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Ground beetles (*Coleoptera*: *Carabidae*) from district Alwar, Rajasthan, India

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Abstract
Alwar district features a varied landscape that includes rivers, hills, plains, and semi-arid zones. The area falls within a sub-humid climatic region, which provides favourable conditions for the proliferation of ground beetles. In the Alwar district, we carried out field sampling between July 2022 and June 2023. We selected two distinct sites based on their diverse environments. Site A – an agricultural field of village Jatka and Site B – the mountain region of Bala Quila. Diversity indices verified that the research area's ground beetles had a high degree of species richness and abundance. Individuals of 640 ground beetles of the Carabidae family were characterized by 8 subfamilies, 11 genera, and 18 species. The most species-rich subfamilies were Trechinae (5 species) and Harpallinae (4 species), followed by Brachininae, Scaritinae and Lebiinae (2 species each), Paussinae, Anthiinae, and Carabinae (1 species each). In terms of individual count, *Dromius quadrimaculatus* emerged as the most dominant species, comprising 16.95% of all collected beetles, followed by *Chlaenius bimaculatus* (11.09%), *Tetragonoderus intermedius* (10.15%), *Chlaenius pseudotristis* (8.43%), and *Bembidion ambiguum* (5.62%). The Simpson's Diversity Index was calculated at 0.9137 for Site A and 0.9327 for Site B, indicating almost similar levels of species diversity across the two sites.

Keywords: Alwar, abundance, carabidae, coleoptera, ground beetle's diversity

Introduction

The largest and most varied group in the animal kingdom, the Arthropoda phylum, which includes invertebrates, is distinguished by segmented bodies, jointed limbs, and protective exoskeletons. While many species of arthropods are specialized for aquatic habitats, some are able to survive on land, and some have even evolved to fly. There are an estimated 1,302,809 species in the Arthropoda, including 45,769 fossil species. More than 80% of all arthropods belong to the most successful group, the Insecta (1,070,781 species) (Zhang, 2013) [31]. Some arthropods act as predators of crop pests, which attack various parts of plants—from roots to seeds—and even stored grains. Certain beetles serve a decomposer role, feeding on organic matter in various stages of decay. Despite being primarily terrestrial, certain species have aquatic adaptations and have a major impact on the dynamics of aquatic ecosystems (Sahoo *et al*., 2020) [25]. The order Coleoptera (from Greek *coleos* meaning 'sheath' and *ptera* meaning 'wings') includes beetles. It is the largest order of organisms, exhibiting remarkable diversity and adaptations to a wide range of environmental conditions and lifestyles (Trigunayat, K. and Sharma, 2017) [30]. Coleopterans are characterised by a distinctive feature—their hardened forewings, known as elytra. While these elytra are not used for flight, they serve as protective shields, enabling beetles to withstand diverse environmental challenges. Success across diverse environments is largely due to their remarkable adaptive capabilities. Beyond their enormous quantity, coleopterans are diverse in that they play a variety of ecological tasks. Some species prey on other beetles as well as other animals. With at least 20,000 species each, the majority of the species in the 169 families that make up the order Coleoptera are concentrated in six extremely diverse families: Curculionidae, Carabidae, Scarabaeidae, Staphylinidae, Chrysomelidae, and Cerambycidae (ZSI,2012). One of the largest families in the order Coleoptera is the Carabidae, which is also the largest group in the suborder Adephaga (Ślipiński & Lawrence, 2019) [28]. It includes approximately 40,449 described species, distributed across 2,142 genera and 92 tribes worldwide. (Meena and Kumari, 2023) [20]. Certain coleopterans consume dead and decomposing stuff because they are decomposers. Although some are aquatic and play significant roles in aquatic ecosystems, the majority are terrestrial (Sahoo *et al*., 2020) [25]. The Carabidae family is one of the most diverse families within the Coleoptera order, which is the largest order of insects (Andrew, H. 1929,1935) [2, 3]. The Carabidae family encompasses over 40,000 species distributed across various habitats worldwide, though they are particularly abundant in temperate regions. Ground beetles are typically found in soils, under rocks, logs, and within leaf litter, where they play crucial roles in ecosystems as predators of other invertebrates. Globally prevalent in agricultural settings, carabids may be prominent natural regulators of agricultural pest populations (Lövei-Sunderland, 1996) [19]. · Certain species consume plant tissues and exhibit diurnal activity. Typically, a species is restricted to a single or few types of habitats, with clearly defined habitat associations (Morgan *et al*., 2000 [22]; Rafi *et al*., 2010) [24]. Ground beetles' dwell in particular habitats and ecological demands; they are useful markers of living and non-living environmental disruptions, habitat deterioration, or habitat purity (Felix, 2009 [7]; Choi *et al*., 2021) [5]. Because of their behaviours, ground beetles are useful biological markers of climatic zone and agro-ecosystem changes.

