The Biodiversity of Beetles at Songadh Fort, Tapi, Gujarat

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Abstract:
Beetles (Order: Coleoptera) represent the largest and most diverse group of insects and play vital roles in maintaining ecosystem structure and functioning. They contribute significantly to ecological processes such as nutrient cycling, decomposition, pollination, and biological control, and are widely recognized as effective bioindicators of environmental health. The present study was conducted to assess the biodiversity of beetles at Songadh Fort, Tapi District, Gujarat, a historically significant site surrounded by forested and semi-natural habitats. The primary aim of this study was to document beetle diversity and compare species composition across different microhabitats and habitat edges within the study area. Beetle sampling was carried out using hand picking and pitfall trap methods during the study period. Collected specimens were preserved and identified based on external morphological characteristics using standard identification keys and the iNaturalist platform. Observations were supported by photographic documentation to generate a checklist of beetle species. The recorded beetles represented diverse ecological guilds such as herbivores, decomposers, predators, and scavengers, highlighting their functional importance in the ecosystem. Scarabaeid beetles contributed to nutrient recycling, while predatory and herbivorous species reflected habitat quality and vegetation diversity. The findings provide a baseline checklist of beetle diversity in a historically and ecologically significant region. These results serve as a foundation for future research on seasonal variations and the role of beetles as bioindicators of ecosystem health at Songadh Fort.

Introduction:

Studying the immense variety of life on the planet and the complex relations among living things – what we now call biodiversity – has been a fundamental activity of conservationists and has become an important concern due to rapid species loss and increasing habitat degradation around the world. The time has come to record and try to conserve what is present today (Thakkar and Parikh et al 2016).

Nearly 25% of all known animal species are beetles (order Coleoptera), which are the most varied group of insects. Over 4,00,000 species have been described worldwide, with estimates exceeding one million including undescribed taxa (Chung, 2007). The transformation of forewings into tough elytra, which shield the hindwing and abdomen and allow survival variety of environments, is primarily responsible for their evolutionary success (Goczal et al., 2025). Because of this, beetles are found in almost every ecosystem, with the exception of harsh settings like oceans and polar ice caps (Bao 2020).

Beetles have a wide range of ecological functions. Through eating, herbivorous families like Chrysomalidae and Corcumelidae affect the dynamic vegetation (Dury 2013). Carabidae and Coccinellidae are examples of predatory beetles that suppress pest populations and are crucial biological control agents (Fei et al., 2023). While aquatic families like Dytscidae and Hydrophillidae are crucial elements of freshwater ecosystems (Al Abadi and Hatem 2025). Decomposers like Scarabaeidae and Tenebrionidae support soil fertility and nutrient cycling (Muinde and Ochieng 2025). Because of their extensive biological range, beetles are crucial to the stability and proper operation of the ecosystem.

Functional diversity, which measures the extent of trait variation within communities, has become a central concept in modern biodiversity research (Petchey and Gaston, 2006). Species interactions and ecosystem functioning depend on traits like body size, dispersal ability and feeding structures (Woodcock et al., 2010; Faal 2020). Greater functional diversity reduces niche overlap, improving stability and efficiency (Fink and Snyder 2010). Beetle assemblages are influenced by landscape heterogeneity, especially predatory taxa (Woodcock et al., 2013).

With over 15,000 species identified, beetles make up a significant portion of insect biodiversity in India (Chandra et al., 2019). Ecological and functional research is still scarce, nevertheless. Gujarat is home to a variety of ecosystems, such as marshes, grasslands, forests and coastal environments. Scarabaeidae and Carabidae are the two most common families among the 177 beetle species found in 32 families according to a regional assessment (Thakkar and Parikh et al 2016). Despite this, there are still few traits based ecological studies.

Because beetles are sensitive to environmental changes, they are frequently studied as bioindicators. Aquatic beetles reflect freshwater quality (Burghelea et al., 2011) dung beetles shows nitrogen cycling (Nichols et al., 2008), and carabids react to soil and habitat conditions (Rainio and Niemela 2003). They are useful species for tracking ecosystem health under human strain because of their responsiveness.

