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A comprehensive review: Biodiversity and distribution of coleoptera in Indian ecosystems

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Abstract
The review explores the diversity of Coleoptera (beetles) in India across various habitats, highlighting their ecological importance and its role as bioindicators compiling extensive research on diversity of beetles across aquatic, forest, agricultural, and ground habitats in India, highlighting on conservation of beetle habitats to maintain ecological balance and biodiversity. This comprehensive study highlights beetle biodiversity's role in environmental monitoring and ecosystem health, with data ranging over multiple Indian states and habitats. The findings include the importance of conserving beetle habitats to maintain ecological balance and support agricultural productivity, and certain beetle families' dominance in specific ecosystems and their possible applications in pest management and environmental monitoring.

Keywords: Coleoptera, beetles, biodiversity, ecosystem, bioindicators

Introduction

Order Coleoptera which includes beetles play a very crucial role in natural ecosystems. The most species-rich and diversified group of insects are beetles, and comprehending the macro evolutionary processes underlying their variety requires a strong, time-calibrated phylogeny (Zhang *et al*., 2018) [34].

Beetles occur in most terrestrial, freshwater habitats and marine environments (Bouchard *et al*., 2017) [4]. Beetles are ideal indicators of ecosystem health due to their sensitivity (Ghannem *et al*., 2017) [10]. It is a common practice to utilize carabids as a sign of habitat change. They have been applied in boreal forests and grasslands where species abundances and numbers have been seen to vary along a gradient of habitat disturbance (Rainio *et al*., 2003) [22].

India is one of the major mega biodiversity nations, having geographical area of 328.73 million hectare, including agricultural land about 140 million hectares (Kariyanna *et al*., 2017) [16]. The most common type of life-cycle in beetles is holometaboly, which include many larval instars in parasitoid species (Bouchard *et al*., 2017) [4]. Their short life cycles enable them to rapidly adapt to environmental changes, providing insights into ecosystem resilience. They are closely exposed to toxic elements in soil and leaf litter, making them valuable for assessing human impacts (Ghannem *et al*., 2017) [10].

Having over 13,000 species known, the aquatic coleoptera are one of the largest of insects (Short, 2018). The agricultural ecology benefits from the diversity of ground beetles since carabid beetles are important decomposers and lower the number of insect pests, particularly caterpillars (Meena and Kumari, 2023) [20]. Around the world, carabids are common in agricultural fields and could be significant natural enemies of agricultural pests (Lovie, 1996).

Gujarat has the most beetle biodiversity in India, with 177 species spread across 117 genera and 32 families in the order Coleoptera (Thakkar and Parikh, 2016).

Study of Biodiversity of Coleoptera in the 8 States of North East of India Including *viz*. Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura in the agricultural and horticultural fields, medicinal plants, and forest areas of total 2635 specimens of Coleoptera belonging to different families of Suborder Adephaga (2 families) and superfamilies (12 Nos.) of suborder Polyphaga (24 families) was made. The insects were collected from 73 crops (including some weeds) and some unidentified forest trees (Rahman *et al*,.2011) [37].

- **Diversity of Aquatic Beetles**

Aquatic beetles are considered significant bio-indicators that help to understand and manage aquatic ecosystems (Shankar *et al*., 2023) [26]. " The aquatic Coleoptera's habitat choices and variety have been evaluated in this study based on how much time they spend in and out of the water. True water beetles, facultative water beetles, phytophilous water beetles, and other types of insects were categorized by Jach and Bhalke (2008) (Sharma *et al*., 2019) [27].

The Deccan Peninsula (193 species), Western Ghats, Northeast (171 species each), Gangetic Plains (167 species), Semi-Arid (64 species), Islands (43 species), Coasts (37 species), Trans-Himalaya (26 species), and Desert (24 species) have the highest diversity of aquatic beetles in terms of biogeographic distribution, followed by the Indian Himalayan Landscape (357 species) (Chandra *et al.*, 2017) [6].