Methods and Materials

Study Area

The present work has been conducted in two sites of Alwar district of Rajasthan (fig1). Alwar district (fig 2) lies in northeastern Rajasthan, positioned between 27°4' and 28°4' latitude in the north and 76°7' and 77°13' longitude in the east. Located at an elevation of 270 meter above sea level. The Aravalli hills surround Alwar, shielding it from the hot, sandy winds of the Thar Desert. Its diverse geography encompasses rivers, mountains, plains, and semi-arid regions. Alwar experiences a moderate climate within a sub-humid zone. The district has distinct seasons: winters run from November to February, while the monsoon season extends from July to mid- September. Temperatures rise steadily from March to June (the maximum temperature is around 41ºC and the minimum 28ºC), then begin declining from mid-November, reaching their lowest in January (maximum temperature is ~ 23ºC and minimum ~ 8ºC). The district maintains an average temperature of 24.9°C and receives a mean annual rainfall of 668.6 mm. The River Ruparel, the district's principal waterway, supports rich biodiversity in the region. Alwar benefits from a well-organized drainage system, with its territory divided among two major river basins: Sabi and Ruparel (PHED Rajasthan, 2013; Jain *et al*., 2009 [12]; https://alwar.rajasthan.gov.in/jankalyan-category-and-entry-type/23/1/4). For the purpose of the present study, a total of 2 areas of Alwar district were selected for the study of ground beetle diversity, and all two areas have rich biodiversity, namely –

