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Abundance and Season Variability of Rove Beetles (Coleoptera: Staphylinidae) in the Mangrove Ecosystem of Akalapuzha Coastal Region, Kerala, South India

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ABSTRACT

The species composition and diversity of rove beetles (Staphylinidae) in the mangrove coastal region remain poorly explored, particularly in South India. This study aims to understand the rove beetle diversity in the Akalapuzha mangrove coastal ecosystem with respective seasonal changes (pre-summer, summer, and monsoon) as well as the efficacy of different collection methods (pitfall trap, light trap, Berlese funnel, and flotation method). From the study, the collected specimens came under five subfamilies: Oxytelinae, Aleocharinae, Staphylininae, Paederinae, and Tachyporinae. Among this, high taxa abundance was observed in Oxytelinae, followed by Aleocharinae, Staphylininae, Paederinae, and Tachyporinae. Among the documented subfamilies, three subfamilies, namely Oxytelinae, Staphylininae, and Aleocharinae were recorded in all three seasons. In the case of diversity analysis, the highest diversity was observed in the summer season (1-D = 0.277, & H = 0.630), followed by pre-summer (1-D = 0.306, & H = 0.678) and monsoon (1-D = 0.533, & H = 1.069). Among all the different insect collection methods, the flotation method ($p<0.05$) is the most suitable for collecting rove beetles, regardless of seasonal variations, and is followed by light traps, pitfall traps, and Berlese funnel traps. The study revealed the inevitability of protecting the mangrove ecosystem, as it is identified as an ideal habitat for the economically, ecologically, and medically important Coleopteran family, Staphylinidae.

1. Introduction

Tropical insect surveys have traditionally focused on rainforests, with other habitats being largely neglected. Mangrove forests are a prime example of a tropical habitat for which the insect fauna is poorly characterized. Mangroves used to cover more than 200,000 km^2 of the global coastline, but have been experiencing an annual area loss of 1-2% (Duke *et al.* 2007). These changes will not only endanger entire ecosystems that provide essential ecosystem services but also threaten the survival of numerous mangrove species with unique adaptations. Mangrove specialists with such adaptations are well known for vertebrates and vascular plants, but the invertebrate diversity is poorly known (Yeo *et al.* 2021).

Mangrove forest serves as a habitat for a diversity of fauna and flora (Mchenga and Ali 2013). Mangrove insects can be either permanent residents or temporary visitors (Macintosh and Ashton 2002). A study of insect biodiversity can help in determining its potential productivity and in the better management of mangroves (Kulkarni and Mukadam 2015). Family Staphylinidae, belonging to the order Coleoptera, suborder Polyphaga, is one among the insect groups present in mangroves. Staphylinidae, commonly known as Rove beetles, is the second-largest family of beetles (Caterino *et al.* 2005) and is numerically most abundant in the Western Ghats Forest litter ecosystem (Sabu 2006; Newton 2007).

Rove beetles (Staphylinidae) are one of the richest and most diverse families of beetles, which contains

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63000 described species belonging to 3672 genera and 32 subfamilies (Klimaszewski *et al.* 2018). Staphylinid beetles, which are easily distinguished from other beetles by their short, truncate elytra, are often shiny, dark-colored. Still, a few are brilliantly coloured (red, blue, yellow) ones with a hairy borderline. The length of the adult Staphylinidae ranges from less than 1mm to 40 mm (Blackwelder 1936). Body shape (ovoid to elongate), sensory appendages, thoracic and basal abdominal structure, and leg specializations can be explained in terms of locomotor specialization. Staphylinidae beetles help balance ecosystems (Smith 1861), litter decomposition, and play a key role in Forensic Entomology (Heer 1839). They are predators of insects and other invertebrates, thus acting as biocontrol agents. Study of Staphylinidae would have received considerable attention due to its significant influence on the ecosystem (Brown 1950) and its ecological importance (Herman 2001), abundance (Sabu 2006), and diversity (Hicks 1959). The suppression or alteration of native plants causes significant changes in the environment, specifically the structure and function of the native plant community (Macaneiro *et al.* 2017). These changes not only alter the structure of the microenvironment; they also change the insect community (Arenhardt 2024).

