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Research Article

Diversity and Abundance of Beetles (Coleoptera) in Matiari District, Sindh, Pakistan

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ABSTRACT

Matiari district, located in Sindh Province, Pakistan, is endowed with diverse agricultural resources, including rice paddies, guava orchards, and crops such as barley, wheat, and lucerne (*Medicago sativa*). Beetle populations were surveyed in Matiari and neighboring areas, Hala, Saeedabad, Sekhat, Banoth, Odero Lal, and Bhitshah, during 2022-2023 using light traps and pitfall traps to collect adult specimens. Beetles (order Coleoptera) represent one of the most diverse insect orders globally, with over 400,000 described species. A total of 709 beetle specimens were collected, of which 10 species, representing four families, were accurately identified. The recorded species included *Anthia sexguttata* (Fabricius, 1775), *Julodis euphratica* (Laporte and Gory, 1835), *Melolontha furcicauda* (Ancy, 1881), *Chiloloba acuta* (Wiedemann, 1823), *Protaetia indica* (Mikšić, 1965), *Carabus cashmirensis* (Redtenbacher, 1844), *Chlaenius hamifer* (Chaudoir, 1856), *Chlaenius quadricolor* (Oliver, 1790), *Catharsius pithecius* (Fabricius, 1775), and *Hycleus lugens* (Latreille, 1817). Among these, *Catharsius pithecius* was the most abundant species. Most beetles were collected from muddy soils and cultivated fields during July, August, and September, coinciding with peak crop growth. Members of the family Carabidae are recognized as important biological control agents and bioindicators of environmental health. Scarabaeidae play key roles in nutrient cycling, pest regulation, and seed dispersal. Meloidae species are primarily agricultural pests, whereas Buprestidae include species that damage forestry and agricultural systems, although some contribute to decomposition and nutrient cycling. Despite their ecological significance, comprehensive studies on beetle diversity in Pakistan remain scarce.

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Introduction

Beetles (order Coleoptera) represent the largest and most diverse order of animals on Earth, comprising approximately 40% of all known animal species. Globally, more than 400,000 beetle species have been formally described, although estimates suggest that the total number may exceed one million and could reach up to 2.1 million species (Johnson and Triplehorn, 2005). Members

of this order inhabit nearly all terrestrial ecosystems, ranging from arid deserts to dense tropical rainforests. Their remarkable diversity is reflected in their size, morphology, and ecological adaptations, from large species such as the Goliath beetle, which can attain lengths of up to 4.5 inches, to minute species barely visible to the naked eye (Abid and Rana, 2019). Beetles have evolved a wide array of adaptations, including cryptic coloration, specialized

mouthparts for feeding on specific plant or fungal hosts, and, in some groups, bioluminescence used for communication (Lundgren, 2005).

Among beetles, the family Carabidae (ground beetles) is one of the most species-rich groups, comprising approximately 40,000 described species distributed among about 1,860 genera and nearly 100 families worldwide (Baldrige, 2016). According to the Australian Museum, beetles are the most diverse group of insects, with over 350,000 species documented globally. Pakistan contributes significantly to this diversity, particularly in terms of regional concentrations of different beetle families (Sugihara et al., 2003).

Several studies conducted in Pakistan have documented the distribution and diversity of beetle species across different agro-ecological zones. Investigations in the lower and upper Sindh plains have revealed distinct distributional patterns of ground beetles, with one study reporting 18 species belonging to three taxonomic groups from Mandi Bahauddin (Ullah et al., 2011). Research on the family Coccinellidae has recorded its diversity in Gilgit-Baltistan, Faisalabad, Sargodha, and Sindh, with a total of 29 species reported from Sindh, including four new records for Pakistan. Furthermore, studies from Upper Sindh documented six Carabidae species from five sampling sites, while surveys in district Sukkur recorded five ground beetle species. Additional research from Mirpurkhas reported ten beetle species belonging to six families.

