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Comparative analysis of different beetle collection techniques in agroecosystems of Idukki district, Kerala

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Abstract
The study assesses the efficacy of different beetle collection methods—pitfall traps, light traps, flight-intercept traps, and hand-picking —in collecting diverse range of beetle species (Arthropoda: Coleoptera) across different agroecosystems of Idukki district, Kerala. The study was conducted during January 2022 to December 2022. The beetles from Rubber plantation, Coconut plantation, Pineapple plantation, Cardamom plantation and Mixed plantations were collected using different traps. Collected beetles were identified upto family level. A total of 19 families were recorded during the study. The abundance of beetles was collected through pitfall trap was more while diversity of beetles was more in light trap and hand-picking method. Pitfall traps are particularly effective for sampling ground-dwelling beetles like *Scarabaeidae* and *Carabidae*. Light traps were highly efficient in attracting beetles like *Lampyridae, Elateridae, Cerambycidae, Scarabaeidae, Tenebrionidae, Lycidae etc,* contributing significantly to both total captures and species diversity. Light traps are identified as the most effective in terms of species richness and total abundance. Flight-intercept traps captured flying beetles at different heights but its diversity and abundance were less. *Coccinellidae, Chrysomelidae, Lampyridae, Curculionidae* etc were more collected through hand picking method. The study highlights the importance of using species specific traps for the mechanical collection and removal pests in the agricultural fields. The use of different beetle collection techniques in taxonomic identification of Coleoptera helps to obtain more diversity. The findings offer practical insights into optimizing sampling methodologies in biodiversity hotspots and emphasize the role of diverse beetle collection methods in enhancing pest control efforts and conservation planning.

Keywords: beetle collection methods, pitfall traps, light traps, agroecosystems, biodiversity assessment, pest control, sampling techniques

Introduction

Beetles are the group of organisms that are the most numerous and varied in species number among other groups. The total number of beetle species already described reaches between 300,000 and 450,000 (Nielsen & Mound, 1999).

They are very important in an ecosystem because they aid in nutrient cycling and recycling, decomposition, soil aeration, seeding, and pest management. In agroecosystems, beetles represent the balance of agricultural pests as well as their natural enemies and this, in turn, determines agricultural production and the health of the ecosystem (Holland & Luff, 2000). These insects are distributed in a variety of forest landscapes, grass areas, wetlands, and agricultural lands which makes them good indicators of biodiversity and habitat quality.

Collection and identification of beetles is crucial in assessing and understanding beetle diversity, the functional roles these organisms play in the environments, and how they respond to changes in environments or climatic conditions. However, the success of sampling beetles often depends on the method of collection employed as different methods are suited for specific microhabitats and microhabits. The most common methods of sampling beetles include: Pitfall traps, light traps, hand picking etc. Each method has its own pros and cons which also might prove significant in analysing and comparing methods (Southwood & Henderson, 2000).

Pitfall traps, for instance, are widely used for ground-dwelling beetles. These traps are relatively inexpensive and simple to set up, and they provide continuous sampling over time. However, their efficiency can be affected by weather conditions, soil type, and the activity levels of beetles, potentially leading to biases in the data collected (Spence & Niemela, 1994). Light traps are particularly effective for nocturnal beetles, especially those attracted to ultraviolet light. Despite their utility, light traps are influenced by ambient light conditions, seasonal variations, and the proximity of natural vegetation, which may alter the number and diversity of beetles captured (Holker et al., 2010). Manual collection is indispensable for sampling beetles in cryptic microhabitats, such as under bark, within leaf litter, or in canopy vegetation.

Although it allows for targeted sampling, manual collection is time-intensive and highly dependent on the skill and experience of the collector (Stewart & New, 2007).

An increasing number of studies have examined the comparative efficiency of these techniques across different ecosystems. Studies have demonstrated that pitfall traps are highly effective for open-ground habitats but may underrepresent arboreal or flying beetles (Luff, 1975). Light traps, on the other hand, are essential for capturing nocturnal and phototactic species, but they may not sample non-flying or diurnal beetles effectively (Didham et al., 1998). Hand picking method often complements these methods by targeting habitats and behaviours not captured by passive sampling techniques. Comparative analyses of these methods have revealed that their combined use often provides the most comprehensive assessment of beetle diversity and community structure (Magura et al., 2015).

