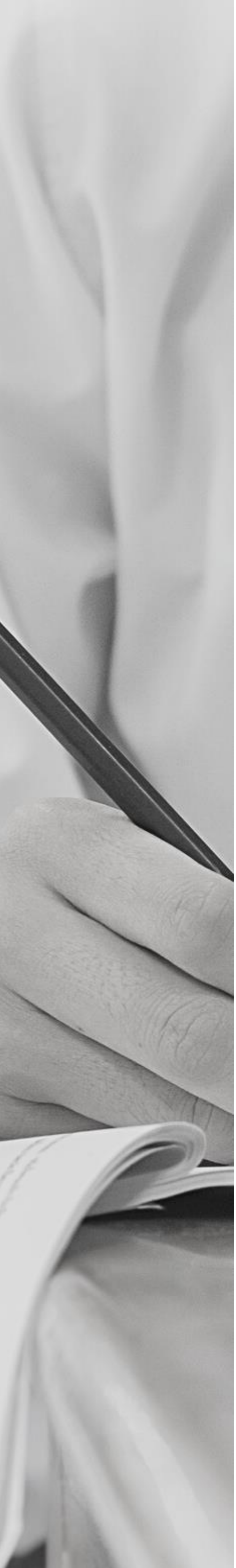

T K M COLLEGE OF ARTS AND SCIENCE KOLLAM

Unearthing Biodiversity: A Study of Ground-Dwelling Insects on the TKMCAS Campus

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PROJECT REPORT

B.Sc Zoology (2022-25)

MARCH 2025

CERTIFICATE

This is to certify that the project titled 'Unearthing Biodiversity: A Study of Ground-Dwelling Insects on the TKMCAS Campus' was conducted by a team of eight students mentioned below under my supervision and guidance. No part of this project has been submitted elsewhere for any academic or professional program.

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DECLARATION

I, …………………………… (………………………), solemnly declare that the project titled 'Unearthing Biodiversity: A Study of Ground-Dwelling Insects on the TKMCAS Campus', conducted by us, represents original work undertaken under the supervision and guidance of Dr. Jasin Rahman V. K., Assistant Professor, Department of Zoology.

I affirm that all aspects of this project, including the research, data collection, analysis, and conclusions drawn, are genuine and authentic to the best of our knowledge. This project has not been submitted elsewhere for any academic or professional program.

…………………………………..

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to our supervisor Dr. Jasin Rahman V. K. for his invaluable guidance, unwavering support, and mentorship throughout the course of this project. We are indebted to him for his assistance in the identification of specimens and meticulous corrections to the drafts. His expertise and encouragement have been instrumental in shaping the outcome of this work.

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I extend my heartfelt thanks to everyone who has contributed in various capacities, making this endeavor a success.

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INTRODUCTION

Introduction to Ground-Dwelling Insects

Ground-dwelling insects represent a fascinating and diverse group of organisms that play crucial roles in terrestrial ecosystems. These insects are defined by their primary habitat—the soil surface or within the upper layers of the soil. Their ecological significance stems from their contributions to nutrient cycling, soil aeration, pest control, and as a food source for other organisms. Understanding ground-dwelling insects is essential not only for their ecological roles but also for their impact on agriculture, forestry, and even urban environments.

Diversity and Adaptations

Ground-dwelling insects encompass a wide range of species across multiple orders, including Coleoptera (beetles), Hymenoptera (ants), Orthoptera (grasshoppers and crickets), Isoptera (termites), and Diptera (flies). This diversity is a testament to their remarkable adaptability to life on or beneath the ground. Many of these insects have evolved specialized structures and behaviors that enable them to thrive in their unique habitats. For instance, burrowing beetles possess robust legs adapted for digging, while ants exhibit complex social behaviors that allow them to construct and maintain extensive underground colonies.

