H = 3.015$); Simpson's Diversity index ranged from 0.8603 to 0.9511 and was recorded highest at agriculture ($1-D = 0.9511$); Dominance index ranged from 0.1397 to 0.06591 and was recorded highest at open forest (D

$= 0.06591$); Evenness ranged from 0.7978 to 0.8972 and was recorded highest at agriculture habitat ($E = 0.8972$); and also Margalef's ranged from 2.14 to 3.967 and was recorded highest at agriculture habitat (3.967) (Fig. 11).

DISCUSSION

This research examined that the diversity, abundance, and composition of scarab beetle species varied with respect to habitat types in the Jaipur that will be incorporated into coleopteran fauna of Rajasthan, for the future research, monitoring, and conservation. 1,044 scarab beetles representing 25 species of scarab beetles of Scarabaeidae family, encompassing 6 subfamilies and 18 genera, were collected. The extrapolation and interpolation curves demonstrated the possibility of discovering more species in the study area. Similarly, 94 species of scarab beetles from 30 genera and 9 subfamilies were recorded in Madhya Pradesh (Chandra 2000), later in 2015 this record had extended to 53 scarab beetle species, 27 genera, and 6 subfamilies was documented. Also, Bhawane *et al.* (2012) identified a checklist of 26 dung beetle species within the Scarabaeinae subfamily in the Sindhudurg region of Maharashtra. Furthermore, 13 distinct species of dung beetles attracted to unconventional resources in various regions of India (Karimbumkara and Priyadarsanan 2016). Additionally, 44 species of scarab beetles from Assam, representing 21 genera across 6 subfamilies were recognized (Bhattacharyya *et al.* 2017). Also, 34 dung beetle species from 11 genera and 7 tribes were found across a forest-agriculture habitat in South Western Ghats (Latha and Sabu 2018).

In the present work, the subfamily Scarabaeinae emerged as the quantitatively predominant, accounting for 43.97% of the total collected beetles followed by Melolonthinae at 21.26%. This study is in agreement with Thakare *et al.* (2011), who identified the Scarabaeinae subfamily exhibiting the highest diversity, including 15 species, in the Kolkas area of the Melghat Tiger Reserve, Amravati, Maharashtra. Furthermore, Aparna *et al.* (2018) identified Melolonthinae (18) and Aphodiinae (9) as most abundant groups across six coastal ecosystems in Puttur, Karnataka. Similarly, Dadmal and Khada-

kkar (2014), Pathania *et al.* (2015), Bhattacharyya *et al.* (2017), and Sreedevi *et al.* (2017) informed predominance of the Scarabaeinae and Melolonthinae subfamilies in terms of both abundance and species richness, aligning with the observations of previous researchers. Similarly, Geetha and Agarwala (2018), reported 19 species of scarab beetles in Tripura. Moreover, Patole (2019) provided an updated checklist of 15 species of scarabaeoid beetles in Sakri, Dhulia District, Maharashtra. Also, Murthy (2020) reported the abundance of the Melolonthinae subfamily at 38.23%, followed by Rutelinae at 20.58%, Cetoniinae at 17.66%, Scarabaeinae at 17.64%, and Dynastinae at 5.88% among scarab beetles in South Indian states. Similarly, Pralhad (2022) documented 22 scarab species from 12 genera and three subfamilies in Mahad tehsil, Raigad district, Western Ghats, Maharashtra.

In Rajasthan, although comprehensive work was not undertaken specially on scarab beetles fauna. Earlier, 22 scarab beetle species in the Thar Desert of Rajasthan (Kazmi and Ramamurthy 2004), and 12 genera and 85 species of dung beetles in the Thar Desert areas of both Gujarat and Rajasthan (Sewak 2009) were reported. Further, 8 species of the scarab beetles in Bikaner, Western Rajasthan (Parvez and Srivastava 2010), 9 genera from the Shekhawati region (Chaudhary 2019), 09 scarab species (Melolonthinae and Rutelinae) across various locations in Rajasthan (Jakhar *et al.* 2021), 12 species within 10 genera of the Scarabaeidae family in the Aravalli range of Jaipur (Prajapat *et al.* 2025), and 45 scarab species from Jhunjhunu District, Rajasthan (Meena, 2025) were identified.

