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ORIGINAL ARTICLE

Diversity and Seasonal Distribution of Scarab Beetles (Scarabaeidae; Coleoptera) in Jaipur Region, Rajasthan, India

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ABSTRACT

A study on the diversity of the scarab beetle was carried out from March 2023 to February 2024 at four sites in Jaipur region, Rajasthan. A total of 992 individuals of scarab beetles, representing 23 species and 16 genera belonging to the family Scarabaeidae were recorded. Scarabaeinae was recorded the largest subfamily with 10 species, followed by Melolonthinae (6), Dynastinae (4), Cetoniinae (2), and Rutelinae (1). The maximum abundance of scarab beetle was found during the monsoon season. The subfamily Scarabaeinae was recorded as most abundant with 423 individuals, followed by Melolonthinae, Dynastinae, Cetoniinae, and Rutelinae.*Digitonthophagus gazelle, Onthophagus taurus, Maladera castanea, Oryctes rhinoceros,* and *Holotrichia serrate* were the most abundant species across all sites. The values of alpha diversity indices, *viz.,* Shannon diversity index was recorded highest at site 1 (H'= 3.015) and Simpson's diversity index highest at site 4 (1-D'=0.9487). Dominance was recorded highest at site 3 (D=0.06994), and Evenness highest at site 1 (E=0.9367), respectively. The Pearson correlation showed statistically significant results between relative abundance and species richness with temperature and precipitation, whereas non-significant with relative humidity. This study represents a magnificent record of the abundance and diversity of scarab beetles in Jaipur region.

KEY WORDS: Dung beetle, diversity, ecosystem, relative abundance, Scarabaeidae

INTRODUCTION

Scarab beetles belong to the family Scarabaeidae and order Coleoptera are polyphagous and holometabolous insects (Piñero & Dudenhoeffer, 2018). These beetles are usually small to large in size, with robust bodies with horns and many with bright metallic colors. They can be easily recognized by the shape of their antennae. They are found in nearly all natural ecosystems, including trees, vegetative foliage, and their bark, leaves, and flowers, and underground near roots, even inside plants like tissue and galls, including dead or decaying ones (Gullan & Cranston, 2010). Scarab beetle numbers are highest in tropical regions globally, especially in Africa and East Asia. There are approximately 36,448 species of scarab beetles reported worldwide, comprising 19 subfamilies (GBIF.org, June 4, 2021). India is a major region for the scarab beetle variety, with over 6,598 species belonging to the Aphodiinae, Cetoninae, Dynastinae, Melolonthinae, Rutelinae, Scarabaeinae, and Orphinae subfamilies (GBIF.org, June 4, 2021). In nature, scarab beetles have a favorable impact on ecosystems and the economy by decomposing organic matter (Li *et al.*, 2010). Scarab beetles are susceptible to change in their habitat; they can indicate whether the ecosystem is changing. They additionally help improve soil health by allowing water to seep into the soil and making it less compacted. This may lessen surface runoff and have an impact on local water flow patterns (Sewak, 2006). These beetles can be categorized into coprophagous and phytophagous (including saprophagous) lineages based on their feeding behaviours. The coprophagus beetles, known as dung beetles, contribute significantly to the cleanliness of nature by improving soil quality, facilitating the dispersal of seeds, and recycling nutrients in the soil (Chatterjee & Biswas, 2000). Furthermore, their interactions with dung-breeding flies help managing pests and parasites, which are a threat to both livestock and crops (Sewak, 2006; Nichols *et al.*, 2008; Li *et al.*, 2010). However, phytophagous beetles, commonly known as leaf-

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chafer, cause serious pest issues in agricultural crops, plantations, and forests (Chandra, 2000; Dadmal & Khadakkar, 2014; Franzini *et al*., 2016). Their growing economic impact in India underscores the need for efficient methods of managing phytophagous scarab beetle pests (Chatterjee & Biswas, 2000; Smith, 2008).

Scarab beetle diversity from multiple Indian states has been compiled by Sabatinelli (1992), Sabu *et al.* (2006), Chandra & Ahirwar (2007), Ahrens & Fabrizi (2011), Bhawane *et al*. (2014), Chandra *et al*. (2015), Sreedevi (2018), Kalawate (2018), Sharma *et al*. (2019), and Singh *et al*. (2020). Mostly scarab beetle composition and diversity, distribution was observed to be very high in forest, agriculture, and grassland with other mammalian species.