Beyond their numerical dominance, beetles play crucial ecological roles as decomposers, facilitating the breakdown of organic matter and nutrient cycling, and as pollinators, contributing to the reproduction of flowering plants (Zahoor et al., 2003). Ground beetles (Carabidae) are of particular importance in ecological research due to their value in testing ecological theories and their functional roles as herbivores, scavengers, and predators (Lövei and Sunderland, 1996). Their ability to occupy a wide range of ecological niches has contributed to their evolutionary success across diverse ecosystems (Pitman et al., 2003). The present study was conducted to investigate the diversity and distribution of beetle species (Coleoptera) in Matiari district, Sindh. The findings revealed considerable variation in species composition and abundance across different localities. Beetle distribution and habitat preferences are influenced by both abiotic and biotic factors, including temperature, light, moisture, food availability, and life-history traits;

however, abiotic factors were found to exert a stronger influence on species distribution than biotic factors (Urooj et al., 2016). The primary objective of this research was to assess the diversity and abundance of beetle families occurring in the study area.

Materials and Methods

The study was conducted in the Matiari district of Sindh Province, Pakistan. This area encompasses diverse ecosystems, including farmlands, fruit orchards, and semi-natural vegetation, creating a mosaic of microhabitats that support the survival and dispersal of various insect species, particularly beetles. Specific sites within the district, Hala Saheedabad, Bhitshah, Odero Lal, Sekhat, and Banoth, were deliberately selected due to their ecological significance and habitat heterogeneity (Figure 1). All these locations are situated on the left bank of the Indus River (Seibold et al., 2016).

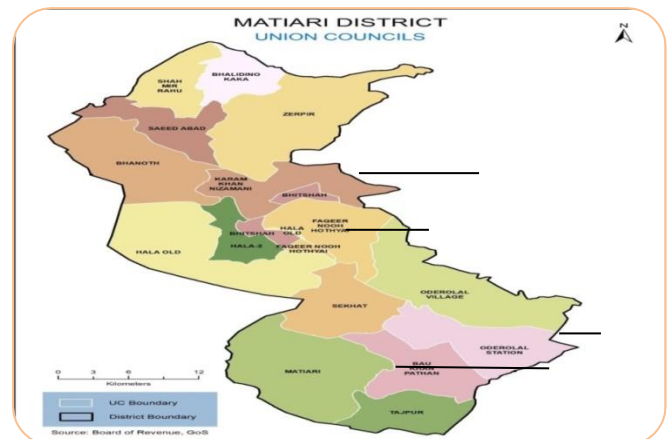


Figure 1. Map of the study area showing sampling localities in Matiari district, Sindh Province, Pakistan.

The selected towns represent a combination of natural and anthropogenic landscapes. The presence of crops such as rice, wheat, barley, and guava, alongside uncultivated soils and seasonal variations in vegetation, enhances the ecological diversity of the area. This diversity provides an optimal setting for assessing the distribution, abundance, and diversity of beetle populations under varying environmental conditions. During the year 2022-2023, the climate in Matiari was generally moderate. Summers were hot, humid, and breezy, whereas winters were short, mild, and dry. The region remains predominantly clear throughout the year. Temperatures typically ranged from 11.1°C to 41.1°C rarely dropping below 7.8°C or exceeding 44.4°C (Table 1).

Table 1. Geographic coordinates (latitude, longitude, and altitude) of surveyed localities in the Matiari District, Sindh, Pakistan.

Locality	Latitude	Longitude	Altitude (in meters)
Hala	25.8167566°N	68.4233593°E	39 m
Saeedabad	25.69°N	68.44°E	23 m
Bhitshah	25.8044° N	68.4927° E	19 m
Odero Lal	25.7013347°N	68.5614382°E	19 m
Sekhat	25.6488° N	68.4971° E	14 m
Banoth	25° 52' 0" N	68° 20' 60" E	19 m

Sampling strategies of beetles

To obtain a comprehensive and representative collection of beetle species for ecological studies, it is essential to employ multiple sampling methods. Each technique targets different beetle habitats and activities, ensuring the capture of a wide diversity of species. Ground beetles were collected during 2022 and 2023 from six sites along the left bank of the Indus River, with minimal variation in soil composition, moisture availability, crops, and vegetation across different months. GPS coordinates (latitude, longitude, and altitude) were recorded for each Upper Sindh sampling site using an online application.