In the current study, alpha diversity values of scarab beetles varied significantly across the habitats, with ranges of diversity index viz., Shannon ($H' = 2.077\text{--}3.11$), dominance ($D = 0.04889\text{--}0.1397$), and evenness ($E = 0.7978\text{--}0.8972$). Similarly a comparable investigation reported on alpha diversity indices, specifically the Shannon index ($H = 3.01\text{--}3.03$) and the Simpson's index of diversity ($D = 0.94$), with the highest values observed in Palampur (Pathania *et al.* 2015). Similarly, the highest recorded Shannon index ($H' = 3.03$) and Simpson's index of diversity ($D = 0.92$) were found in various ecosystems within Puttur taluk, located in the coastal region of Karnataka, India

(Aparna *et al.* 2018). Additionally, Kotilingam (2020) documented a notable Shannon-Weiner diversity index of 2.73 for scarabaeid beetles in Karnataka, highlighting the significant species diversity present in these agricultural environments.

The research hypothesized that the Jaipur region possessed greater species diversity, richness, and abundance of scarab beetle populations because of the increase in herbivores in grassland and agricultural ecosystems which positively influences the abundance of scarab beetle populations. The rural area of Jaipur, characterized by a significant cattle population, increases the availability of dung resources, thereby fostering a diverse array of dung beetle species. The variations in species composition and abundance in these areas indicate the impact of habitat structure, vegetation cover, organic matter input, and microclimatic conditions on beetle assemblages. In the study, across all habitats, the species composition of scarab beetles in agricultural ecosystems exhibited the highest richness, comprising 40.6% of the total population, followed by grasslands (34.2%), open forest (18.8%), and rocky habitat with the lowest species richness (6.61%). The agricultural habitats showed the greatest number of numerous species, such as *M. castanea* (31), *P. aurichalcea* (30), *A. moestus* (30), *P. alboguttata* (26), and *D. gazella* (28). This richness can be attributed to common human activities like the presence of cattle, the use of manure, and the piling up of crop residues, which increase the quantity of dung and organic matter, key resources for coprophagous beetles. Relatively uniform soil moisture due to irrigation, coupled with a heterogeneous plant matrix, also enhances detritivorous beetle microhabitat suitability. Similar observations were reported by Ndozi *et al.* (2025), where agroecosystems, despite being disturbed, supported a high abundance of beetles when dung input was sustained. Grasslands supported the highest species representation and moderately high density, with dominant species including *D. gazella* (35), *O. taurus* (26), *A. moestus* (24), *O. rhinoceros* (23), and *C. molossus* (20). These open habitats offer stable herbaceous cover and are frequently visited by grazing livestock and wild herbivores, providing a consistent source of dung. Furthermore, the structural simplicity of grasslands may facilitate easier detection of dung patches and lessen interspecific competition.

Similarly noted by Salomão *et al.* (2023), moderately disturbed grasslands maintained high beetle diversity based on intermediate habitat complexity and resource stability. Furthermore, open forests showed moderate but ecologically rich infestations of beetles, with the presence of species like *O. philemon* (14), *P. alboguttata* (16), *M. castanea* (17) and *P. aurichalcea* (19), in abundance. The partial canopy cover allows for the co-occurrence of both sun-adapted and shade-tolerant species, and the addition of leaf fall and decaying organic matter aids in the heterogeneity of resources. However, the decreased dung input due to low herbivore activity could explain the slightly reduced abundance compared to grasslands and agricultural areas. However, the forest structure offers refugia and microhabitats that can accommodate species requiring more complex environmental cues for feeding and oviposition. Moreover, rocky habitats exhibited the lowest abundance of beetles and the most restricted representation of species. There were only a few species, such as *C. molossus* (7), *C. pithecius* (9), *D. gazelle* (15), and *S. brunnea* (10), that were moderately represented, while most were rare or not present. These habitats are typically typified by low vegetation cover, poor soil development, high surface temperatures, and low water-holding capacity, which collectively cause low rates of dung decomposition and limited resource availability. The extreme microclimatic conditions and limited organic substrate availability explain the low colonization success in such environments. Similar low species richness has been reported in disturbed or marginal environments around the globe owing to these restrictions. Also, the soil profile of the region, predominantly sandy loam to alluvial with interspersed gravel and rocks, further facilitates the burrowing and nesting behaviors that are essential to the life cycles of scarab beetles. During the monsoon season, high rainfall and vegetation cover are directly correlated with the diversity and species composition of scarab beetles because the rainy season plays a crucial role in stimulating reproductive activity and larval development, as increased soil moisture and organic matter decomposition create favorable conditions for beetle emergence and foraging (Zou *et al.* 2013). Also, Sabu *et al.* (2006) proposed that agricultural landscapes function as transitional zones, facilitating the presence of species from diverse ecosystems of Western Ghats