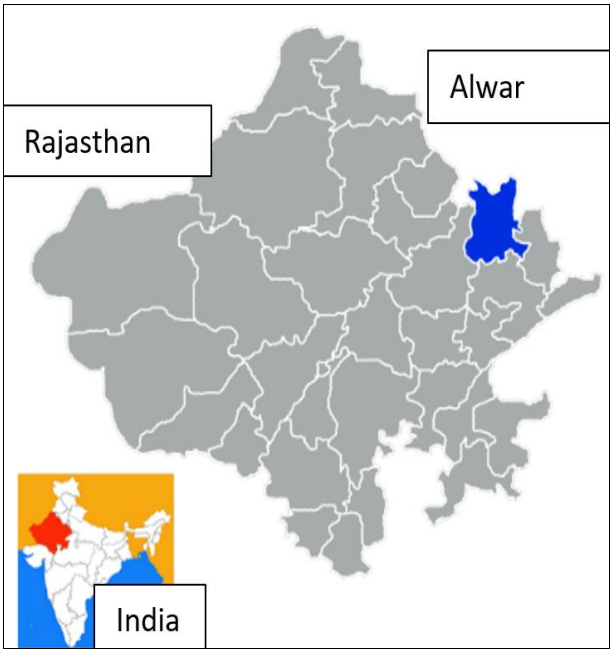

Fig 1

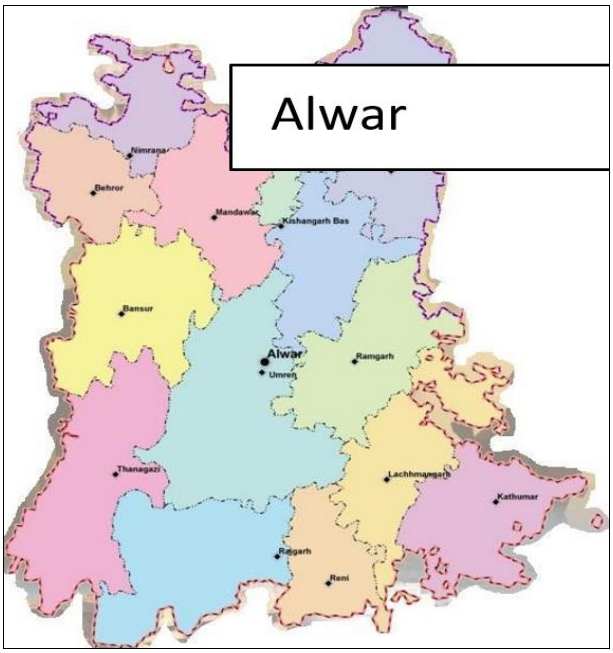

Fig 2

Site A

Fig 3: depicts Agricultural land in village Jatka (Site A).

Jatka Village is located in the Alwar District of Rajasthan, India. The village's proximity to the Aravalli's affects its climate and the surrounding natural landscape.

Site B

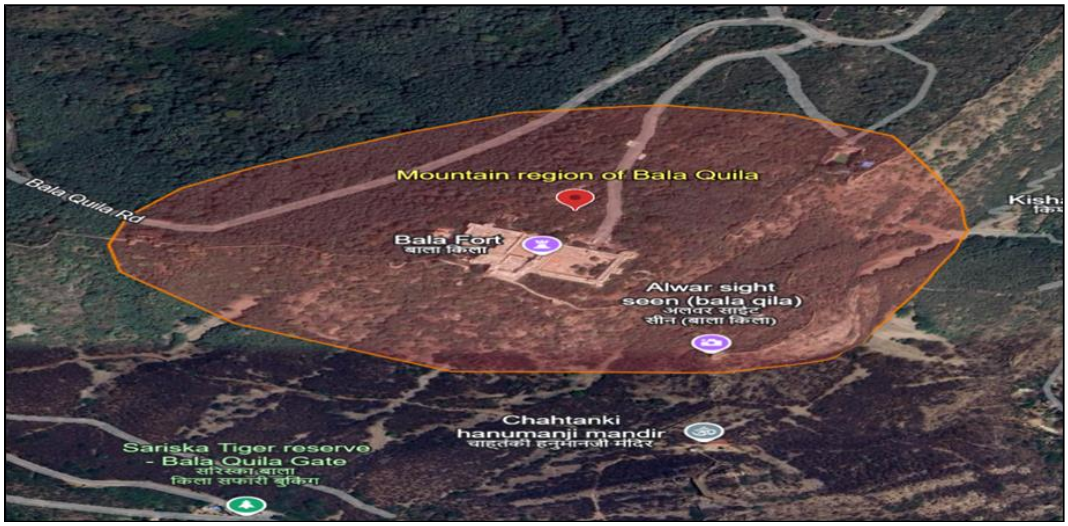

Fig 4: depicts Mountain region of Bala Quila (Site B).

The Bala Quila (also known as Alwar Fort) is situated on a hilltop in the Aravalli Range, overlooking the city of Alwar. The fort's location also offers panoramic views of the surrounding landscape, including the city of Alwar and the natural beauty of the Aravallis (Dang,2005) [6].