The morphological and physiological adaptations of these insects are closely linked to their environmental challenges. Ground-dwelling insects often face threats from predators, extreme temperatures, and moisture fluctuations. To overcome these challenges, they have developed strategies such as camouflage, nocturnal activity, and the ability to enter diapause during unfavorable conditions. Moreover, their life cycles are often synchronized with seasonal changes, ensuring their survival and reproduction align with optimal environmental conditions.

Ecological Roles

Ground-dwelling insects are indispensable for maintaining ecosystem health. As decomposers, species like dung beetles and certain ants break down organic matter, recycling nutrients back into the soil. This process not only enriches the soil but also enhances its structure and fertility.

Predatory ground beetles and ants help regulate populations of other insects, including agricultural pests, thereby providing natural pest control services.

These insects also play a pivotal role in soil aeration and mixing through their burrowing activities. By creating tunnels and galleries, they facilitate water infiltration, root penetration, and the redistribution of organic material within the soil profile. Additionally, ground-dwelling insects serve as a critical food source for a variety of vertebrates, including birds, reptiles, and mammals, thus contributing to the stability of food webs.

Human and Agricultural Relevance

In agricultural systems, ground-dwelling insects have both positive and negative impacts. Beneficial species, such as predatory beetles and parasitoid wasps, aid in controlling crop pests, reducing the need for chemical pesticides. However, some ground-dwelling insects, like certain termite species and root-feeding beetles, can cause significant damage to crops, forestry plantations, and even human infrastructure. Balancing these interactions requires a nuanced understanding of their ecology and behavior.

Conservation Challenges

Despite their importance, ground-dwelling insects face numerous threats due to habitat loss, pesticide use, climate change, and soil degradation. Urbanization and intensive agricultural practices have particularly detrimental effects, leading to declines in their populations and the services they provide. Conservation efforts must focus on preserving natural habitats, promoting sustainable agricultural practices, and minimizing chemical inputs to ensure the survival of these vital organisms.

In conclusion, ground-dwelling insects are integral to the functioning of terrestrial ecosystems. Their diversity, ecological roles, and adaptability make them a subject of immense scientific interest. By studying and conserving these insects, we can better understand and sustain the intricate web of life that supports our planet.

REVIEW OF LITERATURE

Conducting a comprehensive survey of ground-dwelling insects necessitates a thorough understanding of existing research across various objectives.

1. Species Diversity Assessment

Ground-dwelling insects exhibit immense diversity, contributing significantly to ecosystem complexity. Studies have documented the vast array of species inhabiting different ecosystems. For instance, research highlights the role of insects in grassland ecosystems, emphasizing their diversity and ecological significance (Debinski, D.M. 2023). Ground-dwelling insects represent a crucial component of terrestrial ecosystems, contributing significantly to biodiversity. For instance, studies by Larsen et al. (2005) highlight the immense species diversity in tropical and subtropical regions, particularly in soil-rich habitats. This diversity is influenced by environmental heterogeneity and availability of resources, which promote niche specialization.

2. Population Density and Distribution

Spatial and temporal distribution of ground-dwelling insects is determined by factors such as vegetation cover, soil moisture, and microhabitat availability. Research by Thiele (1977) has shown that beetle populations exhibit patchy distributions, largely influenced by local habitat characteristics. Similarly, studies on ant species indicate significant variability in their population densities based on soil texture and canopy cover (Andersen, 1997).

3. Role in Ecosystem Functions

Ground-dwelling insects play pivotal roles in ecosystem functions, including decomposition, soil aeration, and nutrient cycling. Their activities enhance soil fertility and structure, promoting plant growth. Studies have shown that insects serve as decomposers, breaking down organic matter and recycling nutrients back into the soil (Debinski, D.M. 2023). Ground-dwelling insects serve critical ecological roles, particularly as decomposers and predators. Dung beetles, for instance, enhance nutrient cycling and soil aeration (Nichols et al., 2008). Similarly, ground beetles are vital predators, regulating pest populations in agricultural landscapes (Kromp, 1999).