Only limited studies were available related to the diversity and seasonal variations of rove beetles (Staphylinidae) from South India, especially in the mangrove coastal regions. Akalapuzha coastal region is one of the important eco-tourist areas in Kerala, South India, and studies on this mangrove-associated fauna and flora are little explored. This study is a preliminary attempt to understand the composition and diversity of rove beetles in the Akalapuzha mangrove coastal region under different seasons and using different insect collection methods.

2. Materials and Methods

2.1. Study Area

The study was conducted during pre-summer (February and March), summer (April and May), and monsoon (June to August) of 2018 in the mangrove ecosystem of Akalapuzha coast (11º33'43" N, 75º77’13” E), Kozhikkode, Kerala, India (Figure 1 and 2).

2.2. Sampling Method

The rove beetles were collected from the mangrove ecosystem by different collection methods, such as light trap (Hollingsworth and Hartstack 1972), Berlese funnel (Tullgren 1918), dung flotation (Moore 1954), and baited pitfall trap (Spector and Forsyth 1998) methods (Figure 2). A total of 30 traps from each method were independently randomly set in different areas of mangrove ecosystems (study period: February to August, 2018). The samples were periodically collected from each trap (samples were collected from the respective trap in a three-day periodic interval, and collection mostly done between 09:00 am to 02:00 pm), and were preserved in 75% alcohol labelled vials for further identification purposes.

2.3. Specimen Identification and Imaging

Collected specimens were carried out in the Taxonomy Laboratory, Department of Zoology, St. Joseph's College Devagiri, Kozhikkode, Kerala, and identified with the help of taxonomic keys (Cameron 1939)—imaging of the adult beetles using a Stereo Zoom Trinocular Microscope Leica M 205C.

2.4. Data Analysis and Diversity Indices Calculations

Species richness, relative abundance, species evenness, species diversity, species abundance index, and dominance index were calculated to understand the ecological community and seasonal variability of rove beetles in the mangrove ecosystem. Kruskal-Wallis test and One-Way ANOVA multiple comparison test were used to analyze the statistical significance between the seasonal variability and different collection methods. All the statistical analyses were done in PAST software and Origin 2025 software.

3. Results

From the study site, the collected specimens fell under the five subfamilies such as Oxytelinae, Staphylininae, Paederinae, Aleocharinae, and Tachyporinae. Among this, high taxa abundance was observed in Oxytelinae (D = 0.443, 1-D = 0.556, H = 0.903, Fisher alpha = 0.395), and followed by Aleocharinae (D = 0.416, 1-D = 0.583, H = 0.985, Fisher alpha = 0.658), Staphylininae (D = 0.357, 1-D = 0.642, H = 1.06, Fisher alpha = 0.692), Paederinae (D = 0.355, 1-D = 0.644, H = 1.065, Fisher alpha = 0.704), and Tachyporinae (D = 0.381, 1-D = 0.618, H = 1.007, Fisher alpha = 1.359) (Table 1 and Figure 3). Among the documented subfamilies, three subfamilies namely Oxytelinae, Staphylininae and Aleocharinae were recorded in all the three seasons.

Table 1. Diversity of rove beetles from the mangrove ecosystem of Akala coastal regions

Subfamily	Tribe	Genus name	Distribution
Oxytelinae	Oxytelini	*Oxytelus insicus*	Indes orientals. Kannur
		Oxytelus sp. 2	Arni khad- north India
		Oxytelus sp. 3	Musoorie district, Arni Khad- north India
Staphylininae	Xantholini	*Leptacinus parumpunctatus*	Nilgiri hills, north India
	Staphylinini	*Philonthus rotundicollis*	Widely distributed in India, the Pamirs
		Philonthus cinctulus	Cosmopolitan- India and Ceylon
Paederinae	Paederini	*Scopaeus* sp.	Indes orientals, south India-Nilgiri hills
		Lathrobium sp.	North India-Musoorie district, Burma
		Astenus sp.	North India-Chakrata district, Burma, Java
		Medon sp.	Ceylon: dikoya, south India-Nilgiris hills
		Sclerochiton sp.	South India-Nilgiris hills
		Paederinae fusiceps	South India-Nilgiris hills
		Lithocharis sp.	Ceylon: Kandy, Singapore, South India-Nilgiris hills
Aleocharinae	Pronomaeini	*Pronomaea* sp.	Dehra dun - north India
	Oligotini	*Oligotta* sp.	Cosmopolitan- India and Ceylon
	Phloeoporini	*Microglotta* sp.	Assam - Naga Hills
	Myllaenini	*Myllaena* sp.	Dehra dun - north India
	Eusteniamorphini	*Eusteniamorpha* sp.	Musoorie district, Arni Khad- north India