Rajasthan is rich in terms of biological biodiversity due to its distinct biogeographic status, varied climatic conditions, and enormous eco-diversity and geodiversity. Scarab beetle diversity has been extensively studied in different forests and agricultural areas. In previous records, very few studies on scarab beetles have been conducted in Rajasthan. Moreover, in Thar Desert, Rajasthan scarab beetles diversity is explored by Kazmi & Ramurthy (2004), Sewak (2005), Parvez & Srivastava (2010), Kumar *et al.* (2017), Chaudhary (2019), Jakhar *et al*. (2021), Prajapat *et al*. (2022), Meena & Kumari (2022). The present study was conducted on the species composition, abundance and diversity of scarab beetles in various habitats in and around Jaipur, Rajasthan. This study will provide first, even preliminary knowledge required for scarab beetles conservation and their application in an integrated pest control strategy.

MATERIALS AND METHODS

Scarab beetles were surveyed in Jaipur region, Rajasthan, India, spanning from March 2023 and February 2024. This region extends from 26° 46' to 27° 01 N latitude and 75° 37' to 76° 57' E longitude with an elevation of 431 m. The total area of Jaipur region is 11,152 km^2. The summer temperatures in Jaipur were very high (40 to 47°C), while the winters were extremely cold (4-9°C and even fall below 0°C). In Jaipur, the monsoon season (July to September) receives 633 mm of precipitation on average annually.

The selected study area was divided into different study sites: site 1-Chomu (Agricultural, Grassland, Rocky, and Open Forest), site 2-Viratnagar (Grassland, Rocky), site 3-Amer (Open Forest, Rocky) and site 4-Bassi (Agricultural, Grassland). Site-1 is located at geographical coordinate's 27.1656° N latitude and 76.0521° E longitude, followed by Site-2 (27.4316° N latitude and 76.1794° E longitude), Site-3 (26.9880° N latitude and 75.8610° E longitude) and Site-4 (26.8419° N latitude and 76.0521° E longitude), respectively. Throughout the study period, the samples were accomplished fortnightly in a month at selected sites in the morning and evening hours. Scarab beetles were collected using pitfall traps, handpicking with cow dung scratching method and light traps. Pitfall traps, which have a 15 cm depth and a 12 cm diameter were buried up to the rim in the ground, as it is the most effective way for collecting dung beetles. Beetles were sampled and then brought to the Department of Zoology, entomology laboratory at the University of Rajasthan in Jaipur.All the beetles thus collected were then processed for pinning, stretching, and drying, and then preserved in wooden boxes with para dichlorobenzene for further study. Specimens were narcotized by exposure to chloroform vapour for maintaining their original colour. Specimen were identified to species levels using taxonomic keys provided by Arrow (1931), Balthasar (1963 a, b), Vaz de Mello *et al.* (2011), Chandra & Gupta (2013), Nemes & Price (2015), Kharel *et al*. (2020), and by comparing with the verified specimens in the insect museum, Department of Zoology, University of Rajasthan.

The different meteorological data, including temperature (maximum ; minimum) and relative humidity, were recorded during the study with the help of a hygrometer and thermometer. The total rainfall data was collected (2023-2024) from the IMD Jaipur, Rajasthan. The monthly sampled population of scarab beetles was correlated with abiotic factors across different seasons.

DATA ANALYSIS

Species diversity indices were determined based on abundance records of Scarabaeidae individuals (Magurran, 1988). The diversity indices, species richness, evenness and dominance indxes were calculated with the help of the PAST ver. 4.03 tool and Pearson correlation with MS Excel.

RESULT

A total of 23 species, 16 genera, and 5 subfamilies of the family Scarabaeidae were reported across the four sites in Jaipur, Rajasthan. In total, 992 individuals were collected from the family Scarabaeidae. Thus the subfamily Scarabaeinae was recorded most abundant with 423 individuals (42.64 relative abundance), followed by Melolonthinae with 256 individuals (25.81 relative abundance), Dynastinae with 141 individuals (14.21 relative abundance), Cetoniinae with 111 individuals (11.19 relative abundance), and Rutelinae with 61 individuals (6.15 relative abundance) (Fig. 2). The subfamily Scarabaeniae was most specious (10 species and 5 genera) with the highest composition (43%), followed by Melolonthinae (26%) with 6 species and 5 genera, Dynastinae (14%) with 4 species and 3 genera, and followed by Cetoniinae (11%) with 2 species and 2 genera (Table 1; Fig. 1). The occurrence of scarab beetle species *Heliocpris hamadryas, Catharsius*