To gain a deeper understanding of beetle diversity and ecological roles, this study combines taxonomic and functional methodologies. Although species inventories have been the main emphasis of Indian research, merging taxonomy and functional characteristic analysis offers greater insights into community structure and ecosystem functioning, supporting ecosystem management and biodiversity conservation.

Materials and Methods

The current investigation was carried out at Songadh Fort, which is situated in Gujarat, India. Built ny Pillaji Rao Gaekwad in the early 1700s, the fort is perched atop a hill that offers abroad perspective of the surrounding terrain. The location (fig. 1) is roughly 21.16966º N latitude and 73.56357º E longitude, with an average elevation of roughly 112 meters above sea level. The region is environmentally favourable for biodiversity assessment research since it is surrounded by hills, rocky terrain, and seminatural woods. In order to maximise beetle sampling throughout diurnal and crepuscular intervals, field surveys were carried out from August 2025 to February 2026 during morning and evening session.

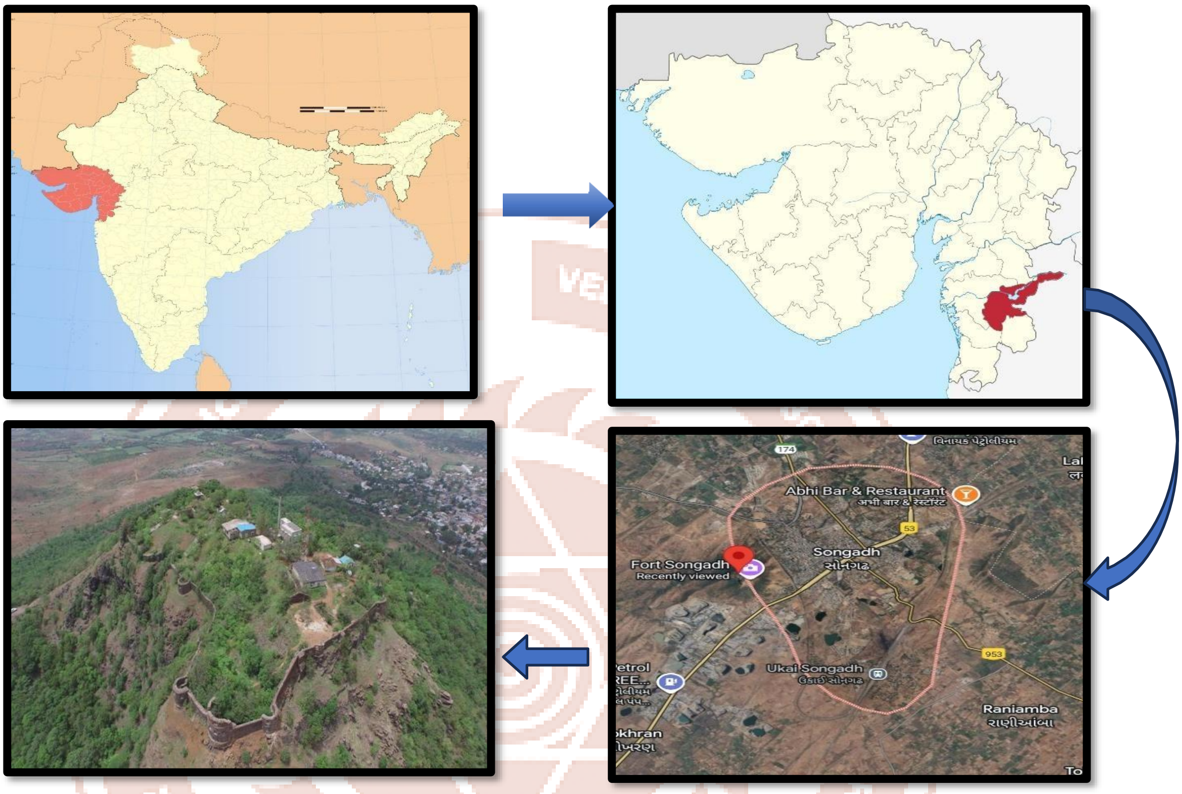


Figure 1: Study area

A variety of conventional entomological techniques were used to sample beetles. Visible beetles were collected by hand from dirt, leaf litter, stones and decaying logs. The specimens were then stored in 70% ethanol. In order to capture ground dwelling species, pitfall traps (7 -9 cm diameter) were placed at ground level and filled with soapy water or 10% formalin. The traps were left for 24 to 48 hours (Stasiov at al., 2021) using UV/Mersury vapour lamps against white cloth sheets, light trapping was used for nocturnal and phototactic beetles between dusk and 22.30 hours. Specimen were gathered with forceps and stored for identification (Dubey 2021).

Results and Discussion

During the study period (August 2025 to February 2026), 261 beetle individuals representing 23 species and 10 families were recorded at Songadh Fort (table 1). It was evident from the family-wise distribution that herbivorous gropus dominated the ecosystem. The most prevalent family (29%) was Chrysomelidae, suggesting that phytophagous beetles are supported by rich and varied vegetation. Meloidae (23%), which is primarily dominated by Epicauta vittata, came next, indicating habitat suitability for individual species