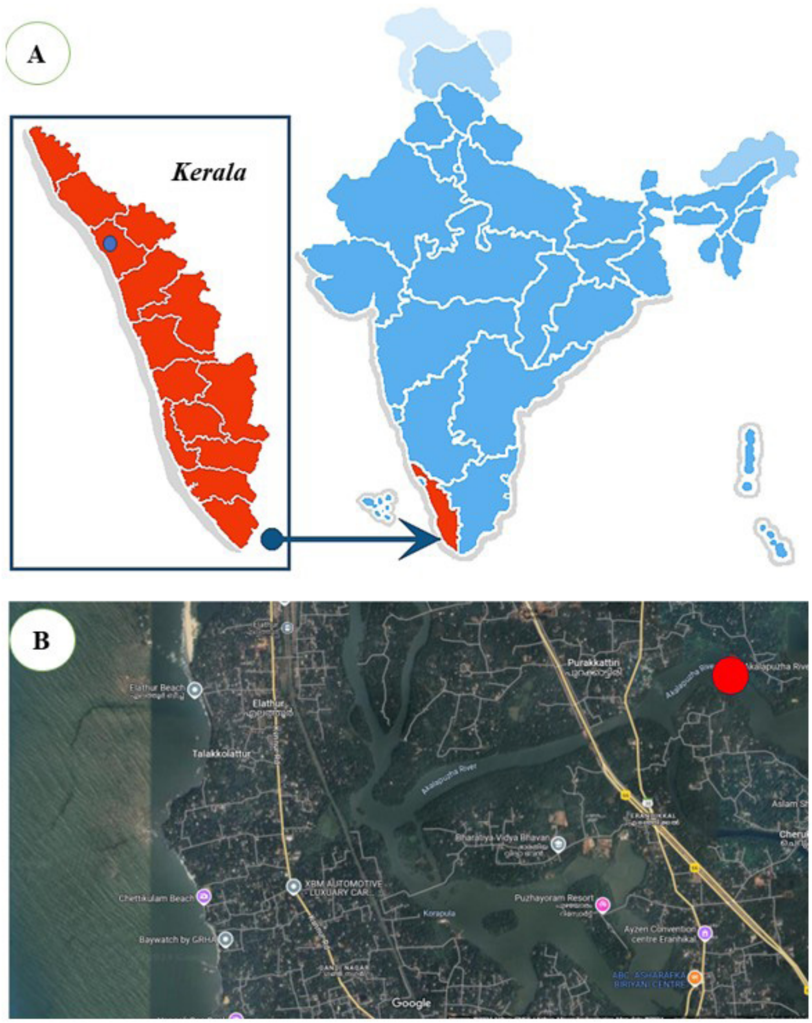

Figure 1. Study site, (A) Kerala state, (B) Akalapuzha coastal mangrove area (marked in red colour)