42 species of beetles belonging to four families *viz*., Dytiscidae, Hydrophilidae, Gyrinidae and Noteridae were identified from Koundinya Wildlife Sanctuary, Andhra Pradesh, India (Shankar *et al*., 2023) [26]. Family Dytiscidae is the most diverse group that includes 21 species followed by Hydrophilidae 11 species, Gyrinidae 7 species, Noteridae with 2 species (Shankar *et al*., 2023) [26]. Research has described over 3,50,000 beetle species to date, with 12,000 of those species known to exist in aquatic environments. Myxophaga (90%) aquatic, Adephaga (18%), and Polyphaga (1.25% aquatic) are the three aquatic representatives of the four suborders of Coleoptera. Of the 15 families found in Polyphaga, the Hydrophilidae family has the greatest number of species (2,652) (Sharma *et al*., 2019) [27].

There are 137 genera, 17 families, and 3 suborders among the 776 species of quatic beetles that make up India's fauna. 371 species, 353 species of Adephaga, and 7 species of Myxophaga are members of the suborder Polyphaga. There

are a maximum of 256 species in the Dytiscidae family, by the following families: Hydrophilidae (212 species), Scirtidae (75 species), Gyrinidae (73 species), Hydraenidae (45 species), Psephenidae (24 species), Noteridae (16 species), Dryopidae (10 species), Georissidae, Helophoridae (7 species each), Hydroscaphidae, Hydrochidae (5 species each), Epimetopidae (4 species), Spercheidae(3), and Sphaeriusidae (2 species) (Chandra *et al*., 2017) [6].

Biodiversity of aquatic beetles' fauna of Kawal Tiger Reserve, Telangana, India reported around 41 species belonging to the four families, out of 41 species 39 reported first times between years 2018-2022. The study documented 27 species of genus *Allocotocerus* thought the globe in which 4 species known from India, single species *Allocotocerus leachi* know from Tamil Nadu. New discovery in which genus *Hydrovatus, Coelostoma* were collected and documented for the first time from tiger reserve and the state of Telangana (Jaiswal *et al*., 2022) [15]. a total of 19 species of aquatic coleoptera, divided into 13 genera and 3 families. According to research, the family Dytiscidae is the most species-rich group, followed by the Hydrohilidae and Gyrinidae. This study, which was conducted in 2017 to learn more about the diversity of water beetles, found sixteen species in Maharashtra's Navegaon National Park for the first time (Deb and Subramanian, 2023) [8].

A study carried out during the 2019 and 2020 Rabi seasons on the aquatic coleopteran diversity in rice, in Karaikal, Union Territory of Puducherry, at Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), found that irrigated rice ecosystem showed 24 species, organized into 18 genera and 5 families. *Berosus indicus* being the predominant species in both seasons. The two most prevalent families were Dytiscidae (47.89%) and Hydrophilidae (49.23%) (Gopianand and Kandibane, 2022) [11].

One of the studies recorded and examined that the range of aquatic beetles in correlation with vegetation and water quality parameters such as pH levels, total dissolved solids (TDS), salinity, electrical conductivity (EC), and dissolved oxygen (DO) which shows that aquatic beetles have a crucial impact on multiple biological processes in aquatic environments. (Rong *et al*., 2024) [24].

During a research aquatic habitat carried out in Dhurwa Dam of Jharkhand, India, more than 121 water beetle samples were examined, consisting of 15 species which were then grouped into 12 genera and 3 families. 8 species of Hydrohilidae, 6 species of Dytiscidae, and 1 species of Noteridae were there. The Chota Nagpur Plateau in Jharkhand was the first place where the species *Cybister sugillatus* (Erichson, 1834), *Leiodytes orissaensis* (Vazirani, 1969), and *Sternolophus rufipes* (Fabricius, 1792) were documented (Sonali *et al*., 2024) [31].

From January to May 2012, an inventory was carried out to evaluate the aquatic entomofauna, variety, and distribution in three urban freshwater lakes in Tripura, northeast India. There were 2159 individuals in all, which corresponded to 31 species, 23 genera, 15 families, and 4 orders. The Maharaja Bir Bikram College Lake had the most diversity, with 30 species and 1191 individuals (rich in vegetation). Minimum diversity was recorded in the Laxminarayan Bari Lake with11 species and 215 individuals (vegetation-poor) (Mujumdar *et al*., 2013).