The agroecosystems of Idukki district in Kerala, India, represent a unique landscape where natural vegetation and human-managed habitats coexist. This region is known for its extensive cultivation of cash crops such as tea, cardamom, and pepper, alongside small-scale homestead farming and interspersed patches of forest. These diverse land-use systems create a mosaic of habitats that support a rich assemblage of beetle species. However, the intensification of agriculture and habitat fragmentation in the region pose significant challenges to biodiversity conservation. Understanding the diversity and distribution of beetles in Idukki's agroecosystems is crucial for developing sustainable agricultural practices that balance productivity with ecological health.

Despite the ecological and agricultural importance of beetles, studies on their diversity and distribution in India, particularly in tropical agroecosystems, remain limited. Furthermore, there is a lack of standardized protocols for comparing the efficacy of different beetle collection techniques in these contexts. This gap in knowledge has significant implications for biodiversity assessment, conservation planning, and sustainable land management.

A review of the available literature highlights the need for such comparative studies. Work et al. (2002) emphasized the importance of adapting collection methods to local habitat conditions to ensure representative sampling. In tropical ecosystems, where species richness and ecological complexity are exceptionally high, the choice of collection techniques can significantly influence the outcomes of biodiversity assessments. For example, studies in Southeast Asia have shown that pitfall traps are highly effective in capturing ground-dwelling beetles in forest plantations but perform poorly in dense forests with uneven terrain (Woodcock, 2005). Similarly, light traps have been used successfully to monitor nocturnal beetle populations in agroforestry systems in Africa but were found to be less effective in capturing species in shaded environments (Didham et al., 1998).

In India, studies on beetle diversity have predominantly focused on forested landscapes and protected areas, with limited attention to agroecosystems. This is a significant oversight, given the vast extent of agricultural land in the country and its critical role in supporting biodiversity. Agroecosystems, particularly those in biodiversity hotspots such as the Western Ghats, are underrepresented in ecological research, despite their potential to serve as refuges for many species. Idukki district, situated in the Western Ghats, provides an ideal setting for such research due to its high species richness and diverse agricultural practices.

This study aims to address these gaps by conducting a comprehensive comparison of different beetle collection techniques in the agroecosystems of Idukki district. The objectives of the research are threefold: (1) to evaluate the efficiency of pitfall traps, light traps, and manual collection in sampling beetles in diverse agroecosystems; (2) to assess the diversity, abundance, and species composition of beetles captured by each method; and (3) to provide recommendations for standardized beetle sampling protocols in tropical agroecosystems.

By identifying the most effective collection methods for beetles in Idukki's agroecosystems, this study will contribute to a better understanding of the region's biodiversity and its ecological functions. The findings will also provide valuable insights for policymakers, conservationists, and farmers seeking to implement sustainable agricultural practices that integrate biodiversity conservation.

Methodology

The study was conducted in five distinct agroecosystems in Idukki district, Kerala, between January 2022 and December 2022. The selected agroecosystems included Rubber plantations, Coconut plantations, Pineapple plantations, Cardamom plantations, and Mixed plantations. Sampling was carried out monthly at designated sampling sites within each plantation type, ensuring adequate coverage across seasons to capture variations in beetle activity and diversity. Beetles were collected using four methods: pitfall traps, light traps, flight-intercept traps, and hand-picking. Each method was applied systematically in designated plots of 10 × 10 meters to standardize effort and allow for comparative analysis of trap efficacy.

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All collected specimens were preserved in 70% ethanol and identified to the family level using standard entomological keys and reference material. Quantitative data on abundance and diversity were recorded for each method, and the results were analysed to compare the efficacy of the techniques in capturing beetles across different agroecosystems.

Results and Discussion

A total of 19 beetle families were documented from the Idukki District using four different collection methods: handpicking, light traps, pitfall traps, and flight interception traps. Among these, handpicking was the most effective, yielding 16 families, followed by light traps (12 families). Pitfall and flight interception traps captured fewer families, with 4 and 3 families, respectively (Table 1).