Table 1: Geographical information about selected sites for carabidae samplings

S.No.	Sites	Geographical Co-ordinates		Elevation (m)	Habitat types
		Latitude	Longitude		
1	Agricultural land in village Jatka	27.8454884°	76.7358548°	305	Human habitation with agricultural land
2	Mountain region of Bala Quila	27.5748897°	76.5874558°	601	Dry deciduous forests, Scrubland, and Rocky terrain

Collecting methods: Ground beetles were collected through a combination of hand collection, pitfall trapping, and light trapping methods. Figure 5(a, b, c) illustrates the pitfall trapping method in figure a, b. and the hand-picking approach in figure c.

Figure 5 (a)

Figure 5 (b)

Figure 5 (c)

Hand picking: This technique entails the manual collection of specimens in their natural settings, typically using paintbrushes and forceps to ensure precision. Pitfall traps: Ground beetles, which predominantly inhabit the soil surface, were sampled using pitfall traps designed to reflect their ecological characteristics. Three pitfall traps were used for each sampling site. These pitfall traps were arranged at a uniform distance of ten metres. The traps were placed with their openings level with the ground surface to facilitate beetle entry. Transparent plastic bottles were used as trap containers, each measuring 10.5 cm in height, 8 cm in diameter, and holding a volume of 500ml. To prevent disturbance or predation by medium- to large-sized animals such as rodents and reptiles, plastic filters with six holes (each 2 cm in diameter) were fitted. Additionally, a plastic cover was positioned 5 cm above the trap opening to shield the traps from rainwater. Preservation: A preservative solution composed of ethyl alcohol and ethylene glycol in a 1:1 ratio was used to maintain the condition of collected specimens. Identification: all accessible resources, including standard taxonomic keys from books and pictorial illustrated guides, were used for identification. The species of ground beetle has been identified by the Zoological Survey of India, which is situated in Kolkata. Taxonomic keys were primarily utilized to identify Carabidae species (Choate, 1999.) [4] Lefroy, 1909 [18]; Miroshnikov, 2018) [21], and the iNaturalist website was used for this.

Statistical Analysis: Relative species abundance of beetles was enumerated by the following formula:

Relative species abundance (%) = (Number of individuals / Total number of individuals) ×100

Diversity indices	
Simpson's Diversity Index (D^x):	**$D = \frac{\Sigma n(n-1)}{N(N-1)}$**
n= total number of organisms of a particular species	
N= total number of organisms of all species.	
Where: The value of D ranges between 0 and 1. (Simpson, 1949) [27]	