The diversity of aquatic insects was studied in the Mukundpur Tiger Reserve, located in Satna, Madhya Pradesh. A total of 36 species of aquatic insects were recorded. Order Coleoptera was the dominant order (Chakradhari and Tiwari, 2022) [5].

- **Diversity of Forest Area Beetles**

In the South Western Ghats, a study of the diversity of dung beetle (Coleoptera: Scarabaeidae) community structure across an ecotone of forest and agriculture habitat discovered 1,425 dung beetles in three habitats: 622 from the forest, 460 from the ecotone, and 343 from the agricultural habitat (Thomas *et al*., 2018). A study identified 6 tenebrionid beetle species from 5 genera and 4 tribes, demonstrating the richness of darkling beetles (Coleoptera: Tenebrionidae) found in forest locations in the southwestern Ghats (South India) (Anuraj *et al*., 2017).

The beetle diversity and quantity in Lakhimpur, Assam, India, located on the northern bank of the Bramhaputra River receives tropical wet evergreen forest, were observed to include 25 beetle species from 13 distinct families. The following notable beetles were found in Lakhimpur: *Compsosternus auratus, Gyrinus substriatus, Heteronychus arator, Gonocephalum simplex, Derobrachus geminates*, Oriental beetle, Aphodine dung beetle, and May beetle. (Jashodeb *et al*., 2022).

Oniticellini Kolbe tribe, which was found in Baikunthapur Forest in the Himalayan foothills of the Indian state of West Bengal, was described in the first faunistic record in 1905. The tribe has total 5 species, spread across 2 genera. Records for *Tiniocellus* and *Liatongus* from several surveys of the Fores' scarab fauna were yielded (Sarkar and Kharel, 2020) [25].

In a study on the diversity of beetles in and around Amba Reserve Forest, Western Ghat, Kolhapur, 152 species from 101 genera and 25 families of beetles were recorded during the current investigations. It was discovered that the dominant family, Scarabaeidae, has 65 species, followed by Cerambycidae, which had 18. While the families Tenebrionidae, Histeridae, and Buprestidae each had five species, the families Curculionidae and Chrysomelidae had eleven and seven species, respectively (Aland *et al*., 2012).

Two species were recorded from Arunachal Pradesh for the first time out of a checklist of 63 species under 33 genera, representing 16 tribes across five subfamilies of the Tenebrionidae family (Hedge, 2019). In the Nagaland state of India scarab beetles' diversity of 62 species belonging to 34 genera under 5 subfamilies were studied and altogether, 87 species belonging to 52 genera, 22 tribes and 5 subfamilies of family Scarabaeidae are reported from the state of Manipur, in North-east biogeographic zone of India (Ghosh *et al*., 2020) [36].

- **Diversity of Agriculture Field Beetles**

Study of diversity of beetles during the five months in different agro-ecosystem in Chikkamagaluru, Karnataka, in the three different habitats of coffee, pepper and coconut plantation has done from July to November in 2015. The study revealed total of 18 species of beetles belonging to 7 families. Carabidae was represented higher diversity with 8 beetles species followed by Crysomellidae with 3 beetles, Carabidae and Meloidae 2 species each, Cerambycidae and Coccinelidae only one species each (Annapurneshwari and Deepika, 2018) [1]. Total of 15 species of Scarabid beetles

were documented in Panhala tehsil of Kolhapur district, Maharashtra India (Bhusnar *et al*., 2023).

Another study done on the darkling beetles (Coleoptera: Tenebrionidae) of agricultural fields in the south Western Ghats (South India) reported 22 species belonging to 14 genera and 8 tribe (Anuraj *et al*., 2017). The dominant plant in the field of agriculture was *Luprops tristis*. There have been reports of both detritivores and mycetophagous guilds from the South Western Ghats' agricultural fields. Similar research on the diversity and community structure of dung beetles (Coleoptera: Scarabaedae) was conducted on the southern Indian Malabar coast. 519 dung beetles in all, representing 26 species across eight genera and five tribes, 17 minor, and 6 rare species, were found; the two most common species were *Tiniocellus spinipes* (44.89%) and *Caccobius vulcanus* (17.92%) (Venugopal *et al*., 2012) [33].