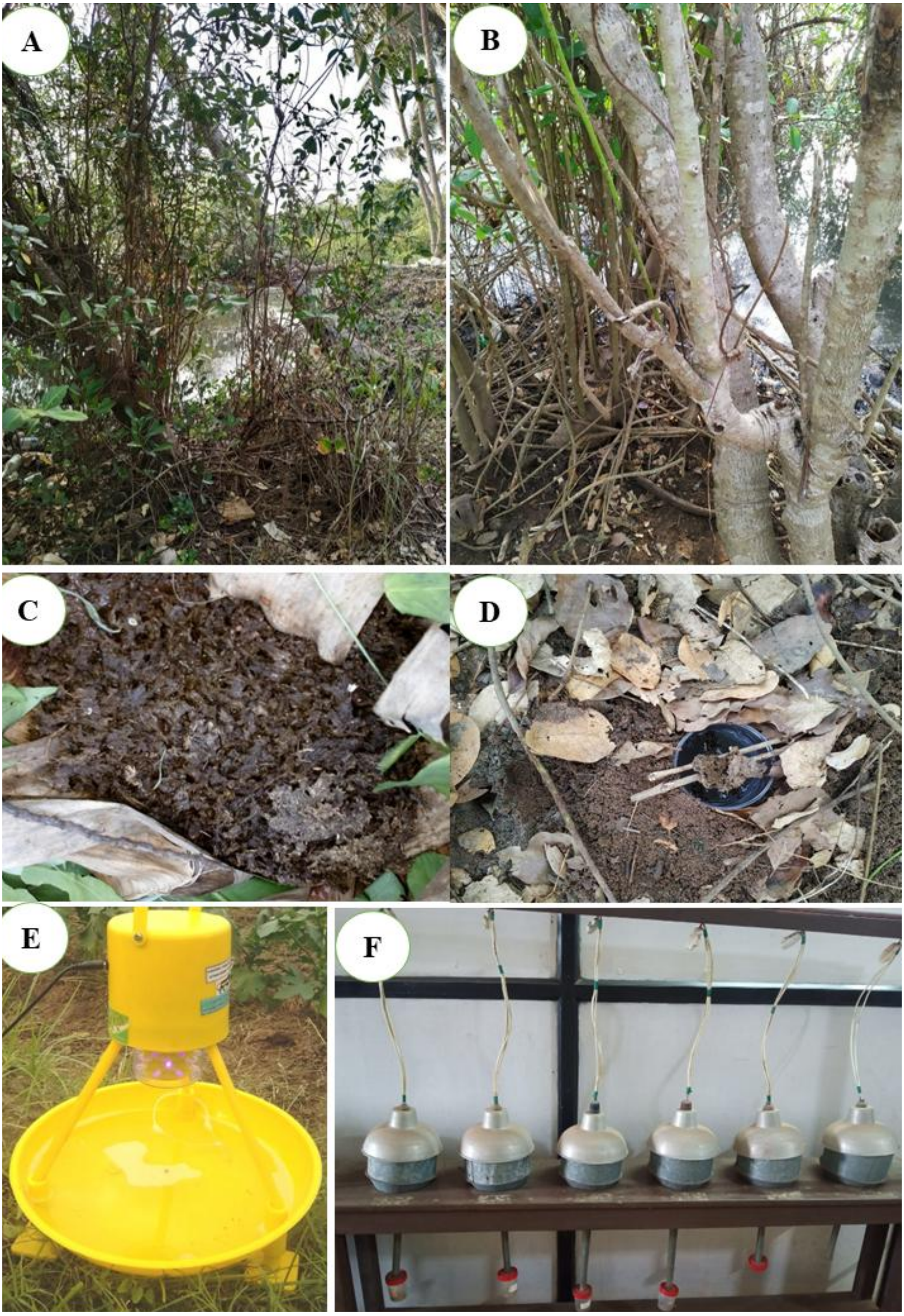

Figure 2. (A) and (B) Habitat of Akalpuzha mangrove coastal area, (C) dung pat in floatation method, (D) pitfall trap, (E) light trap, and (F) berlese funnel method