Biodiversity was quantified using Simpson's Diversity Index (SDI), which accounts for both species richness and the evenness of their distribution within a community.

$$D = 1 - (i=1 \sum S_{pi}^2)$$

Where:

D is the Simpson's Diversity Index,

S is the total number of species in the community,

Pi is the proportion of the total sample belonging to the i-th species (calculated as the number of individuals of the i-th species divided by the total number of individuals in the sample).

The mean population size was calculated by dividing the overall count of individuals (N) by the species number (S). One of the simplest methods employed was hand-collecting, through which beetles from various natural surfaces were gathered. This approach is particularly useful for obtaining larger or slower-moving species that are readily visible. Hand collection allows for precise sampling, especially when targeting beetles associated with specific host plants or microhabitats (González-Céspedes et al., 2021).

Another method used was pitfall trapping, a highly efficient passive technique for sampling soil-dwelling beetles. Pitfall

traps consist of containers, such as jars or cups, embedded in the ground so that their rims are flush with the soil surface (Figure 2). This method is particularly advantageous in agricultural fields, forests, and pastures, as it enables continuous monitoring of ground-active species. Pitfall traps are easy to set up, non-invasive, and effective in capturing numerous beetle species over extended periods, making them ideal for assessing population trends and species diversity (Raffa, et al., 1983).

Light traps were also employed to attract nocturnal beetles exhibiting photo taxis (movement toward light). These traps typically feature a light source, often ultraviolet (UV), positioned above or near a collection container. Nocturnal beetles are drawn to the light and subsequently captured in the container below. Light traps are especially effective for detecting species that are difficult to observe during the day and provide valuable insights into the diversity and behavior of nocturnal beetle populations (Figure 2). Collectively, these sampling techniques enhance the accuracy and comprehensiveness of beetle biodiversity assessments, ensuring that daytime and nighttime, ground-dwelling, and plant-associated species are adequately represented.

Identification of beetles

Beetles were collected using a light lamp placed at the center or corner of a designated area, following the methodology described by (Axmacher and Fiedler, 2004) for light tower sampling. Ground beetles resting on the light tower were captured using jars containing diethyl ether. Sampling was conducted from early March 2022 to February 2023. Light towers operated for three hours each night, beginning just prior to sunset. Each night, three plots with different treatments were sampled, with each plot sampled once per phase, resulting in two samples per month. All captured carabids were preserved in bottles containing 75% alcohol.



Figure 2. Methods used for the collection of beetles in different agricultural lands of Matiari district, Sindh, Pakistan.

Pitfall traps were deployed during the same two five-day periods in which light trapping occurred each month. Although the influence of the two sampling methods cannot be entirely excluded, consistency across the area is assumed because light towers operated for one night per plot during each pitfall trapping interval. In each area, eight pitfall traps (8 cm diameter × 11.5 cm height) were placed along two intersecting diagonal lines oriented N-S and E-W at distances of 4 m and 7 m from the plot center. Each pitfall was protected from rain by a simple aluminum cover positioned approximately 5 cm above the trap and partially filled with 75% alcohol to kill and preserve specimens.

After collection, beetles were identified based on diagnostic morphological characteristics following Bousquet (1990). Identification was carried out using standard dichotomous keys, which emphasize morphological traits, supported by microscopy for detailed examination of fine structures. In addition, machine learning-based image analysis was employed to assist in automated species recognition.

These approaches enabled reliable differentiation among major coleopteran families. Scarabaeidae are typically robust and heavily sclerotized (“armored”) beetles. Meloidae are generally elongated, soft-bodied beetles with long legs or tarsi and a velvety texture, often displaying a metallic sheen. Buprestidae (jewel beetles) are characterized by brilliant, iridescent coloration, deflexed heads, and serrate antennae. Carabidae possess a hard, shiny body, usually black or brown with metallic reflections, prominent mandibles, long legs adapted for rapid running, and distinct longitudinal grooves (striae) on the elytra that meet in a straight line; their antennae are typically filiform.