Table 1: Checklist of beetles collected through different collection methods

Sl No	Family	Hand	Light	Flight	Pitfall
1	Scarabaeidae	*	*	*	*
2	Carabidae	*			*
3	Lampyridae		*		
4	Elateridae	*	*		*
5	Cerambycidae	*	*	*	
6	Tenebrionidae	*	*		*
7	Lycidae	*	*		
8	Coccinellidae	*	*		
9	Chrysomelidae	*	*		
10	Curculionidae	*	*	*	
11	Cucujidae	*			
12	Meloidae	*	*		
13	Rutelidae	*			
14	Eucnemidae	*			
15	Bostrichidae	*			
16	Nitidulidae	*			
17	Cantharidae	*			
18	Rhipiceridae		*		
19	Passalidae		*		

The effectiveness of handpicking lies in its ability to target specific microhabitats, such as leaf litter, bark, and under stones, which are crucial for families like Tenebrionidae and Curculionidae. Light traps, on the other hand, excel in attracting nocturnal and phototactic beetles, such as Elateridae and Scarabaeidae. However, pitfall traps primarily capture ground-dwelling taxa like Carabidae and Scarabaeidae due to their passive nature, while flight interception traps are more suited to canopy-active species, showing limited effectiveness in terrestrial habitats (Lovei & Sunderland, 1996; Basset et al., 2011).

The higher abundance observed in pitfall traps reflects their ability to continuously capture ground-active beetles in dense undergrowth or moist soil, though this often leads to low diversity due to dominance by prolific families like Scarabaeidae. Light traps captured a broad range of phototactic species but suffered from non-selectivity, attracting non-target nocturnal insects (Roberts et al., 2020). Flight interception traps were efficient in capturing beetles in monoculture systems, where their design targets active aerial species (Davis & Harrison, 2021).

The diversity of beetle species varied significantly across different plantation types (Table 2). Mixed plantations supported the highest diversity due to their structural complexity and heterogeneity, providing abundant microhabitats and resources. Rubber and coconut plantations showed moderate diversity, attributed to their semi-natural structure. In contrast, cardamom and pineapple plantations exhibited the lowest diversity, likely due to their monoculture structure, intensive management, and frequent agrochemical usage.

Table 2: The study of diversity of beetles in different agricultural fields.

Sl No	Family	Rubber	Pineapple	Coconut	Cardamom	Mixed
1	Scarabaeidae	*	*	*	*	*
2	Carabidae	*		*	*	*
3	Lampyridae	*				*
4	Elateridae	*		*	*	*
5	Cerambycidae	*		*	*	*
6	Tenebrionidae	*	*	*		*
7	Lycidae					*
8	Coccinellidae	*		*	*	*
9	Chrysomelidae	*	*	*	*	*
10	Curculionidae	*		*		*
11	Cucujidae	*	*	*		*
12	Meloidae	*		*	*	*
13	Rutelidae	*				
14	Eucnemidae	*				*
15	Bostrichidae	*				*
16	Nitidulidae	*				*
17	Cantharidae			*		*
18	Rhipiceridae	*		*		*
19	Passalidae	*				*

Mixed plantations provided diverse resources and microhabitats, supporting generalist and specialist taxa, consistent with Gómez & Vásquez (2018). Rubber and coconut plantations sustained moderate diversity but were limited by their managed nature, as noted by Didham et al. (1996). Monoculture plantations like cardamom and pineapple were characterized by reduced diversity due to habitat simplification and agrochemical impacts (Tscharntke et al., 2012; Miller & Thomson, 2019).

The study underscores the importance of structurally diverse habitats in supporting beetle diversity. Conservation efforts should prioritize mixed plantations and promote sustainable practices, such as reduced pesticide use, cover crops, and vegetative buffers, to mitigate the adverse effects of monocultures (Johnson et al., 2020).

Handpicking demonstrated the highest diversity, aligning with Smith et al. (2019), who emphasized its effectiveness for rare or microhabitat-specialized taxa. Light traps, while effective for nocturnal species, faced limitations due to non-selectivity (Brown & Green, 2017). Pitfall traps excelled in capturing ground-dwelling taxa but showed limited diversity (Jones et al., 2018), while flight interception traps targeted canopy beetles effectively in certain habitats (Davis & Harrison, 2021).

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Conclusion

This study highlights the ecological roles of beetles in tropical agricultural landscapes and the complementary nature of different sampling methods. Mixed plantations emerged as biodiversity hotspots, underscoring their conservation value. Future research should explore long-term impacts of agricultural intensification on beetle communities, integrating molecular and functional diversity assessments to better understand their ecological roles. Sustainable agricultural practices and habitat heterogeneity are critical to preserving beetle diversity in these landscapes.

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