Behavioral Studies

The behavior of ground-dwelling insects, such as burrowing and foraging, has been extensively studied. Research by Holldobler and Wilson (1990) provides detailed insights into the social structures and foraging strategies of ants, which are among the most studied ground-dwelling insects.

Environmental and Habitat Factors

Environmental variables, such as temperature and humidity, significantly impact the diversity and abundance of ground-dwelling insects. For example, a study on Carabid beetles by Lövei and Sunderland (1996) demonstrated that changes in microclimatic conditions directly affect their activity patterns and survival.

Interactions with Other Organisms

Ground-dwelling insects engage in complex interactions with other organisms. Mutualistic relationships between ants and aphids have been documented extensively (Stadler and Dixon, 2005). Furthermore, they act as prey for many vertebrates, highlighting their role in sustaining higher trophic levels.

Pest vs. Beneficial Species Analysis

While many ground-dwelling insects provide ecosystem services, some are agricultural pests. For instance, white grubs (Scarabaeidae larvae) damage crop roots, causing significant yield losses (Villani and Wright, 1990). On the other hand, predatory beetles and parasitic wasps help manage pest populations naturally, reducing the dependency on chemical pesticides.

Conservation Status and Threats

Habitat destruction, urbanization, and pesticide use are major threats to ground-dwelling insects. A global assessment by Sánchez-Bayo and Wyckhuys (2019) revealed alarming declines in insect populations, emphasizing the urgent need for conservation initiatives.

OBJECTIVES OF THE STUDY

- To identify and categorize the different species of ground-dwelling insects present on the college campus.
- To record the microhabitat of each insect recorded during the survey
- To investigate the ecological roles of these insects, such as their contributions to decomposition, soil aeration, and pest control.

AREA OF THE STUDY

Kollam, situated in the southern part of Kerala, is a district known for its unique geographical and climatic characteristics that significantly shape its landscape, vegetation, and livelihoods of its inhabitants.

Geographical Peculiarities:

Kollam district, positioned between 8°56' and 9°14' North latitude and 76°17' and 77°9' East longitude, boasts a diverse topography. It encompasses a vast coastal area along the Arabian Sea, extending inland to include plains, hills, and the Western Ghats. Its coastal location influences its weather patterns, livelihoods, and biodiversity. The district is adorned with numerous rivers, including the Ashtamudi Lake, the second-largest estuarine system in Kerala.

Monsoon and Climate:

Kollam experiences a tropical climate with distinct monsoons. The southwest monsoon from June to September brings heavy rainfall, vital for agriculture in the region. The northeast monsoon occurs from October to November. The district enjoys a warm and humid climate throughout the year, with temperatures ranging from 22°C to 32°C. The ample precipitation contributes to the lush greenery and agricultural productivity.

Vegetation Features:

The district's varied topography and climatic conditions foster diverse vegetation. The coastal regions host mangroves and coconut palms, while the plains are adorned with paddy fields, spices like pepper and cardamom, and cash crops like rubber. As you move inland towards the Western Ghats, the landscape transforms into dense tropical forests with teak, rosewood, and bamboo, fostering rich biodiversity with endemic flora and fauna.

Kollam's geographical diversity, from its coastal stretches to the lush hills of the Western Ghats, contributes to its ecological richness and sustains livelihoods through agriculture, fishing, and forestry. The district's climatic conditions, accentuated by the monsoons, shape its cultural practices, agricultural cycles, and natural landscapes, making it an integral part of Kerala's diverse geography.

MATERIALS AND METHODS

Study Area: The study was conducted on the college campus, which spans approximately 5 acres and includes diverse microhabitats such as gardens, tree bases, open grounds, and areas with leaf litter. The geographical coordinates of the campus are Lat 8.9154° Long 76.6342°. A preliminary survey was conducted to identify sampling locations representative of the campus's environmental heterogeneity.

1. Species Diversity Assessment

Sampling Design: To identify ground-dwelling insect species, sampling was carried out across different microhabitats, including leaf litter, near tree bases, and open ground. A stratified random sampling approach was employed to ensure adequate representation of all microhabitats.