Results and Discussion

During the course of the investigation, 640 ground beetle specimens characterised by 8 subfamilies, 11 genera and 18 species of the Carabidae family were seen. The most prevalent subfamilies in terms of species count were Trechinae (5 species) and Harpalinae (4 species), which were followed by Brachininae (2 species), Scaritinae (2 species), Lebiinae (2 species), Anthiinae (1 species), Carabinae (1 species) and Paussinae (1 species) in that order (Table 3). The subfamily Harpalinae exhibited the highest relative abundance (34.84%), followed by Trechinae (22.96%), Lebiinae (19.84%), Scaritinae (6.71%), Brachininae (6.56%), Carabinae (4.21%), Anthiinae (4.06%), and Paussinae (0.78%) (Figure 6). In their study on the composition and species richness of carabids in Hungary, Kutasi, et.al. (2004) observed similar trends. According to their findings, the most prevalent species in nearby orchard habitats were *Pseudoophonus rufipes* (96 individuals), *Harpalus distinguendus* (47), *Harpalus tardus* (46), *Anisodactylus binotatus* (20), *Calathus fuscipes* (19), *Calathus erratus* (18), *Amara aenea* (17), *Harpalus affinis* (17), and *Pterostichus melanarius* (16). Carabus orientalis, Anthia sexmaculata, and Calosoma maderae are three species of Carabidae that were reported from the Indian Thar Desert in Rajasthan by Kazmi and Ramamurthy (2004) [13]. The results of this investigation corroborate their findings. Furthermore, the carabid fauna of New Zealand comprises 476 species-group taxa (461 species and 15 subspecies), 21 tribes, 86 genera, and 7 subfamilies, according to Larochelle and Larivière (2007) [17]. Out of them, 17 genera (20%) are native, 19 genera (22%) are adventive, and 50 genera (58%) are endemic. In a parallel study, Thakare *et al*. (2013) [29] found ten species of ground beetles from the Melghat Tiger Reserve in Central India, representing six subfamilies of the Carabidae family. According to Kushwaha et.al. (2017) [15], there are 15 distinct ground beetle species (Coleoptera: Carabidae) which are classified into five subfamilies. The most prevalent subfamily among these was Cicindelinae, which had nine species. Trechinae and Lebiinae, on the other hand, each had two species, while Brachininae and Licininae each had one species. Notably, seven of these species were recorded for the first time from the deltaic islands. Shirbhate's 2020 [26] project, which ran from August 2016 to February 2020, was a thorough examination of the diversity of beetles in the Akola area of Maharashtra, India. The 34 species of ground beetles (Carabidae family) that they found in both forest and agricultural settings were among the 90 beetle species they found in 68 genera and 13 families. Similarly, Ali *et al*. (2021) reported the collection of 37 specimens comprising 10 species from 10 genera and 4 subfamilies, which were new records for Oman. In their study, the subfamilies Lebiinae and Harpalinae dominated the carabid assemblage. Overall, 956 carabid beetle individuals representing 28 species, 19 genera, and 11 subfamilies were identified by Meena and Kumari (2023) [20]. The subfamilies were collected from various environments in the research region.

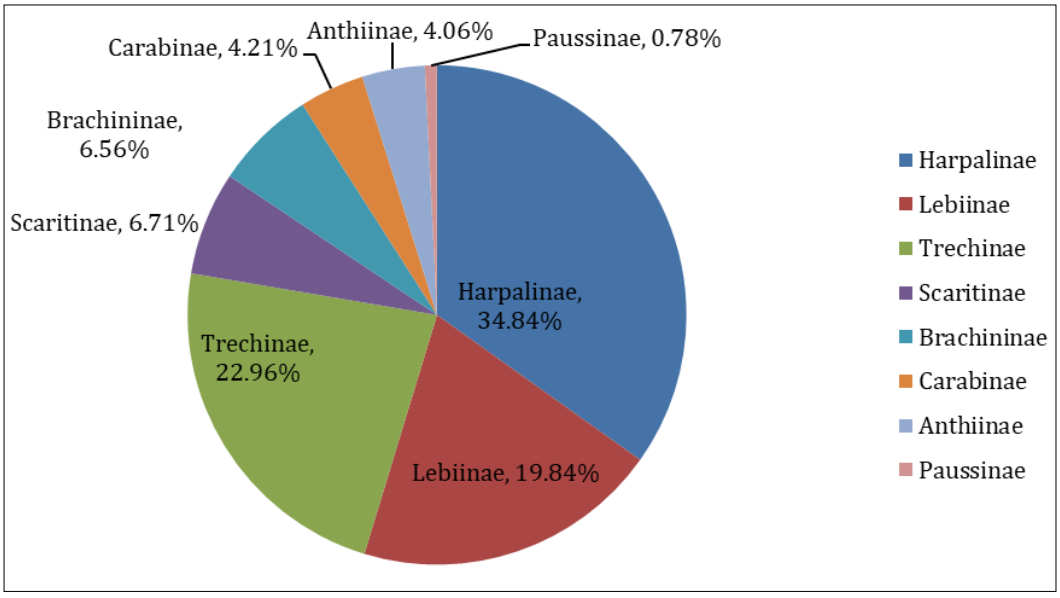

Fig 6: Observed relative abundance in sub families of Carabidae Family of Coleoptera from July 2022 to June 2023 at District Alwar, Rajasthan.