forests. This edge effect enhances scarab diversity by offering habitats for various fauna. Differences in habitats, seasons, study period, study area size, and sampling design could all explain the variation in the number of scarab beetle species and genera recorded in these region, which attributed with the studies of Jakhar *et al.* (2021) and Prajapat *et al.* (2025) from the Jaipur region, Rajasthan.

The findings of this research revealed that habitat features in the Jaipur area can support a diverse ecological and functional scarab beetle community. These beetles play a vital role in maintaining ecological balance by contributing to decomposition, soil aeration, pollination, and pest control. There is very little information available on the community structure and diversity pattern of scarab beetles due to a lack of interest and continuous research works. The results of this study concluded that the Jaipur region can provide a rich ecological and functional scarab beetle community. The findings achieved from this research will form the baseline knowledge of scarab beetle community structure and diversity in various habitats. Future studies should emphasize long-term monitoring, habitat preservation, and integrated pest management strategies to maintain both ecological stability and agricultural productivity in Rajasthan.

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REFERENCES

- Andresen, E. (2003). Effect of forest fragmentation on dung beetle communities and functional consequences for plant regeneration. *Echography*, 26 (1), 87–97.
<https://doi.org/10.1034/j.1600-0587.2003.03362.x>
- Ahrens, D., & Fabrizi, S. (2011). New species of Sericini from