Collection Methods:

- **Pitfall Traps:** Pitfall traps (plastic containers, 10 cm in diameter, buried flush with the ground and filled with 70% ethanol as a preservative) were placed at 10 random locations in each microhabitat. Traps were left in place for 48 hours and covered with a small roof to protect against rain.
- **Hand Collection:** Insects were manually collected using forceps and aspirators for species that were not efficiently captured by pitfall traps.
- **Leaf Litter Sieving:** Leaf litter from a 1 m^2 area was collected and sieved to extract insects.

Species Identification: Collected specimens were preserved in 70% ethanol and identified up to the species level using taxonomic keys and relevant literature. Taxonomic classification was verified through consultation with entomologists and online databases such as BugGuide (bugguide.net), iNaturalist (inaturalist.org), Global Biodiversity Information Facility (gbif.org), Discover Life (discoverlife.org), AntWeb (antweb.org), Coleoptera.org (coleoptera.org).

2. Record of microhabitat

In this study, the microhabitat of each ground-dwelling insect species was recorded through direct field observations and habitat characterization. Surveys were conducted in various areas, including leaf litter, under rocks, decaying wood, soil surfaces, and near vegetation. Environmental parameters such as moisture levels, temperature, and organic matter presence were noted to understand species preferences. The data were systematically documented to analyze habitat associations and ecological interactions, contributing to a comprehensive understanding of insect distribution and microhabitat utilization.

3. Functional Role Assessment

- **Decomposition:** The role of insects in decomposition was assessed by observing insect activity on decomposing leaf litter and organic matter. Litter bags (10 cm × 10 cm, mesh size 2 mm) filled with leaf litter were placed in the field for one month. Insects found in these bags were identified and their activity recorded.
- **Soil Aeration:** Soil samples were collected from areas with visible insect activity to assess changes in soil structure and aeration. Indicators such as burrow density and soil porosity were measured.
- **Pests:** The functional role of pests was assessed by identifying species responsible for damaging plants or degrading soil quality. Direct observations and reports from the campus garden were used to document pest activities. Damage symptoms, such as leaf discoloration, wilting, or reduced plant growth, were recorded. The extent of damage caused by pest species was quantified by measuring the affected area or counting damaged plants.
- **Natural Enemy:** Observations of predatory activity and prey availability were recorded to evaluate the role of predatory insects in natural pest regulation.

RESULTS AND DISCUSSION

This study aimed to document the diversity of ground dwelling insects on TKMCAS campus. Ground-dwelling insects, a diverse and complex group of invertebrates, play vital roles in ecosystems, acting as both beneficial organisms and potential pests within native vegetation. Our survey identified several ground-dwelling insects, as summarized in Table 1.

Species Diversity Assessment

A total of 45 ground-dwelling insect species were identified on the college campus, belonging to 7 taxonomic orders. The most abundant orders were Coleoptera, and Hymenoptera which comprised 53.3 % of the total population. Rare species included *Pheropsophus verticalis* (Bombardier Beetle), *Platymeris rhadamanthus* (Assassin Bug), and *Cybister limbatus* (Predaceous Diving Beetle), indicating favourable habitat conditions. High species richness was observed in microhabitats such as soil, leaf litter, and decaying wood, likely due to the availability of organic matter, moisture, and shelter. The observed diversity indicates the ecological richness of the campus environment. High diversity within orders like Coleoptera, and Hymenoptera aligns with similar studies in urban green spaces (McKinney, 2008). Urban green areas often serve as refuges for diverse insect species, as they provide suitable microhabitats (Matteson et al., 2008). Factors such as vegetation type, human interference, and soil composition may have influenced the diversity observed (Niemelä et al., 2002).