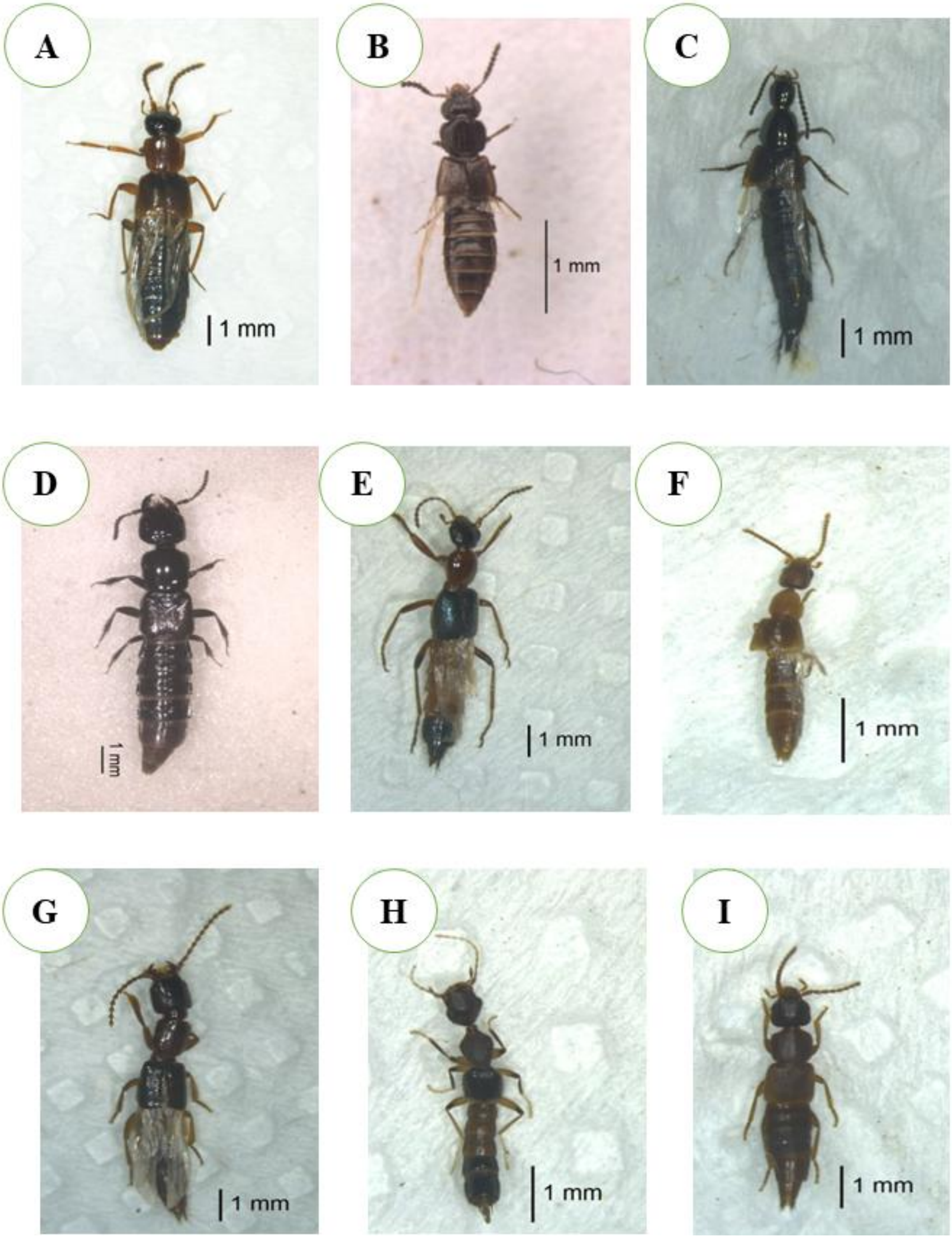

Figure 3. Rove beetle diversity in study sites. (A) *Myllaena* sp. (B), *Oxytelus* sp. (C), *Philonthus* sp.(D), *Indoscitalinus* sp. (E), *Paederus* sp. (F), *Scopaeus* sp. (G), *Lathrobium* sp. (H), *Astenus* sp., and (I) *Lithocharis* sp.

The population distribution analysis showed that nonsignificant ($p>0.05$) diversity was observed in all the seasons. It indicated that the population is highly heterogeneous, with the highest number of taxa documented in the pre-summer season, followed by summer and monsoon. Seasonally based, species evenness analysis confirmed that the highest and significant species evenness was observed in the monsoon (0.533), followed by the pre-summer (0.394) and the summer (0.375). In the case of diversity analysis, highest diversity was observed in the summer season (D = 0.722, 1-D = 0.277, H = 0.630, Fisher alpha = 0.831) and followed by pre-summer (D = 0.693, 1-D = 0.306, H = 0.678, Fisher alpha = 0.767) and monsoon (D = 0.466, 1-D = 0.533, H = 1.069, Fisher alpha = 1.117) (Figure 4A).