- the Himalaya and adjacent mountains (Coleoptera: Scarabaeidae). *Bonn Zoological Bulletin*, 60 (2), 139—164.
- Aparna, S., Naik, D., & Kumar, A. R. V. (2018). Structural composition and diversity of Scarab beetle communities in different ecosystems of South Karnataka. *Journal of Entomology and Zoology Studies*, 6 (5), 61—66.
- Arrow, G. J. (1931). The Coleopterous genus *Trichillum* (Copriidae) with a key to the species. *The Annals and Magazine of Natural History*, 8 (48), 609—611.
<https://doi.org/10.1080/00222933108673452>
- Balthasar, V. (1963a). Monographie der Scarabaeidae und Aphodiidae der Palaearktischen und Orientalischen region. Verlag der Tschechoslowakischen Akademie der Wissenschaften. *Prag*, 617.
- Balthasar, V. (1963b). Monographie der Scarabaeidae und Aphodiidae der Palaearktischen und Orientalischen region. Verlag der Tschechoslowakischen Akademie der Wissenschaften. *Prag*, 381.
- Barlow, J., Louzada, J., Parry, L., Hernandez, M. I., Hawes, J., Peres, C. A., & Gardner, T. A. (2010). Improving the design and management of forest strips in human-dominated tropical landscapes: A field test on Amazonian dung beetles. *Journal of Applied Ecology*, 47 (4), 779—788.
- Bhawane, G. P., Mamlayya, A. B., Wagh, S. R., & Chaugule, A. K. (2012). Diversity of white grub beetles and their host range from Northern Western Ghats, Kolhapur District (MS) India. *The Bioscan*, 7 (4), 589—596.
- Bhattacharyya, B., Handique, G., Pujari, D., Bhagawati, S., Mishra, H., Gogoi, D., & Debnath, H. (2017). Species diversity and relative abundance of scarab beetle fauna in Assam, Northeast India. *Journal of Entomology and Zoology Studies*, 5 (1), 711—716.
- Braga, R. F., Korasaki, V., Andresen, E., & Louzada, J. (2013). Dung beetle community and functions along a habitat-disturbance gradient in the Amazon: A rapid assessment of ecological functions associated to biodiversity. *Public Library of Science ONE*, 8 (2), 57786.
<https://doi.org/10.1371/journal.pone.0057786>
- Chandra, K. (2000). Inventory of Scarab beetles (Coleoptera) from Madhya Pradesh, India. *Zoos' Print Journal*, 15 (11), 359—362.
- Chandra, K., & Ahirwar, S. C. (2007). Insecta: Coleoptera: Scarabaeidae, Zoological Survey of India, Fauna of Madhya Pradesh (including Chhattisgarh), *State Fauna Series*, 15 (1), 273—300.
- Chandra, K., & Gupta, D. (2013). Taxonomic studies on dung beetles (Coleoptera: Scarabaeidae, Geotrupidae, Hybosoridae) of Chhattisgarh, India. *Munis Entomology & Zoology*, 8 (1), 331—360.
- Chandra, K., Gupta, D., & Goel, S. C. (2015). On Scarab beetles (Coleoptera: Scarabaeidae) from Sidhi district of Madhya Pradesh, India. *Uttar Pradesh Journal of Zoology*, 35 (3), 235—243.
- Chaudhary, M. (2019). Ecology and present taxonomic status of beetles in Shekhawati region of Rajasthan. *Journal of Global Resources*, 5 (1), 116—122.
- Culot, L., Bovy, E., Vaz-de-Mello, F. Z., Guevara, R., & Galetti, M. (2013). Selective defaunation affects dung beetle communities in continuous Atlantic rainforest. *Biological Conservation*, 163, 79—89.
- Dadmal, S. M., & Khadakkar, S. (2014). Revision of *Holotri chia-Hope* (Scarabaeidae : Melolonthinae) in different agro – climatic zones of Maharashtra (India). *Journal of Entomology and Zoology Studies*, 2 (3), 50—58.
- Fincher, G. T., Monson, W. G., & Burton, G. W. (1981). Effects of cattle feces rapidly buried by dung beetles on yield and quality of coastal Bermuda grass 1. *Agronomy Journal*, 73 (5), 775—779.
- GBIF. Org (7 July 2024) GBIF occurrence (<https://www.gbif.org>).
- Geetha, K. V., & Agarwala, B. K. (2018). Taxonomy of Scarabaeidae (Insecta: Coleoptera) of Tripura, North East India. *International Journal of Zoology and Applied Biosciences*, 3 (5), 411—422.
- Halfitter, G., & Edmonds, W. D. (1982). The nesting behavior of dung beetles (Scarabaeinae). *An Ecological and Evolutionary Approach*. 176.
- Halfitter, G., & Matthews, E. G. (1966). The natural history of dung beetles of the sub family Scarabaeinae (Coleoptera, Scarabaeidae). *Folia Entomologica Mexicana*, 12—14, 1—132.
- Hanski, I., & Cambefort, Y. (1991). Competition in dung beetles. *Dung beetle ecology*. Princeton University Press. 305—329.
- Henschel, J. R. (2021). Long-term population dynamics of Namib Desert tenebrionid beetles reveal complex relationships to pulse-reserve conditions. *Insects*, 12 (9), 804.
- Horgan, F. G. (2005). Effects of deforestation on diversity, biomass and function of dung beetles on the Eastern slopes of the Peruvian Andes. *Forest Ecology and Management*, 216 (1-3), 117—133.
- Jakhar, B. L., Baloda, A. S., Choudhary, M. D., Saini, K. K., Jakhar, M. L., & Yadav, T. (2021). Biodiversity of white grub, (Coleoptera: Scarabaeidae) in semiarid agro-ecosystem of Rajasthan: Biodiversity of White grub in Rajasthan. *Journal of Agricultural Research*, 8 (2), 112—116.
<https://doi.org/10.21921/jas.v8i2.7293>
- Jiang, L., Wang, Y. L., Wu, Y. H., & Zhang, Z. H. (2026). Larval morphology of *Eophileurus chinensis* (Coleoptera: Scarabaeidae: Dynastinae), with discussions on their living strategies. *Acta Zoologica*, 107 (2), 211—218.
<https://doi.org/10.1111/azo.12547>
- Kalawate, A. S. (2018). A preliminary study on the dung beetles of the Northern Western Ghats, Maharashtra, India. *The Journal of Threatened Taxa*, 10(2), 11316—11331.
<http://doi.org/10.11609/jott.3844.10.2.11316-11331>
- Karimbunkara, S. N., & Priyadarsanan, D. R. (2016). Report of dung beetles (Scarabaeidae: Scarabaeinae) attracted to unconventional resources, with the description of three new species. *Entomon*, 41(4), 265—282.
<https://doi.org/10.33307/entomon.v41i4.213>
- Kazmi, S. I., & Ramamurthy, V. V. (2004). Coleoptera (Insecta) Fauna of Indian Thar desert, Rajasthan. *Zoos' Print Journal*, 19(4), 1447—1448.
<https://doi.org/10.11609/JOTT.ZPJ.1008.1447-8>
- Kenyon, T. M., Mayfield, M. M., Montheith, G. B., & Menéndez, R. (2016). The effects of land use change on native dung beetle diversity and function in Australia's Wet Tropics. *Austral Ecology*, 41, 797—808.
- Kharel, B. P., Schoolmeesters, P., & Sarkar, S. K. (2020). A first faunistic account on the Onthophagus Latreille, 1802 (Coleoptera, Scarabaeidae, Scarabaeinae) of the Nadia dis-