Role in Ecosystem Functions

Ground-dwelling insects on the campus were found to play crucial ecological roles. Species such as *Onthophagus taurus* and *Periplaneta americana* contributed to decomposition, breaking down organic matter and enhancing nutrient cycling. Others, such as *Paederus fuscipes*, *Platymeris rhadamanthus*, and *Rhynocoris marginatus* were identified as predators, aiding in pest control by preying on *Odontotermes obesus* and *Blattella germanica*. Some species, such as *Oxya hyla* and *Dysdercus cingulatus* were identified as potential agricultural pests due to their feeding habits on several vegetable crops. The decomposition process facilitated by *Onthophagus taurus* and *Sarcophaga ruficornis* is crucial for nutrient recycling, as highlighted by (Halffter & Matthews, 1966). Soil aeration by burrowing insects like *Gryllotalpa orientalis* and *Odontotermes obesus* has been shown to improve water infiltration and root penetration (Lavelle et al., 1997). Predatory insects such as *Cicindela sexguttata* and *Rhynocoris marginatus* play a vital role in natural pest control, aligning with findings by (Schaefer & Panizzi, 2000). However, species such as *Dysdercus cingulatus* and *Oxya hyla* were identified as agricultural pests, necessitating management practices to mitigate their impacts (Sithanantham et al., 2013).

Campus Management Practices to Protect and Promote Insect Habitats

Based on the ecological roles and habitat preferences of the identified species, the following management practices are proposed:

- Maintenance of leaf litter and organic matter in specific areas to support decomposer communities.
- Avoidance of pesticide usage near critical habitats like tree bases and leaf litter zones.
- Creation of 'insect-friendly zones' with native vegetation to provide food and shelter.
- Awareness programs for students and staff on the importance of insect conservation.

Management strategies tailored to the ecological needs of insect species can enhance their populations and ecosystem services. Retention of leaf litter and organic matter creates microhabitats for decomposers and soil aerators (*Odontotermes obesus* and *Onthophagus taurus*) (Evans & Gleeson, 2006). Reduced pesticide use near critical habitats aligns with studies showing that pesticide exposure significantly reduces insect diversity and abundance (Desneux et al., 2007). Establishing native vegetation zones can attract pollinators and other beneficial insects, as demonstrated by (Potts et al., 2016). Educational initiatives are essential to ensure stakeholder participation in conservation efforts, fostering a sustainable campus ecosystem (Scholtz & Chown, 1995).