These diagnostic traits facilitated accurate identification of the diverse range of coleopteran species examined. Figure 3 illustrates representative beetle families, highlighting their

distinctive morphological features and coloration.

Results and Discussion

The study conducted across different areas of Matiari, Sindh resulted in the collection of 709 beetle specimens from six talukas: Hala, Saheedabad, Sekhat, Banoth, Odera Lal, and Bhitshah. These locations were selected to assess beetle biodiversity and population dynamics, highlighting their ecological significance. The specimens were classified into four families: Carabidae, Scarabaeidae, Meloidae, and Buprestidae, detailed as follows:

The Carabidae family comprised three genera: *Carabus*, *Chlaenius*, and *Anthia*. The Scarabaeidae family included four genera: *Catharsius*, *Melolontha*, *Chiloloba*, and *Protaetia*. The Meloidae family contained a single genus, *Hycleus*, and the Buprestidae family included one genus, *Julodis*.

***Carabus cashmirensis* (Redtenbacher, 1844)**

Like other carabids, *C. cashmirensis* acts as a biological control agent by preying on numerous agricultural pests and feeding on weed seeds, thus reducing weed growth in farming areas. The beetle is black, with a slim, sleek head, prominent eyes, a triangular mentum tooth, and a somewhat transverse prothorax broader than the head. The elytra are oval and elongated, with concentrated protarsi. This species is distributed across Asia, with records in Azad Kashmir, Dera Ismail Khan, and Sindh Province (Figure 3a).

***Chlaenius quadricolor* (Oliver, 1790)**

This ground beetle occurs widely in Pakistan, especially in the Upper Sindh plains. Its abundance is influenced by environmental factors such as moisture, temperature, and vegetation. The beetle has 3-3.5 mm long antennae, downward-facing mouthparts, triangular mentum teeth, prominent eyes, and an enlarged thorax broader than the head. Its elytra extend to the abdomen tip, and adults measure up to 14 mm in length (Figure 3b).

***Chlaenius hamifer* (Chaudoir, 1856)**

Recognized by its metallic green coloration, the head and pronotum exhibit a metallic sheen. Elytral fasciae are comma-shaped, positioned a third from the apex. The pronotum is quadrate, moderately punctate, and pubescent, with more punctures in the basal region. The labrum apex is nearly truncate, and the terminal segments of the maxillary and labial palpi are conical. This species occurs in Sindh, Khyber Pakhtunkhwa, Azad Kashmir, and Baluchistan, inhabiting mountains, grassy hills, and scrub woodlands (Figure 3c).

***Anthia sexguttata* (Fabricius, 1775)**

Found in arid South Asian regions, this species inhabits woodlands, scrub areas, agricultural fields, and urban zones. Adults are approximately 4 cm long, black, with six large white dorsal spots. Larvae are flattened with prominent mandibles. Adults prey on insects and snails and serve as important predators of beetle pests in sugarcane crops (Figure 3d).

***Catharsius pithecius* (Fabricius, 1775)**

A dung beetle, this genus includes ~100 species (15-50 mm). *Catharsius* species improve soil quality by incorporating large amounts of manure. They are glossy black, with partially opaque pronotum, reddish antennae and appendages, and highly convex, ovate bodies. Elytra are finely striated. Due to its hard elytra, *C. pithecius* was the most abundant species in Matiari (32.05%) (Figure 3e).

***Melolontha furcicauda* (Ancey, 1881)**

Distributed in Ghotki, Hyderabad, Matiari, Badin, Jacobabad, Jamshoro, Karachi East and West, Qambar Shahdadkot, Sukkur, and Shikarpur. The body is pale creamy with light to dark brown streaks. Males have

uniform, dense punctae on the head and pronotum, whereas females show coarse, irregular punctae with a granular central pronotum. The scutellum is small and rounded (Figure 3f).