Table 1: Occurrence and relative abundance of scarab beetles species across four sites of Jaipur region

Species	Authority name	Site 1	Site 2	Site 3	Site 4	Abundance	Relative abundance (%)
Heliocpris hamadryas	(Fabricius, 1775)	+	+	+	+	41	4.13
Catharsius molossus	(Linnaeus, 1758)	+	+	-	+	52	5.24
Digitonthophagus gazelle	(Fabricius, 1787)	+	+	+	+	89	8.97
Onitis alexis	(Klug, 1835)	+	+	+	+	47	4.74
Catharsius philus	(Kolbe, 1893)	+	+	+	+	26	2.62
Catharsius calaharicus	(Hope, 1837)	+	+	-	+	21	2.12
Catharsius pithecius	(Fabricius, 1775)	+	+	+	+	45	4.54
Onthophagus taurus	(Schreber, 1759)	+	+	+	+	65	6.55
Onthophagus falsus	(Gillet, 1925)	+	-	-	+	19	1.92
Catharsius sagax	(Quensel, 1806)	+	-	-	+	18	1.81
Phyllophaga vetula	(Horn, 1887)	+	+	+	+	32	3.23
Phyllophaga elenans	(Harris, 1827)	+	+	+	+	44	4.44
Holotrichia serrata	(Fabricius, 1781)	+	+	+	+	62	6.25
Anoxia villosa	(Fabricius, 1781)	+	+	-	+	27	2.72
Maladera castanea	(Arrow, 1913)	+	+	+	+	71	7.16
Serica brunnea	(Linnaeus, 1758)	+	+	-	+	20	2.02
Heteronychus arator	(Fabricius, 1775)	+	+	+	+	22	2.22
Oryctes rhinoceros	(Linnaeus, 1758)	+	+	+	+	65	6.55
Cyclocephala lurida	(Bland, 1863)	+	+	+	+	35	3.53
Cyclocephala borealis	(Arrow, 1911)	+	+	-	+	19	1.92
Protactia alboguttata	(Vigors, 1826)	+	+	+	+	62	6.25
Heterrrhina elegans	(Fabricius, 1781)	+	-	+	+	49	4.94
Anomala sp.	(Samouelle, 1819)	+	+	+	+	61	6.15

Table 2: Diversity indices of scarab beetles across different sites in Jaipur region

Sampling sites	Simpson's index (1-D')	Shannon Wiener index (H')	Margalef index (M)	Dominance (D)	Evenness (E)	Abundance
Site 1	0.9459	3.015	3.634	0.05412	0.8864	426
Site 2	0.9405	2.902	3.818	0.0595	0.9101	145
Site 3	0.9301	2.707	3.197	0.06994	0.9367	109
Site 4	0.9487	3.044	3.831	0.0513	0.9126	312

philus, C. pithecius, Onthophagus taurus, Digitonthophagus gazelle, Onitis alexis, Oryctes rhinoceros, Heteronychus arator, Phyllophaga vetula, p. elenans, Holotrichia serrate, Maladera castanea, Cyclocephala lurida and *Protactia alboguttata, Anomala* sp., were commonly recorded at all four sites. In the study sites, species abundance and species richness were reported to be maximum at site 1 (423 individuals and 23 species) and site 4 (312 individuals and 23 species), which are dense agricultural and grassland habitats. Moderate abundance and richness was recorded at site 2 (145 individuals and 20 species),and least at site 3 (109 individuals and 16 species) (Fig. 3). *Digitonthophagus gazelle* (89 individuals and 8.97% relative abundance), *Maladera castanea* (71 individuals and 7.16% relative abundance), *Onthophagus taurus* and *Oryctes rhinoceros* (65 individuals and 6.55% relative abundance),and *Holotrichia serrate* (62 individuals and 6.25% relative abundance) were observed as the most abundant species across all sites.