Table 1. List of insects identified from the TKMCAS campus

Sl. No	Scientific name	Common name	Order: Family	Microhabitat	Ecological role
1.	*Anthia sexmaculata*	Six-Spotted Ground Beetle	Coleoptera: Carabidae	Soil, under stones	Predator, scavenger
2.	*Apis cerana indica*	Indian Honey Bee	Hymenoptera: Apidae	Hollow trees, under rocks	Pollinator
3.	*Brachymeria lasus*	Chalcid Wasp	Hymenoptera: Chalcididae	Soil, plant litter	Parasitoid of Lepidoptera larvae
4.	*Blattella germanica*	German Cockroach	Blattodea: Ectobiidae	Moist soil, organic debris	Decomposer, scavenger
5.	*Blissus insularis*	Chinch Bug	Hemiptera: Blissidae	Grassy areas, soil	Herbivore, pest
6.	*Bombus haemorrhoidalis*	Bumblebee	Hymenoptera: Apidae	Soil nests, leaf litter	Pollinator
7.	*Camponotus compressus*	Carpenter Ant	Hymenoptera: Formicidae	Rotten wood, soil	Decomposer, scavenger
8.	*Chelisoches morio*	Black Earwig	Dermaptera: Chelisochidae	Rotting wood, soil	Predator, scavenger
9.	*Chrysochus pulcher*	Leaf Beetle	Coleoptera: Chrysomelidae	Under leaves, on soil	Herbivore
10.	*Cicindela sexguttata*	Six-Spotted Tiger Beetle	Coleoptera: Carabidae	Soil, leaf litter, near water bodies	Predator
11.	*Cylas formicarius*	Sweet Potato Weevil	Coleoptera: Brentidae	Root crops, soil	Herbivore, pest
12.	*Dyschirius thoracicus*	Ground Beetle	Coleoptera: Carabidae	Moist soil, under leaf litter	Predator
13.	*Dysdercus cingulatus*	Cotton Stainer Bug	Hemiptera: Pyrrhocoridae	Near cotton plants, soil	Herbivore, pest
14.	*Euborellia annulipes*	Ring-legged Earwig	Dermaptera: Anisolabididae	Leaf litter, under rocks	Predator, scavenger
15.	*Gryllotalpa orientalis*	Mole Cricket	Orthoptera: Gryllotalpidae	Underground tunnels	Soil aerator, herbivore
16.	*Gryllus bimaculatus*	Field Cricket	Orthoptera: Gryllidae	Soil, burrows, leaf litter	Decomposer, prey
17.	*Harpalus calceatus*	Darkling Beetle	Coleoptera: Tenebrionidae	Soil, decaying matter	Decomposer, scavenger
18.	*Heteronychus lioderes*	Rhinoceros Beetle	Coleoptera: Scarabaeidae	Soil, compost heaps	Decomposer
19.	*Hieroglyphus banian*	Grasshopper	Orthoptera: Acrididae	Tall grasses, soil	Herbivore
20.	*Lasius niger*	Black Garden Ant	Hymenoptera: Formicidae	Soil, under rocks	Scavenger, soil aerator
21.	*Lucilia sericata*	Green Bottle Fly	Diptera: Calliphoridae	Soil, decaying organic material	Decomposer, pollinator
22.	*Musca domestica*	House Fly	Diptera: Muscidae	Soil, animal waste	Decomposer, scavenger
23.	*Myrmecia gulosa*	Red Bull Ant	Hymenoptera: Formicidae	Soil, under rocks, decaying wood	Predator, scavenger
24.	*Nomia iridescens*	Sweat Bee	Hymenoptera: Halictidae	Soil burrows	Pollinator
25.	*Odontomachus haematodus*	Trap-jaw Ant	Hymenoptera: Formicidae	Soil, leaf litter, tree bases	Predator
26.	*Odontotermes obesus*	Termite	Blattodea: Termitidae	Soil, decaying wood, leaf litter	Decomposer, soil aerator
27.	*Onthophagus taurus*	Dung Beetle	Coleoptera: Scarabaeidae	Soil, dung piles	Nutrient recycler
28.	*Oxya hyla*	Paddy Grasshopper	Orthoptera: Acrididae	Paddy fields, grasslands	Herbivore
29.	*Paederus fuscipes*	Rove Beetle	Coleoptera: Staphylinidae	Soil, decaying organic matter	Predator, scavenger
30.	*Periplaneta americana*	American Cockroach	Blattodea: Blattidae	Soil, leaf litter, human dwellings	Decomposer, scavenger

31.	*Pheropsophus verticalis*	Bombardier Beetle	Coleoptera: Carabidae	Moist soil, leaf litter	Predator, defensive species
32.	*Phlebotomus argentipes*	Sand Fly	Diptera: Psychodidae	Soil, cracks in walls	Pollinator, parasite vector
33.	*Platymeris rhadamanthus*	Assassin Bug	Hemiptera: Reduviidae	Soil, under leaf litter	Predator
34.	*Polistes stigma*	Paper Wasp	Hymenoptera: Vespidae	Soil, tree trunks	Predator, pollinator
35.	*Reticulitermes flavipes*	Eastern subterranean termite	Blattodea: Rhinotermitidae	Soil, decaying wood, leaf litter	Decomposer, soil aerator
36.	*Rhynocoris marginatus*	Assassin Bug	Hemiptera: Reduviidae	Soil, leaf litter	Predator
37.	*Sarcophaga ruficornis*	Flesh Fly	Diptera: Sarcophagidae	Animal remains, decaying matter	Decomposer, scavenger
38.	*Simulium indicum*	Black Fly	Diptera: Simuliidae	Near water bodies, soil	Pollinator, pest
39.	*Solenopsis geminata*	Fire Ant	Hymenoptera: Formicidae	Soil, leaf litter	Predator, decomposer
40.	*Tachytes javanus*	Sand Wasp	Hymenoptera: Crabronidae	Sandy soil burrows	Predator
41.	*Tarbinskiellus annulatus*	House Cricket	Orthoptera: Gryllidae	Leaf litter, under logs	Decomposer, scavenger
42.	*Tessaratomma javanica*	Shield Bug	Hemiptera: Tessaratomidae	Under leaf litter	Herbivore
43.	*Tetramorium bicarinatum*	Pavement Ant	Hymenoptera: Formicidae	Soil, under stones, leaf litter	Seed disperser, scavenger
44.	*Xylocopa latipes*	Large Carpenter Bee	Hymenoptera: Apidae	Rotten wood, tree stumps	Pollinator, wood borer
45.	*Zophobas atratus*	Superworm Beetle	Coleoptera: Tenebrionidae	Leaf litter, decaying wood	Decomposer