***Chiloloba acuta* (Wiedemann, 1823)**

First recorded in Pakistan in 2021-2022 (Sindh Province). Adults are metallic green, sometimes appearing red or dark blue, with glossy bodies and short hairs. The clypeus has a central ridge, and the elytra form a crest at the posterior margin. The species feeds on grasses during the monsoon and may damage cereal and millet crops, including sorghum and maize (Figure 3g).

***Protaetia indica* (Mikšić, 1965)**

Found in Pakistan (Jammu & Kashmir), India, and Afghanistan. As a flower chafer, it serves as a pollinator. Adults feed on nectar, pollen, tree resin, and decomposing fruit, while larvae inhabit decaying organic matter, including wood and soil (Figure 3h).

***Hycleus lugens* (Gyllenhaal, 1810)**

Belonging to the Meloidae family, these beetles produce cantharidin, a blistering agent. Larvae are carnivorous, preying mainly on bees and grasshopper eggs. Adults are brightly colored with curved, slightly cylindrical bodies and bead-textured antennae. Cantharidin serves as a defense mechanism against predators (Figure 3i).

***Julodis euphratica* (Laporte and Gory, 1835)**

Known as the Sulphurous or Euphratic jewel beetle, this Buprestidae species inhabits dry regions of Pakistan. Adults feed on nectar from wildflowers, and larvae develop inside acacia trees. Adults live approximately three months, while the larval stage lasts about nine months. The species measures 29-31 mm (Figure III3j).

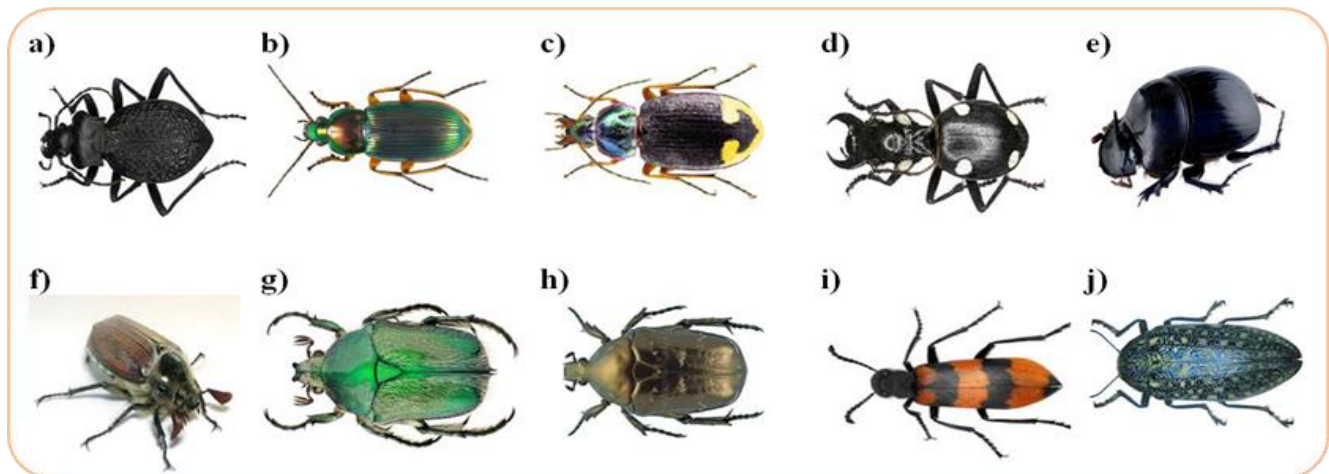


Figure 3. Representative beetle species recorded in the study: *C. caschmirensis* (a), *C. quadricolor* (b), *C. hamifer* (c), *A. sexguttata* (d), *C. pithecius* (e), *M. furcicauda* (f), *C. acuta* (g), *P. indica* (h), *H. lugens* (i), and *J. euphratica* (j).