- trict, West Bengal, with a preliminary checklist from India. *Check List* 16 (2), 361—381.
<https://doi.org/10.15560/16.2.361>
- Kotilingam, S. M. (2020). Assessment Scarabaeid Beetle Diversity in Various Cropping Regions of Karnataka. *Entomology, Ornithology & Herpetology: Current Research*, 9, 224.
 DOI: 10.35248/2161-0983.20.9.224.
- Kumar, A., Singh, R., Prasad, C. S., Tiwari, G. N., & Kumar, S. (2017). New records of predatory coccinellids beetles (Coccinellidae: Coleoptera) in Western plain zone of Uttar Pradesh. *Journal of Entomology and Zoology Studies*, 5 (3), 1140—1147.
- Latha, T., & Sabu, T. K. (2018). Dung beetle (Coleoptera: Scarabaeinae) community structure across a forest-agriculture habitat ecotone in South Western Ghats. *International Journal of Environment, Agriculture and Biotechnology*, (5), 266204.
 DOI: 10.22161/ijeab/3.5.41
- Li, L. C., Yang, S. P., & Wang, C. C. (2010). Revision of the *Melolontha guttigera* group (Coleoptera, Scarabaeidae) with a key and an annotated checklist of the East and South-East Asian *Melolontha* Groups. *Annals of the Entomological Society of America*, 103, 341—359.
 DOI:10.1603/AN09088
- Magurran, A. E. (1988). *Ecological diversity and its measurement*. Princeton University, Princeton, Nueva Jersey, EE.UU.
- Magurran, A. E. (2004). *Measuring biological diversity*. Blackwell, Malden.
- McCune, B., & Mefford, M. J. (1999). PC-ORD. Multivariate analysis of ecological data, version 4. MjM Software, Design Gleneden Beach, Oregon USA.S.
- Meena, R. (2025). Diversity and abundance of scarab beetles (Coleoptera: Scarabaeidae) in Jhunjhunu district of Rajasthan, India. *International Journal of Zoology Studies*, 10 (1), 65—70.
- Murthy, S. K. (2020). Diversity and abundance of scarabaeid beetles in South India. *Journal of Entomology and Zoology Studies*, 8, 1078—1082.
- Ndozi, M. H., Gohole, L., & Mapaure, I. (2025). Comparison of species diversity, richness and abundance of dung beetles between wildlife and wildlife-livestock systems in North-eastern Namibia. *International Journal of Tropical Insect Science*, 1—14.
- Nemes, S. N., & Price, D. L. (2015). Illustrated keys to the Scarabaeinae (Coleoptera: Scarabaeidae) of Maryland. *Northeastern Naturalist*, 22 (2), 318—344.
- Newbold, T., Hudson, L. N., Hill, S. L. L., Contu, S., Lysenko, I., Senior, R. A., Borger, L., Bennett, D. J., Choimes, A., Colten, B., Day, J., De Palma, A., Díaz, S., Londoño, S., Echeverria, Edgar, M. J., Feldman, A., Garon, M., Harrison, M. L. K., Alhusseini, T., Ingram, D. J., Itescu, Y., Kattge, J., Kemp, V., Kirkpatrick, L., Kleyer, M., Correia, D. L. P., Martin, C. D., Meiri, S., Novosolov, M., Pan, Y., Phillips, H. R. P., Purves, D. W., Robinson, A., Simpson, J., Tuck, E., Weiher, H. J., White, R. M., Ewers, Mace, G. M., Scharlemann, J. P. W., & Purvis, A. (2015). Global effects of land use on local terrestrial biodiversity. *Nature*, 520, 45—50.
<https://doi.org/10.1038/nature14324>
- Nichols, E., Spector, S., Louzada, J., Larsen, T. H., & Amezcuita, S. (2008). Ecological functions and ecosystem services provided by Scarabaeinae dung beetles. *Biological Conservation*, 141, 1461—1474.