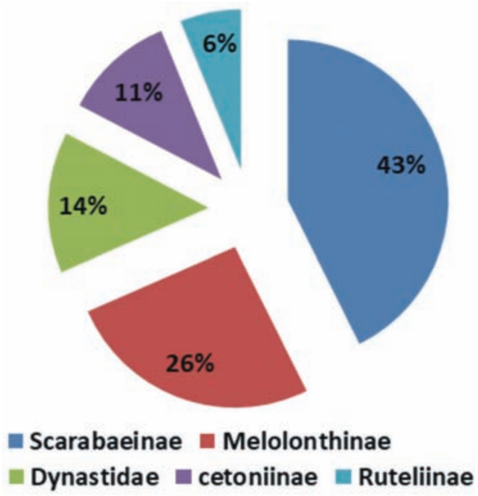

Fig. 1. Relative abundance of subfamilies of scarab beetles

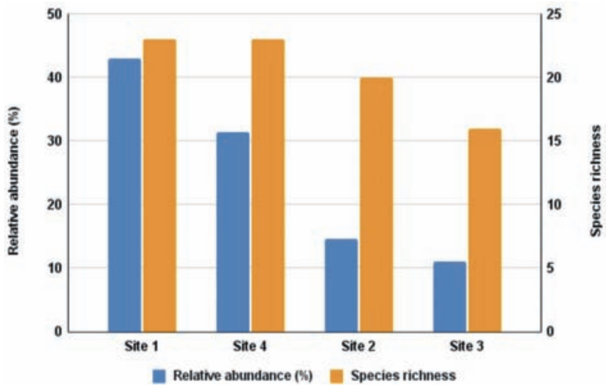

Fig. 3. Species richness and abundance of Scarabaeidae family across different study sites

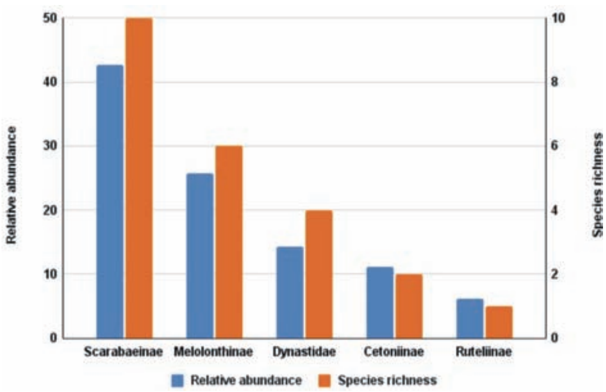

Fig. 2. Species richness and abundance of different subfamilies under the family Scarabaeidae

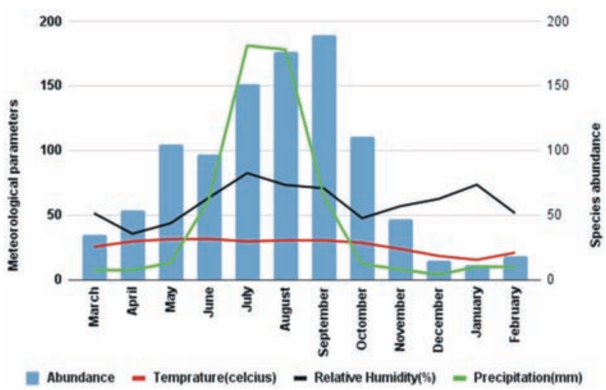

Fig. 4. Scarabaeidae family abundance across different seasons

The association of scarab beetles along with abiotic factors across different seasons revealed maximum abundance during the monsoon season (610 individuals), followed by the pre-monsoon (291 individuals) (Fig. 4). The Pearson correlation was observed statistically significant between relative abundance and species richness with temperature (r = 0.3135; 0.3526, P<0.05*; P<0.01**, respectively) and precipitation (r = 0.28; 0.31755, P<0.05*; P<0.01**, respectively), whereas non-significant (r = 0.0759; 0.04925, P>0.05; P>0.01) with relative humidity. The values of alpha diversity indices, *viz.,* Shannon diversity index ranged from 2.707 to 3.015 and was recorded highest at site 1 (H'= 3.015), Simpson's diversity index ranged from 0.9301-0.9487 and was recorded highest at site 4 (1-D'=0.9487), Dominance index ranged from 0.0513-0.06994 and was recorded highest at site 3 (D=0.06994), and also Evenness ranged from 0.8864-0.9367 and was recorded highest at site 1 (E=0.9367) (Table 2).