rather than total family diversity. Scarabaeidae (14%) and Coccinellidae (13%) showed intermediate representation, indicating the presence of stable prey populations and decaying organic materials. While lesser abundance was seen in carabidae, Cerambycidae, and Curculionidae, indication habitat or host plant restrictions, Tenebrionidae provided 11%, demonstrating adaptability to dray litter-rich microhabitats.

At Songadh Fort, the predominance of phytophagus beetle group is a clear indication of the plant diversity and vegetation structure. Beetle diversity known to be significantly influenced by habitat heterogeneity and the availability of plant resources, especially in the semi-natural environments where a variety of herbivorous species are supported by different flora (Rischen et al., 2021). Therefore, the significant representation of Chryomelodae and Meloidae suggest that the research site offers phytophagus insects favourable tropic resources and niche diversity.

Epicauta vittata (58 individuals) and Lilioceris Cheni (36 individuals), which together accounted for more than one-third of all captures, demonstrated a substantial dominance in species-wise abundance. The functional core of the community was made up of a moderate assemblage of 7 – 21 individuals per species, but certain taxa were rare (lessthan 2 individuals), contributing to overall richness rather than abundance. In insect communities, where niche specialisation, host plant specificity and environmental filtration control species accompanied by a greater number of moderately abundant and rare species is prevalent. Similar finding have been documented in beetle assemblages, where species react differently to environmental factors and habitat layout (Magura and Lovei 2021).

Table 1: Checklist of species

No.	Taxonomic Family	Scientific Name	Common Name
1	Chrysomelidae	*Lilioceris cheni*	Potato leaf beetle
2		*Podagrica fuscicornis*	Mallow Flea beetle
3		*Sphaeroderma rubidum*	Brown flea beetle
4		*Monolepta australis*	Red shouldered leaf beetle
5		*Monolepta signata*	White spotted leaf beetle
6	Cerambycidae	*Batocera rufomaculata*	Mango stem borer
7	Meloidae	*Lytta vesicatoria*	Spanish fly
8		*Epicauta vittata*	Striped blister beetle
9	Buprestidae	*Sternocera chrysis*	Jewel beetle
10	Scarabaeidae	*Catharsius molossus*	Dung beetle
11		*Anomala pallida*	Chafer beetle
12		*Popilius disjunctus*	Bess beetle