- Parvez, A., & Srivastava, M. (2010). A short-term surveillance of coleopteran fauna in an agro-ecosystem near Bikaner (Western Rajasthan), India. *Biological Forum – An International Journal*, 2, 23—29.
- Pathania, M., Chandel, R. S., Verma, K. S., & Mehta, P. K. (2015). Diversity and population dynamics of phytophagous scarabaeid beetles (Coleoptera: Scarabaeidae) in different landscapes of Himachal Pradesh, India. *Arthropods*, 4 (2), 46—68.
- Patole, S. S. (2019). Studies on diversity and relative abundance of dung beetles (Coleoptera: Scarabaeidae) from Sakri Tahsil, District Dhulia (MS) India. *International Journal of Advanced Research*, 9 (10).
- Piñero, J. C., & Dudenhoefter, A. P. (2018). Mass trapping designs for organic control of the Japanese beetle, *Popillia japonica* (Coleoptera: Scarabaeidae). *Pest Management Science*, 74 (7), 1687—1693.
 doi: 10.1002/ps.4862. Epub 2018 Mar 6. PMID: 29337404
- Prajapat, R., Meena, P., Kumawat, N., & Meena, S. (2025). Diversity and seasonal fluctuation of Coleoptera community in the reserve forests of Aravalli range at Jaipur, Rajasthan, India. *Environment and Ecology*, 43 (1), 89—96.
- Pralhad, T. B. (2022). Survey of Dung beetles in Mahad tehsil, Western Ghats, Raigad District, Maharashtra India. *International Journal of Advanced Research in Science, Communication and Technology*, 2 (4), 2581—9429.
- Sabatinielli, G. (1992). Catalogue of the Scarabaeoidea Melolonthidae from Himalaya and North India: Macroductylini, Hopliini, Diplotaxini, Melolonthini and Sericini (Coleoptera). *Memorie della Società Entomologica Italiana*, 71, 593—636.
- Sabu, T. K., Vinod, K. V., & Vineesh, P. J. (2006). Guild structure, diversity and succession of dung beetles associated with Indian Elephant dung in South Western Ghats forests. *Journal of Insect Science*, 6 (1), 17.
- Salomão, R. P., Lopera-Toro, A., Pulido-Herrera, L. A., & Arias-Buriticá, J. A. (2023). Habitat type affects the diversity of dung beetle (Coleoptera: Scarabaeidae) assemblages in a neotropical mountainous region of Colombia. *International Journal of Tropical Insect Science*, 43 (3), 793—803.
- Sewak, R. (2005). Dung beetles (Coleoptera: Scarabaeidae: Coprinae) of Thar Desert of Rajasthan. Changing faunal ecology in the Thar Desert. Scientific, Jodhpur, 143—148.
- Sewak, R. (2006). Insecta: Coleoptera: Scarabaeidae: Coprinae (dung beetles). Zoological Survey of India, Fauna of Arunachal Pradesh, *State Fauna Series*, 13, 191—224.
- Sewak, R. (2009). Dung Beetles: (Coleoptera—Scarabaeidae—Coprinae) of the Thar Desert of Rajasthan and Gujarat. In *Faunal Ecology and Conservation of the Great Indian Desert*. Berlin, Heidelberg. *Springer Berlin Heidelberg*, 25—39.
- Shah, N. A., & Shah, N. (2022). Ecological Benefits of Scarab beetles (Coleoptera: Scarabaeidae) on Nutrient Cycles: A Review Article. *Advances in Biochemistry and Biotechnology*, 7, 10109.
 DOI: <https://doi.org/10.29011/2574-7258.010109>
- Sharma, S., Sharma, G., & Pir, F. A. (2019). Diversity and habitat selection of aquatic beetles (Coleoptera). *Journal of Pharmaceutical and Biological Sciences*, 14, 31—37.