A total of 1,363 species of insects have been recorded from vegetable, crop, and fruit orchards throughout Bhubaneswar's agroclimatic zones. *Propylea dissecta* species contributed the most (344) in the agroclimatic zones, with species of about 25.24% of all individuals, with *Coccinella septempunctata* coming in second at 230 (16.87%) and *C. transversalis* at 226 (16.58%). With 701 beetles, the Coccinellinae subfamily had the most species (6) and the largest abundance in the region, accounting for roughly 51.42% of all the Coccinellinae that were gathered (Mukharjee and Suman., 2017). Because of their pestiferous nature, 31 species of beetles belonging to 26 genera and 17 tribes of four subfamilies were discussed and cited as being important to agriculture in the work done on the host plant and distribution status of agriculturally important longhorn beetles (Coleopteran: Carambycidae) from India (Kariyanna *et al*., 2017) [16].

Carabid beetles can be incorporated into future Integrated Pest Management programs as biological pest control agents with the ability to limit the proliferation of numerous pests due to their voracious feeding habits and abundance in agricultural fields (Meena and Kumari, 2023) [20] and it is harmful also as Indian agriculture is already suffering from various pest (Kariyanna *et al*., 2017) [16]. Total 32,414 beetles belonging to 284 species from Eiffel Mountain range in western Germany (Rischen *et al*., 2021) [23].

Throughout eight states in northeastern India, beetle specimens from various agricultural, horticultural, and forest environments were collected for a study between 2013 and 2016. 580+ adult beetle specimens in all were gathered. A total of 95 distinct taxa were found. 62 taxa were identified at the species level and 19 taxa at the genus level of species among these (Behere *et al*., 2017) [3].

The study concentrated on the distribution and variety of dung beetles (Coleoptera: Scarabaeidae) in two Haryana, India, reserve forests (Sonti and Seonsar). 5921 dung beetles in all were caught, representing 33 species, 16 genera, and 3 subfamilies. Sonti Forest showed 32 species, 4673 individuals. Seonsar Forest included 24 species, 1248 individuals. Species Richness was found to be higher in Sonti Forest, while diversity was seen higher in Seonsar Forest due to its larger size (Jain and Mittal, 2012) [14].

The study assessed the coleopteran fauna in Siswan Forest, Punjab. 43 species were identified, belonging to 32 genera and 12 families. Dominant Families were Scarabaeidae (dung beetles) showing 20 species, Chrysomelidae (leaf beetles) showed 4 species, Coccinellidae (ladybird beetles) included 3 species and Meloidae (blister beetles) showed 3 species. All taxa identified were reported from the area for the first time (Singh *et al*., 2018) [30].

The study examined the species richness, abundance, biomass, and diversity of Coleoptera in an oak forest in the Kumaun Himalaya, Uttarakhand, from August 2013 to July 2015. 18 species were recorded, belonging to 7 families. Family Chrysomelidae (leaf beetles) was dominant, which accounted for 37.9% of the total individuals. 12 species of pollinators were observed visiting different plants and trees regularly (Gariya *et al*., 2019).

- **Diversity of Ground Beetles**

Researchers emphasized the diversity of ground beetles (Coleopteran: Carabidae) from Indian Sundarban and recorded 7 new species are being reported for the first time from this unique deltaic mangrove zone. One species, *Chlaenius sp.* has been identified up to generic level (Kushwaha *et al*., 2017) [17].

In the Jhunjhunu area of Rajasthan, India, a study on the diversity, abundance, and composition of ground beetles (Coleoptera: Carabidae) discovered that 956 ground beetle individuals from 28 species and 19 genera within 11 subfamilies of the Carabidae family were seen during the study period. 2 species of Lebiinae, 3 species of Brachininae, 3 species of Scaritinae while 1 species each of Paussinae, Anthiinae, Carabinae, Pterostichinae, Platyninae, and Cicindelinae were the next most numerous subfamilies based on the total number of species (Meena and Kumari, 2022). During the month of February 2009 to December 2010, the study of ground beetles (Coleoptera: Carabidae) in the Melghat Tiger Reserve, Central India in almost all habitats collected a total of 10 species of ground beetles belonging to 6 subfamilies of family Carabidae were examined (Thakare *et al*., 2013) [32].