13	Curculionidae	*Anthonomus grandis*	Boll weevil
14	Tenebrionidae	*Tenebrio obscurus*	Darkling beetle
15		*Asiopus minimus*	Darkling beetle
16	Coccinellidae	*Cheilomenes sexmaculata*	Six-spotted zigzag ladybird
17		*Coccinella transversalis*	Transverse ladybird
18		*Anegleis cardoni*	Ladybug
19		*Propylea dissecta*	Predaceous ladybird
20		*Henosepilachna vigintioctopunctata*	Hadda beetle
21	Carabidae	*Anthia sexguttata*	Six-spot ground beetle
22		*Galerita orientalis*	False Bombardier beetle
23		*Pheropsophus jessoensis*	Asian bombardier beetle

The comparatively large percentage of Tenebrionidae and Scarabaeidae emphasis the detritivore and decomposer guilds ecological significance in the studied area. These gropus are essential for soil aeration, organic matter breakdown and nutrient cycling. Increased diversity of decomposer beetles improves ecosystem functioning, especially nutrient recycling and soil processes, according to functional ecological research (Noriega et al., 2023). Their moderate abundance indicates that Songadh Fort retains enough microhabitat variety and ecological materials to sustain these ecological processes.

Similarly, a stable prey base and trophic equilibrium throughout the environment are indicated by the prominent presence of predatory Coccinellidae. Functional complementary, which is crucial for preserving ecological stability, is demonstrated by the presence of herbivores, predators and decomposers. Diverse insect assemblages are crucial because functional diversity has been demonstrated to have a favourable impact on ecological processes regardless of environmental fluctuation (Barragan et al., 2011; Noriega et al., 2023).

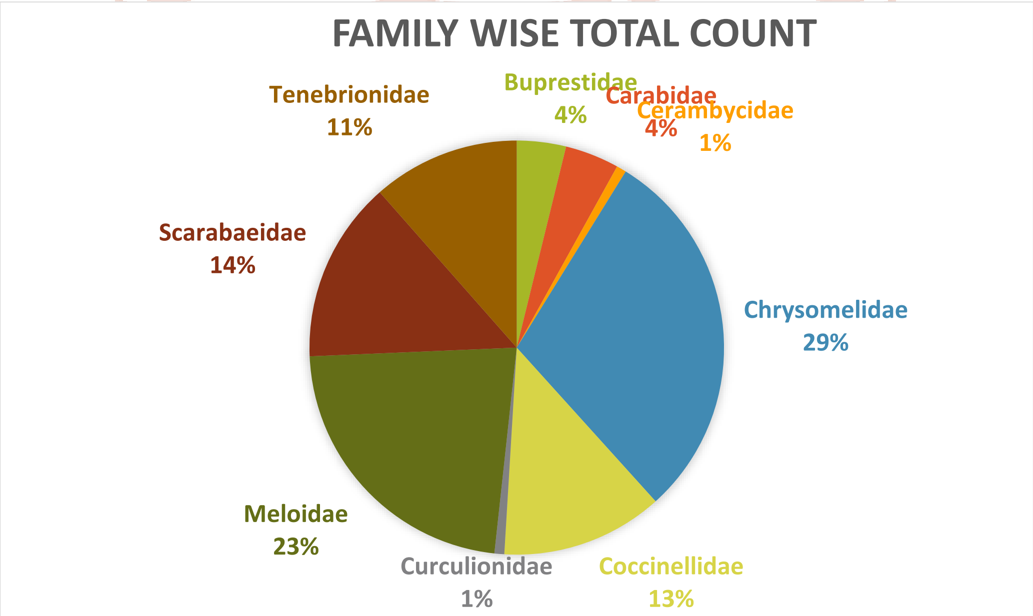


Figure 2: Family wise total count(percentage)

In other hand, habitat specialisation, or limited access to appropriate host plants and microhabitats may be responsible for the decreased abundance of Carabidae, Cerambycidae, and Curculionidae. According to the earlier research, several beetle groups exhibit uneven distribution patterns across landscapes due to their extreme sensitivity to environmental gradients and disturbances (Arellano et al., 2023; Noriega et al., 2023). This implies that although Songadh Fort is home to a varied beetlte community, some taxa may be less common due to microhabitat specialisation.