- Smith, A. B., Hawks, D. C., & Heraty, J. M. (2006). An over view of the classification and evolution of the major scarab beetle clades (Coleoptera: Scarabaeoidea) based on preliminary molecular analyses. *The Coleopterists Bulletin*, 60 (5), 35—46.
- Southwood, T. R. E., & Henderson, P. A. (2000). *Ecological Methods*, 3rd ed. Blackwell Science, London.
- Sreedevi, K., Speer, J., Fabrizi, S., & Ahrens, D. (2018). New species and records of Sericini scarab beetles from the Indian subcontinent (Coleoptera, Scarabaeidae). *ZooKeys*, 772—797.
- Sreedevi, K., Sree Chandana, P., Correya, J. C., Shashank, P. R., Singh, S., & Veenakumari, K. (2022). Economically important wood feeding insects: Their diversity, damage and diagnostics. In *Science of wood degradation and its protection*, Springer Singapore, 115—145.
- Sreedevi, K., Tyagi, S., & Sharma, V. (2017). Species diversity of white grubs (Coleoptera: Scarabaeidae) in the sub-Himalayan and Northern plains of India. *Current Science*, 322—329.
- Smith, A. B. (2008). South American Melolonthinae (Coleoptera: Scarabaeidae) classification and nomenclature: Some problems and solutions. *Insecta Mundi*, 0060, 1—28.
- Tarasov, S., & Génier, F. (2015). Innovative Bayesian and parsimony phylogeny of dung beetles (Coleoptera, Scarabaeidae, Scarabaeinae) enhanced by ontology-based partitioning of morphological characters. *Public Library of Science ONE*, 10 (3), 0116671.
- Thakare, V. G., Zade, V. S., & Chandra, K. (2011). Diversity and abundance of scarab beetles (Coleoptera: Scarabaeidae) in Kolkas Region of Melghat Tiger Reserve (MTR), District Amravati, Maharashtra, India. *World Journal of Zoology*, 6 (1), 73—79.
- Vaz de Mello, F. Z., Edmonds, W. D., Ocampo, F. C., & Schoolmeesters, P. (2011). A multilingual key to the genera and subgenera of the subfamily Scarabaeinae of the New World (Coleoptera: Scarabaeidae). Magnolia Press; *Zootaxa*, 1 (4), 1—73.
- Young, O. P. (2015). Predation on dung beetles (Coleoptera: Scarabaeidae): A literature review. *Transactions of the American Entomological Society*, 141, 111—115.
- Zou, Y., Sang, W., Bai, F., & Axmacher, J. C. (2013). Relationships between plant diversity and the abundance and α -diversity of predatory ground beetles (Coleoptera: Carabidae) in a mature Asian temperate forest ecosystem. *Public Library of Science ONE*, 8 (12), 82792.