Species abundance of Coleoptera in Matiari region

Table 2 summarizes the total abundance of ten Coleopteran species across six neighboring regions of Matiari, Sindh, Pakistan. Among the species recorded, *Carabus caschmirensis* was the most abundant, with a total of 31 individuals, followed by *Chlaenius quadricolor* (19 individuals) and *Anthia sexguttata* (18 individuals). *Protaetia indica* and *Hycleus lugens* were equally represented, each with 17 individuals, while *Catharsius pithecius*, *Chiloloba acuta*, and *Julodis euphratica* each accounted for 16 individuals. *Melolontha furcicauda* had a slightly lower abundance with 15 individuals, and *Chlaenius hamifer* was the least abundant, with 13 individuals. The distribution of species varied across the regions, with some species showing higher prevalence in Banoth and Oderolal, indicating region-specific habitat preferences and ecological niches.

The analysis of coleopteran species abundance in the agricultural fields of Matiari, Sindh, Pakistan, revealed a community strongly dominated by a few species (Figure

4). *C. caschnirensis* was clearly the most prevalent, constituting over one-third (35.00%) of all individuals collected. This was followed by *A. sesguttata* at 28.00% and *C. hamiter* at 21.00%. Together, these three species made up a substantial 84.00% of the total beetle fauna sampled, indicating a low-diversity assemblage with a high degree of dominance. The remaining species contributed minimally to the overall population structure. *C. pinhecius* was present at a moderate level of 14.00%, while *M. furcicauda* accounted for only 7.00%. Notably, species such as *C. acuta*, *P. indica*, *H. lugens*, and *J. euphratica* were recorded with 0.00% abundance in this particular survey, suggesting they were either absent, extremely rare, or not captured during the sampling period in these agro-ecosystems. This skewed distribution highlights the potential ecological dominance of *C. caschnirensis*, *A. sesguttata*, and *C. hamiter* within the local beetle community, which could have implications for pest dynamics, nutrient cycling, and overall biodiversity management in the region's agricultural landscapes.

Table 2. Total abundance of coleopteran species in selected neighboring regions of Matiari district, Sindh, Pakistan.

Number of species	Hala	Saeedaba	Bhitshah	Oderolal	Banoth	Sekhat	Total
<i>Carabus caschmirensis</i>	4	6	4	7	6	4	31
<i>Anthia sexguttata</i>	1	2	1	5	5	4	18
<i>Chlaenius hamifer</i>	2	3	2	2	3	1	13
<i>Chlaenius quadricolor</i>	2	3	4	1	4	5	19
<i>Catharsius pithecius</i>	4	1	2	2	3	4	16
<i>Melolontha furcicauda</i>	2	1	4	3	2	3	15
<i>Chiloloba acuta</i>	1	3	2	3	4	4	16
<i>Protaetia indica</i>	2	3	3	5	3	1	17
<i>Hycleus lugens</i>	3	2	4	4	2	2	17
<i>Julodis euphratica</i>	2	2	2	3	3	4	16