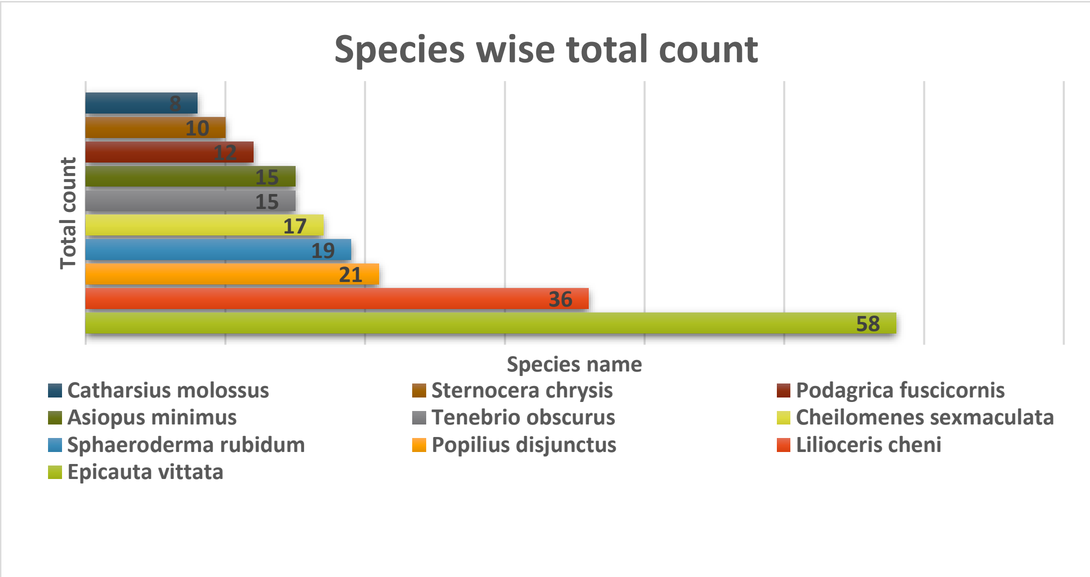


Figure 3: Species-wise total count

A comparatively stable and diverse ecosystem is suggested by the Shannon diversity index (H ′ = 2.64087), which showed moderately high diversity with decent species evenness(Table 2). These patterns of diversity are usually linked to environments with high habitat heterogeneity, where species coexistence is encouraged by differences in vegetation structure, microclimate and resource availability. Beetle diversity patterns across ecosystems are also known to be shaped by community assembly processes involving resource gradients, spatial heterogeneity, and environmental filtering.

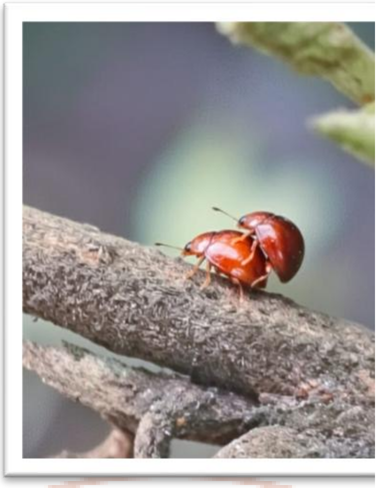
Table 2: Computation of the Shannon Diversity Index (H ′)

Common name	Total Count (ni)	Proportion (pi)	Natural Log (lnpi)	Value (pi×lnpi)
Potato leaf beetle	36	0.137931	-1.981	-0.27324
Mallow Flea beetle	12	0.045977	-3.07961	-0.14159
Brown flea beetle	19	0.072797	-2.62008	-0.19073
Red shouldered leaf beetle	6	0.022989	-3.77276	-0.08673
White spotted leaf beetle	4	0.015326	-4.17823	-0.06403