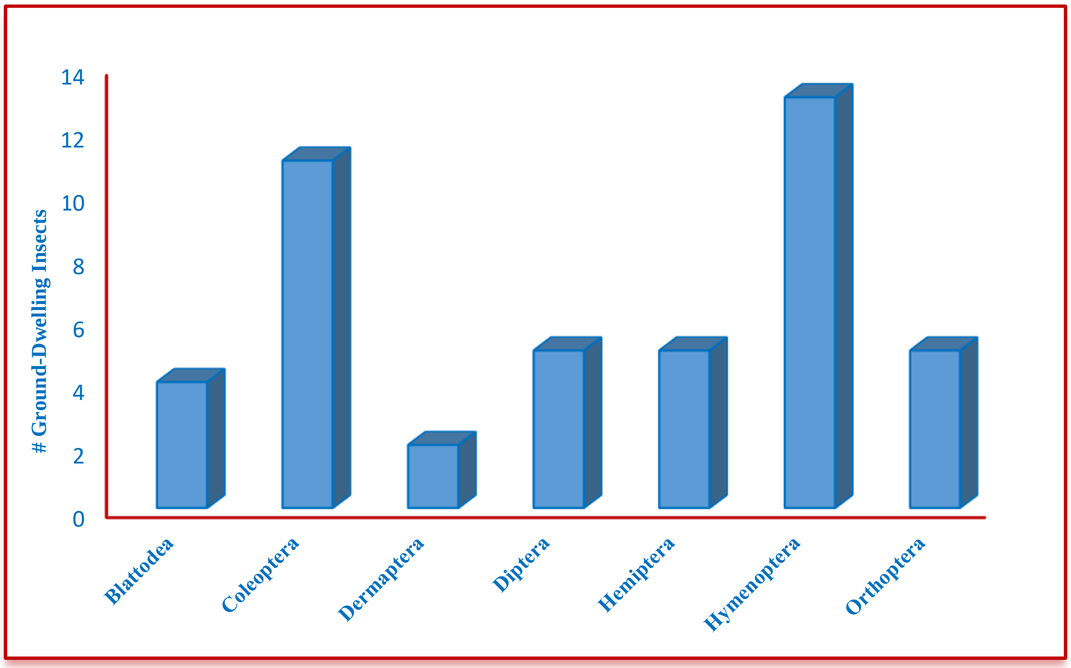
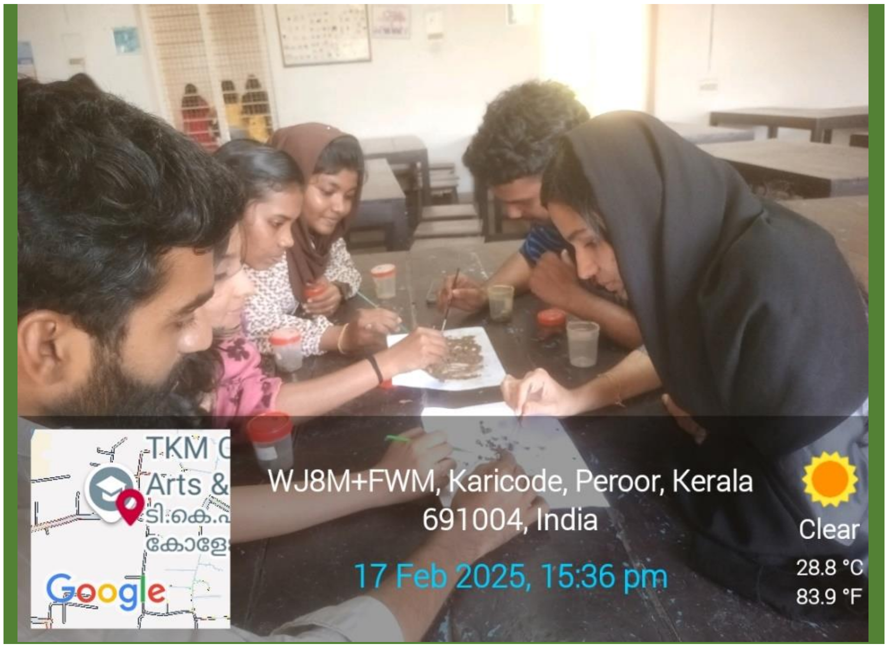