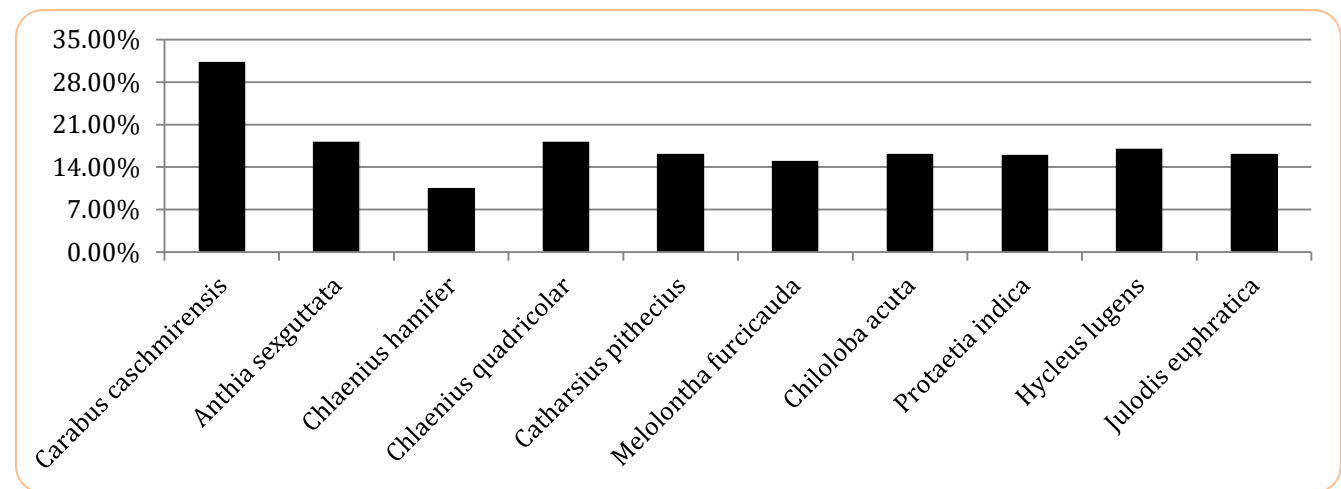


Figure 4. Percentage distribution of coleopteran species recorded in agricultural fields of Matiari, Sindh, Pakistan.

Coleopteran species composition

Carabus caschmirensis and *Catharsius pithecius* were the most frequently observed species, each representing **17%** of the total Coleopteran specimens collected. This was followed by *Hycleus lugens* (**13%**). Several species—*Julodis euphratica*, *Protaetia indica*, *Melolontha furcicauda*, *Chlaenius hamifer*, and *Chlaenius quadricolor*, each accounted for **9%** of the observations. The least represented species were *Chiloloba acuta* and *Anthia sexguttata*, each at **4%**. The results indicate a diverse coleopteran community dominated by two species, with the remaining observations distributed among eight other identified species (Figure 5).

SDI of Coleopteran species across different sites in Matiari district, Sindh

Table 3 presents Simpson’s Diversity Index values for coleopteran species recorded across different sites in Matiari District, Sindh. All species exhibited high diversity values (0.899-0.999), indicating a well-distributed and diverse beetle assemblage across the study area. The highest diversity was observed for *Anthia sexguttata* and *Melolontha furcicauda* (0.999), followed by *Chlaenius quadricolor* (0.998). Most other species, including *Carabus caschmirensis*, *Protaetia*

indica, and *Hycleus lugens*, also showed similarly high indices (0.997), reflecting low dominance and relatively even abundance among species. In contrast, *Chlaenius hamifer* recorded the lowest Simpson’s Diversity Index (0.899), suggesting comparatively lower diversity at sites where this species occurred. Overall, the results demonstrate high coleopteran diversity and ecological stability across the surveyed sites in Matiari district.

Table 3. Simpson’s diversity index of coleopteran species across different sites in Matiari district, Sindh, Pakistan

Number of species	Abundance	Simpson’s Diversity Index
<i>C. caschmirensis</i>	31	0.997
<i>A. sexguttata</i>	18	0.999
<i>C. hamifer</i>	13	0.899
<i>C. quadricolor</i>	19	0.998
<i>C. pithecius</i>	16	0.992
<i>M. furcicauda</i>	15	0.999
<i>C. acuta</i>	16	0.992
<i>P. indica</i>	17	0.997
<i>H. lugens</i>	17	0.997
<i>J. euphratica</i>	16	0.992