Table 3: The distribution pattern, variety, abundance, and relative abundance of the Order Coleoptera family Carabidae at Sites A and B in the district of Alwar, Rajasthan, India were studied between July 2022 and June 2023

Subfamily	Genus and species	Site-A	Site-B	Abundance	Relative abundance (%)
Brachininae	*Pheropsophus verticalis* dejean	4	3	7	1.09375
	Pheropsophus sp.	27	8	35	5.46875
Harpalinae	*Harpalus caliginosus* fabricius	18	15	35	5.15625

	Tetragonoderus intermedius solsk	47	18	65	10.15625
	Chlaenius bimaculatus bohemian	53	18	71	11.09375
	Chlaenius pseudotristis	41	13	54	8.4375
Lebiinae	*Apristus latens* LeConte, 1846	15	5	20	3.125
	Dromius quadrimaculatus linn	84	23	107	16.71875
Scaritinae	*Scarites buparius* forster, 1771	11	5	16	2.50
	Scarites subterraneus fabricius	16	11	27	4.21875
Trechinae	*Bembidion tetracolum* say, 1825	18	13	31	4.84375
	Bembidion ambiguum dejean	22	14	36	5.625
	Bembidion biguttatum fabricius	19	13	32	5.00
	Bembidion petrosum gebler, 1833	16	4	20	3.125
	Bembidion obtusum audinet-Serv	17	11	28	4.375
Anthiinae	*Anthia sexguttata fabricius*, 1775	17	9	26	4.0625
Paussinae	*Paussus favieri* fairmaire, 1851	4	1	5	0.78125
Carabinae	*Calosoma sayi* dejean, 1826	21	6	27	4.21875
	Total	45	190	640	100

Diversity indices of the Carabidae family of Coleoptera in Alwar district (two selected sites) of Rajasthan, India, from July 2022 to June 2023. The Simpson's diversity index of the carabid family is site A which recorded a diversity value of 0.9137, and site B which recorded a diversity value of 0.9327. Our study highlights that both Site A and Site B exhibit similar high species diversity and richness in carabid beetles. This suggests that the availability of agricultural landscapes, the diversity of plant species and habitat structure were key factors in determining carabid beetle diversity. As temperate forest regions have less dense canopy closure due to diversity of herbaceous plants, they provide a heterogeneous vegetation structure that supports a wide range of ground-dwelling carabid beetles. These findings underscore the importance of habitat complexity and plant diversity in supporting carabid beetle communities. Therefore, the high species diversity and richness observed at Sites A and B likely result from the availability of diverse vegetation types, which offer essential resources and microhabitats for carabid beetles.

Conclusion

The initial findings indicate a notable diversity and widespread presence of carabid beetles in the Alwar district, with a particularly high population observed in agricultural areas. In the present study, 18 species of ground beetles belonging to 8 subfamilies were identified. At Site A (agricultural land of village Jatka), 450 individuals were recorded, while at Site B (mountain region of Bala Quila), 190 individuals were recorded. Site A has a greater abundance of ground beetles than Site B, likely due to the presence of open agricultural land, grasslands, crops, good vegetation, and favourable habitat conditions for Carabidae. In this study, the subfamily *Harpalinae* showed the highest relative abundance, while the subfamily *Paussinae* showed the lowest relative abundance in the study area. These beetles, known for their predatory behaviour, actively prey on a variety of common crop pests such as aphids, mites, caterpillars, grubs, snails, and slugs. Due to their high abundance and aggressive feeding habits, carabid beetles hold promise as biological control agents in future Integrated Pest Management (IPM) programs, where they could play a significant role in reducing pest populations naturally. To ensure the continued ecological function and survival of these beneficial insects, it is essential to implement effective conservation measures aimed at protecting their natural microhabitats. These environments are critical for maintaining the biodiversity and species richness of carabid beetles, underlining the importance of habitat preservation in agricultural landscapes.

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