Fig. 1. Relative abundance of Ground-Dwelling Insects under various orders

Observation and identification

Observation and identification



SUMMARY AND CONCLUSION

The observed diversity within the campus ecosystem highlights the ecological richness of the environment, indicating a well-balanced and thriving habitat. The presence of high diversity, particularly within specific orders like Coleoptera, and Hymenoptera strongly suggests that green areas often serve as crucial refuges for a wide variety of insect species. These areas provide essential microhabitats that cater to the specific needs of different organisms. Various environmental factors such as the type of vegetation, degree of human interference, and soil composition play a significant role in shaping the patterns of biodiversity observed.

In particular, certain microhabitats like leaf litter and tree bases were found to be preferred by a number of species. These habitats are known for their ability to retain moisture, offer abundant food resources, and provide shelter from predators, making them ideal for many insects. Furthermore, the distribution patterns of species within the campus varied, with some species, such as *Lasius niger* (Black Garden Ant), displaying clustered patterns. This clustering can often be attributed to the aggregation of resources, such as food or shelter. On the other hand, species like *Odontomachus haematodus* (Trap-jaw Ant) exhibited more uniform distribution patterns, which may reflect territorial behaviors or competition for limited resources. These spatial arrangements have important ecological implications, influencing species interactions, competition, and overall community structure.

The decomposition process, which is facilitated by species like *Sarcophaga ruficornis* (Flesh Fly), plays a crucial role in nutrient recycling within the ecosystem, ensuring the continuous availability of vital resources for plants and other organisms. Additionally, soil aeration by burrowing insects such as *Gryllotalpa orientalis* (Mole Cricket) has been shown to enhance water infiltration and root penetration, contributing to soil health. Predatory insects, such as *Cicindela sexguttata* (Six-Spotted Tiger Beetle), serve as natural pest control agents, maintaining the balance of the ecosystem by regulating populations of potential pest species. However, some species, such as *Dysdercus cingulatus* (Cotton Stainer Bug), have been identified as agricultural pests, and their presence may necessitate specific management strategies to mitigate their negative impacts on crop production.

To promote a healthy and sustainable campus ecosystem, management strategies tailored to the ecological needs of these insect species are essential. Retaining leaf litter and organic matter will help create microhabitats for decomposers and soil aerators, fostering the recycling of nutrients and improving soil quality. Reducing pesticide exposure is also crucial, as excessive use can significantly reduce insect diversity and abundance. Additionally, establishing native vegetation zones can attract pollinators and other beneficial insects, further supporting the health of the ecosystem. Educating stakeholders about the importance of insect diversity and ecosystem services is also essential for fostering a culture of conservation and ensuring long-term sustainability in the campus environment.

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