DISCUSSION

In the current study, a total of 23 species, 16 genera, and 5 subfamilies of the family Scarabaeidae were reported from different sites of Jaipur, Rajasthan. A similar study was reported by Bhawane *et al.* (2014), who presented a checklist of 26 dung beetle species belonging to the Scarabaeinae subfamily in the Sindhudurg region of Maharashtra, India. However, Chandra *et al.* (2015) reported a checklist of 53 scarab beetle species, 27 genera, and 6 subfamilies from Madhya Pradesh, India. Recent research by Karimpumkala & Priyadarsanan (2016) found that 13 different species of dung beetles were drawn to unusual resources in various regions of India. Bhattacharyya *et al.* (2017) identified 44 species of scarab beetles from Assam that belong to 21 genera across 6 subfamilies. However, 34 dung beetle species from 11 genera and 7 tribes were reported by Latha & Sabu (2018).

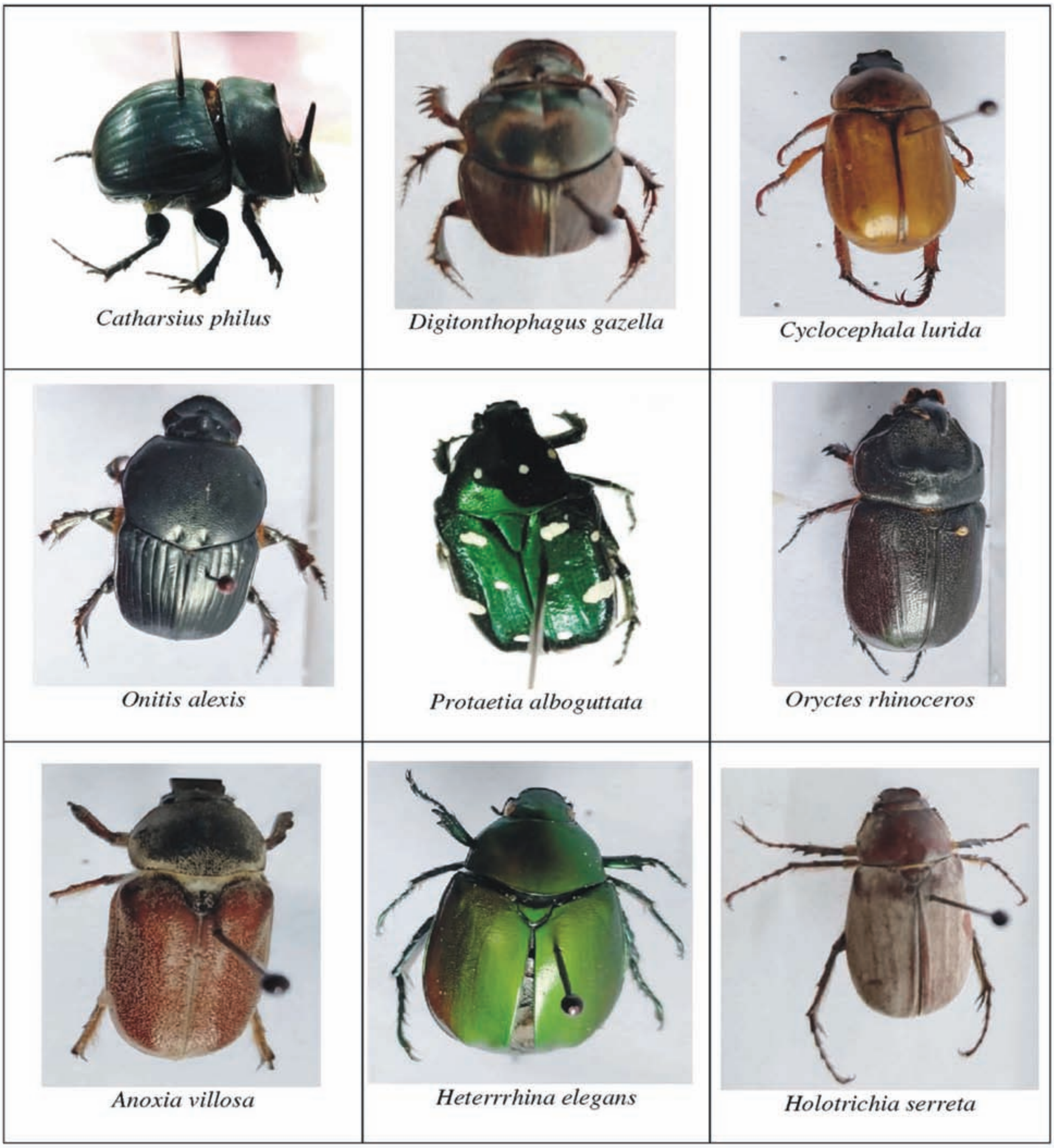

Fig. 5. Scarab beetlespecies collected from Jaipur region

In Rajasthan, Kazmi & Ramamurthy (2004) reported 22 species of the family Scarabaeidae in Thar Desert, Rajasthan, Sewak (2009) reported 12 genera and 85 species of dung beetles from the Thar Desert of Gujarat and Rajasthan, Parvez & Srivastava (2010) explored 8 species of the family Scarabaeidae in an agro-ecosystem near Bikaner, Western Rajasthan, Kumar *et al*. (2017) recorded 12 species under 6 genera of the family Scarabaeidae associated with groundnut crop ecosystems in Andhra Pradesh, Rajasthan, Chaudhary (2019) described 9 genera from 5 sub-families of scarabaeidae from the Shekhawati region of Rajasthan. Recently, Jakhar *et al*. (2021) recorded 9 species under 2 subfamilies (Melolonthinae; Rutelinae) of the family Scarabaeidae during different locations in Rajasthan, Prajapat *et al*. (2022) recorded 12 species with 10 genera of the family Scarabaeidae in the Aravalli range, Jaipur, India, Meena and Kumari (2022) explored 45 species of the family Scarabaeidae from Jhunjhunu District, Rajasthan, India.

In current study, the subfamily Scarabaeinae was recorded most abundant with 43%, followed by Melolonthinae (26%), Dynastinae (14%), Cetoniinae (11%), and Rutelinae (6%). These findings are accordance with Murthy (2020), who reported the Melolonthinae subfamily abundance with 38.23%, followed by Rutelinae 20.58%, Cetoniinae 17.66%, Scarabaeinae 17.64%, and Dynastinae 5.88% Scarab beetles in South Indian states. Also, Jakhar *et al.* (2021), captured 5917 total numbers of scarab beetle individuals in the semi-arid agro-ecosystem of Jaipur, Rajasthan and Prajapat *et al.* (2022)collected 258 scarab beetle individuals of the Aravalli Range, Jaipur, Rajasthan.