Mango stem borer	2	0.007663	-4.87137	-0.03733
Spanish fiy	1	0.003831	-5.56452	-0.02132
Striped blister beetle	58	0.222222	-1.50408	-0.33424
Jewel beetle	10	0.038314	-3.26194	-0.12498
Dung beetle	8	0.030651	-3.48508	-0.10682
Chafer beetle	8	0.030651	-3.48508	-0.10682
Bess beetle	21	0.08046	-2.52	-0.20276
Boll weevil	2	0.007663	-4.87137	-0.03733
Darkling beetle	15	0.057471	-2.85647	-0.16416
Darkling beetle	15	0.057471	-2.85647	-0.16416
Six - spotted zigzag ladybird	17	0.065134	-2.73131	-0.1779
Transverse ladybird	8	0.030651	-3.48508	-0.10682
Ladybug	5	0.019157	-3.95508	-0.07577
Predaceous ladybird	2	0.007663	-4.87137	-0.03733
Hadda beetle	1	0.003831	-5.56452	-0.02132
Six-spot ground beetle	1	0.003831	-5.56452	-0.02132
False Bombardier beetle	2	0.007663	-4.87137	-0.03733
Asian bombardier beetle	8	0.030651	-3.48508	-0.10682
	Sum (N=261)	Sum = 1.00000	-85.4364	Sum = -2.64087

Dominance of a few phytophagus species alongside a well- distributed assemblage of predators, scavengers and detritivores reflects balanced trophic structure. The presence of rare species (less than 2 indiviual) further enhances total species richness and indicates the habitat as a diversity reservoir. Rare taxa often occupy specialised niches and contribute to long term ecosystem resilience and beta diversity.

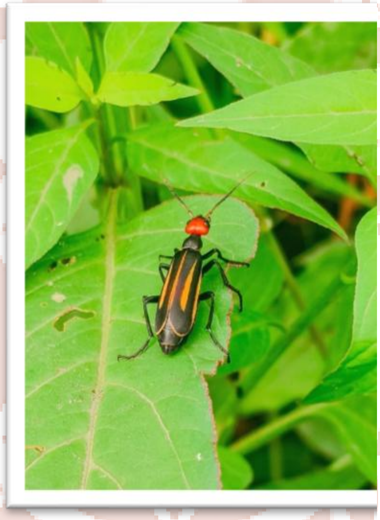
Lilioceris cheni



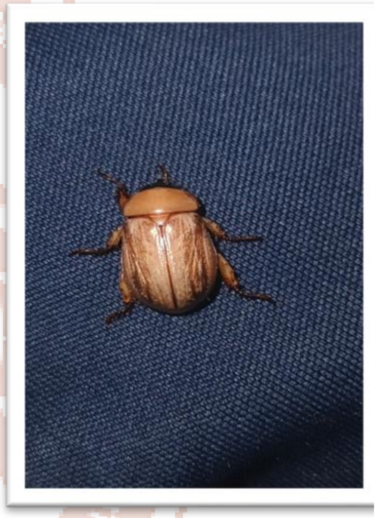
Sphaeroderma rubidum

Batocera rufomaculata

Lytta vesicatoria



Epicauta vittata



Anomala pallida

Galerita orientalis

Coccinella transversalis

Propylea dissecta

Tenebrio obscurus

In line with findings from other semi – natural landscapes in India and other tropical countries, these results verify that Songadh Fort supports a functionally varied beetle community impacted by vegetation complexity, microhabitat variation, and resource availability. Overall, the study emphasises hoe important it is to preserve flora diversity and ecosystem functioning.

Conclusion

The present study demonstrates that Songadh Fort supports a moderately high and functionally diverse beetle community, comprising 23species across 10 families. The dominance of phytophagus groups, along with the presence of decomposers and predators, reflects a well-structured trophic system driven by vegetation complexity and resource availability. The observed diversity and species distribution highlight the ecological importance of habitat heterogeneity in sustaining beetle assemblages. Overall, the findings emphasize the conservation value of semi-natural habitats like Songadh Fort in maintain insect biodiversity and associated ecosystem function.

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