A study on the biodiversity of ground beetles collected from five districts in Chhattisgarh revealed 21 species in 18 genera. *Clivina assamensis* Putzeys, *Sparostes striatulus*, *Macrocheilus astericus*, *Colfax stevensi*, *Bradybaenus festivus*, *Planetes ruficeps*, and *Galerita orientalis* are among the seven species that have been identified for the first time from Chhattisgarh, while *Oxylobus ovalipennis* is a new species that has been added to India's beetle fauna. (Kushwaha *et al*., 2015) [18].

New records of *Siagona* species (Coleoptera: Carabidae: Siagoninae: Siagonini) from Uttar Pradesh, specimens of *Siagona latreille* were collected from Uttar Pradesh and *Siagona pumila*, *Siagona atrata* and *Siagona baconi* were identified for the first time from this state (Hedge and Kushwaha, 2012) [12]. New Record of Six-spot Ground Beetle *Anthia sexguttata sexguttata* was reported in Coleopteran diversity from Jehanabad, Bihar (India), belonging to family Carabidae (Husain and Hasan, 2023) [13].

Table: Coleopteran Diversity in Different Habitats

Habitats	Aquatic	Forest	Agriculture	Ground
Families	Dytiscidae, Hydrophilidae Gyrinidae Georissidae, Helophoridae Hydroscaphidae Hydrochidae Hydrohilidae Epimetopidae Spercheidae Sphaeriusidae Noteridae Dryopidae Scirtidae Hydraenidae Psephenidae	Tenebrionidae Scarabaeidae Cerambycidae Curculionidae Chrysomelidae Histeridae Buprestidae	Crysomellidae Carabidae Meloidae Cerambycidae Coccinelidae Scarabaeidae	Carabidae

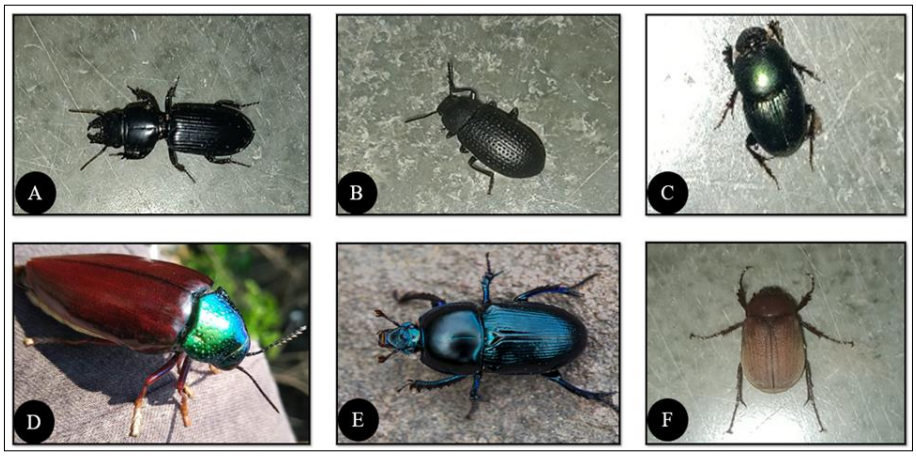

Fig: common Indian coleopteran insects: (A) *Scarites sp.*, (B) *Lycostomus loripes*, (C) *onthophagus sp.*, (D) *sternocera*, (E) *Anoplotrupes stercorosus*, (F) *phyllophaga*

Conclusion

The study of Coleoptera diversity across various habitats in India insights their ecological roles, distribution patterns and the need for conservation. Coleopteran diversity is extensively explored in states like Karnataka, Maharashtra, Tamil Nadu, Telangana, West Bengal, Rajasthan, Odisha, Uttar Pradesh, Bihar, Chhattisgarh, Andhra Pradesh, Jharkhand, Punjab, Uttarakhand, Haryana, Gujarat, Madhya Pradesh, some Northeast states Arunachal Pradesh, Assam, Tripura, Nagaland, Manipur, Meghalaya, Mizoram, Sikkim also few Union territories showed population of Coleopteran species in abundance.

The diverse distribution across regions, from the Western Ghats to the Himalayan foothills, and the critical ecological roles played by families like Carabidae, Hydrophilidae, and Scarabaeidae, add an essential value in maintaining ecosystem health.

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