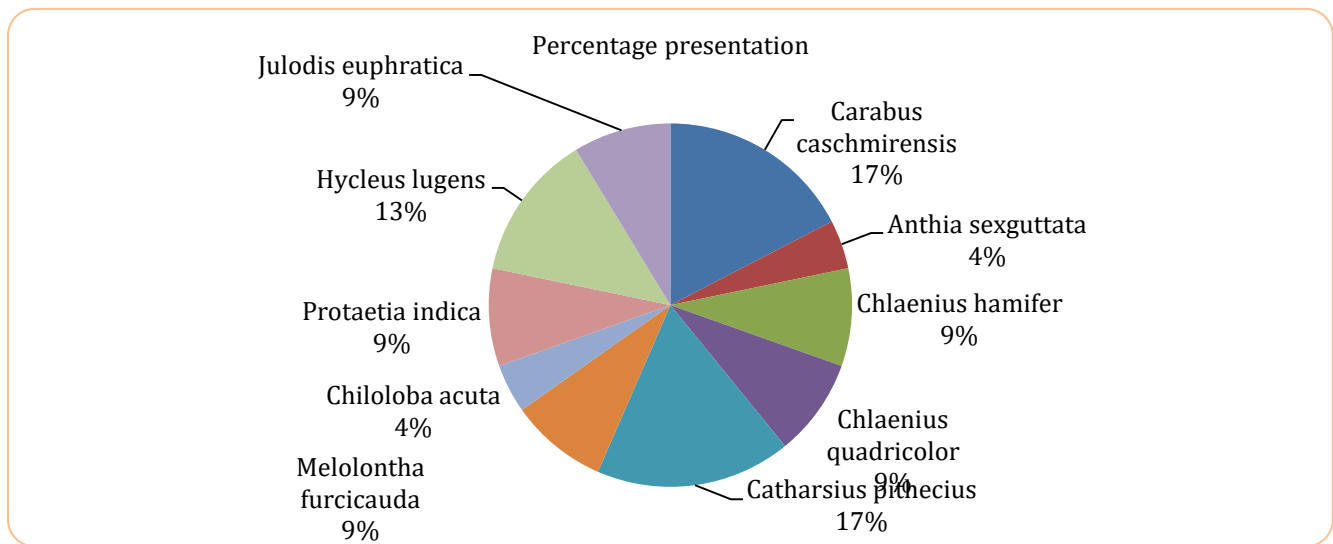


Figure 5. Percentage representation of coleopteran species observed in the agricultural fields of Matiari, Sindh, Pakistan.

Conclusion

The survey conducted in the Matiari district revealed a diverse assemblage of beetle species, highlighting the ecological significance of Coleoptera in the region. From a total of 709 collected specimens, ten beetle species belonging to four families were identified.

These species differed markedly in terms of habitat preference, feeding behavior, ecological niche, and stability within the ecosystem.

The study demonstrated a notable abundance of *C. caschmirensis*, which can be attributed to the extensive agricultural crops and vegetation present at the

sampling sites. Its population peaked during August and September, corresponding to favorable environmental conditions. The species breeds in spring, matures into adults by early summer (June-July), and subsequently becomes abundant later in the season.

C. hamifer was also found to be widely distributed across the surveyed areas, reflecting its adaptability to a broad range of ecoclimatic conditions and its ecological stability. Simpson's Diversity Index indicated high species richness, evenness, and diversity, particularly for *C. caschmirensis* ($E = 0.997$), which corresponded with increased humidity, temperature, vegetation cover, and crop availability during the study period.

Dung beetles (Scarabaeidae) were found to play a vital role in maintaining environmental hygiene and are widely regarded as nature's sanitation workers. This family exhibited considerable diversity, encompassing predatory, pest, parasitic, and coprophagous (dung-feeding) species. Members of the Buprestidae family are saproxylic, contributing to nutrient cycling and soil health by feeding on dead or decaying wood. In contrast, Meloidae species possess complex ecological importance, acting both as agricultural nuisances and as potential sources of bioactive compounds with therapeutic value.

Overall, the findings underscore the ecological importance of coleopteran diversity in Matiari District and highlight the need for continued monitoring and conservation of beetle fauna in agricultural and natural ecosystems.

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Authors' Contributions

KDS and NB conceived and designed the study. KDS conducted field sampling, processed and identified insect specimens, performed data analysis, and prepared the original draft of the manuscript. NB provided critical supervision, constructive feedback, and substantive input to enhance the scientific content and clarity of the manuscript. Both authors reviewed and approved the final version of the manuscript and accept full responsibility for the accuracy, integrity, and transparency of the work.

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Conflict of Interest

The authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger

SDG 13: Climate Action

SDG 15: Life on Land

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