In present study, the association of scarab beetles along with abiotic factors across different seasons revealed maximum abundance during the monsoon season. However, the abiotic variables such as temperature, precipitation, humidity, and moisture might have positively impacted the abundance of beetles (Andresen, 2005; Yumamura *et al*., 2006; Batista *et al*., 2016). Similarly, Kakkar & Gupta (2010) recorded that dung beetle species richness, abundance, and diversity increase in monsoon season. Also, Sima & Srivastava (2012) demonstrated that meteorological factors such as temperature, humidity, and rainfall positively impacted beetles' emergence (Ali, 2001; Pathania, 2015; Chen *et al.*, 2019). It is proved in many researches that there is a positively correlation between the abundance of beetles and the rainy season, because the availability of food resources during the rainy season with leads to a high population peak (Smith *et al*., 2017).

In this study, the values of alpha diversity indices, *viz.,* Shannon diversity index was recorded highest at site 1 (H'= 3.015) and Simpson's diversity index highest at site 4 (1-D'=0.9487). Similarly Pathania (2015) reported alpha diversity indices of beetles, *viz*., the Shannon index (H = 3.01-3.03) and the Simpson's index of diversity (D = 0.94), which was maximum at Palampur. However, the Shannon index (H'=3.03) and the Simpson's index of diversity (D=0.92) were highest recorded in different ecosystems of Puttur taluk (coastal zone of Karnataka, India) (Aparna *et al*., 2018).

CONCLUSION

This preliminary study shows good biodiversity and distribution of scarab beetles in the Jaipur region and concludes that agriculture areas and grasslands are dominated by scarab beetles.Altogether, there hasn't been a prior study till now that documents the diversity of scarab beetles in this area. Thus, this study reveals novel facts about the existence and distribution of all known species of scarab. Since these ecological zones and microhabitats are crucial to preserving the diversity and species richness of scarab beetles, effective conservation efforts will collectively aid in protecting these natural habitats.

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DECLARATION OF INTEREST

The authors state that there is no conflict of interest.

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