Among all the different insect collection methods, the flotation method ($p<0.05$) is the most suitable for collecting rove beetles, regardless of seasonal variations, and is followed by light traps, pitfall traps, and Berlese funnel traps. In the pre-summer analysis, highest diversity observed in flotation method (D = 0.769, 1-D = 0.230 and H = 0.480) and followed by light trap (D = 0.689, 1-D = 0.311 and H = 0.678); and lowest diversity was observed in the pitfall trap (D = 0.499, 1-D = 0.500 and H = 1.051). The summer season also exhibited a similar kind of diversity as in the pre-summer season; the highest diversity was observed in the flotation method (D = 0.780, 1-D = 0.219, and H = 0.469), and the lowest diversity observed in the Berlese funnel trap method (D = 0.488, 1-D = 0.511 and H = 0.901). As compared to pre and summer season, contradictory rove beetle diversity noticed during monsoon season, higher diversity taxa collected in floatation method (D = 0.530, 1-D = 0.469 and H = 0.886) and followed by pitfall trap method (D = 0.500, 1-D = 0.500 and H = 1.004) and lowest diversity observed in Berlese funnel method (D = 0.200, 1-D = 0.800 and H = 1.255) (Table 2 and Figure 4).

4. Discussion

Mangrove forests along the tropical and subtropical coastline hold a vast diversity of flora and fauna, including insects. The study of insect biodiversity can help in determining the potential productivity and better management of mangroves. Family Staphylinidae, commonly known as Rove beetles, is one of the abundant insect groups present in mangroves, performing multi-dimensional ecological roles, including predators, parasites, pollinators, decomposers, and scavengers within the ecosystem. The high abundance and diversity of Staphylinidae beetles in the Akalapuzha region of Kozhikode are primarily attributed to the moist habitat preference, the presence of a large amount of organic matter, and the availability of food sources in the form of prey resources, larvae, and fruit-bearing plants. The variations in plant type influence the different proportion of the insect community in a field (Puspasari *et al.* 2021). Supporting these findings, we also observed that the diversity of rove beetles was linked to the plant species composition. Oxytelinae was the abundant subfamily among the collected beetles, with a preference of the genus Oxytelus towards the

Table 2. Diversity analysis of rove beetles collected from the Akalapuzha mangrove coastal region in different seasons and different collection methods. FM–Flotation method; LT–Light trap; PT–Pitfall trap; and BF–Berlese funnel method

Indices	Pre-summer				Summer				Monsoon			
	FM	LT	PT	BF	FM	LT	PT	BF	FM	LT	PT	BF
Taxa_S	4	5	5	4	4	5	5	3	4	4	4	3
Individuals	244	194	62	17	158	137	44	10	51	24	17	5
Dominance_D	0.769	0.689	0.499	0.507	0.780	0.654	0.513	0.488	0.530	0.391	0.5	0.2
Simpson_1-D	0.230	0.311	0.500	0.492	0.219	0.345	0.486	0.511	0.469	0.608	0.5	0.8
Shannon_H	0.480	0.678	1.051	0.973	0.469	0.748	1.013	0.901	0.886	1.138	1.004	1.255
Evenness_e^H/S	0.404	0.394	0.572	0.661	0.399	0.422	0.550	0.821	0.606	0.779	0.682	1.169
Brillouin	0.451	0.630	0.913	0.689	0.428	0.683	0.839	0.588	0.766	0.901	0.713	0.680
Menhinick	0.256	0.359	0.635	0.970	0.318	0.427	0.753	0.948	0.560	0.816	0.970	1.342
Margalef	0.545	0.759	0.969	1.059	0.592	0.813	1.057	0.868	0.763	0.944	1.059	1.243
Equitability_J	0.346	0.421	0.653	0.702	0.338	0.465	0.629	0.820	0.639	0.820	0.724	1.142
Fisher_alpha	0.679	0.936	1.282	1.649	0.746	1.019	1.452	1.453	1.016	1.371	1.649	3.167
Berger-Parker	0.873	0.824	0.693	0.705	0.879	0.802	0.704	0.7	0.705	0.583	0.705	0.4
Chao-1	4	5	5	4.941	4	5	5.489	3.45	4	4	4.235	3.2
iChao-1	4	5	5	5.353	4	5	5.489	3.45	4	4	4.235	3.2
ACE	5.086	6.102	5	7.667	5.12	5.369	5.514	4.033	4.652	4	4.75	3.75
Squares	4.771	5.691	5	6.206	4.782	5.657	5.526	3.557	4.54	4	4.537	3.409

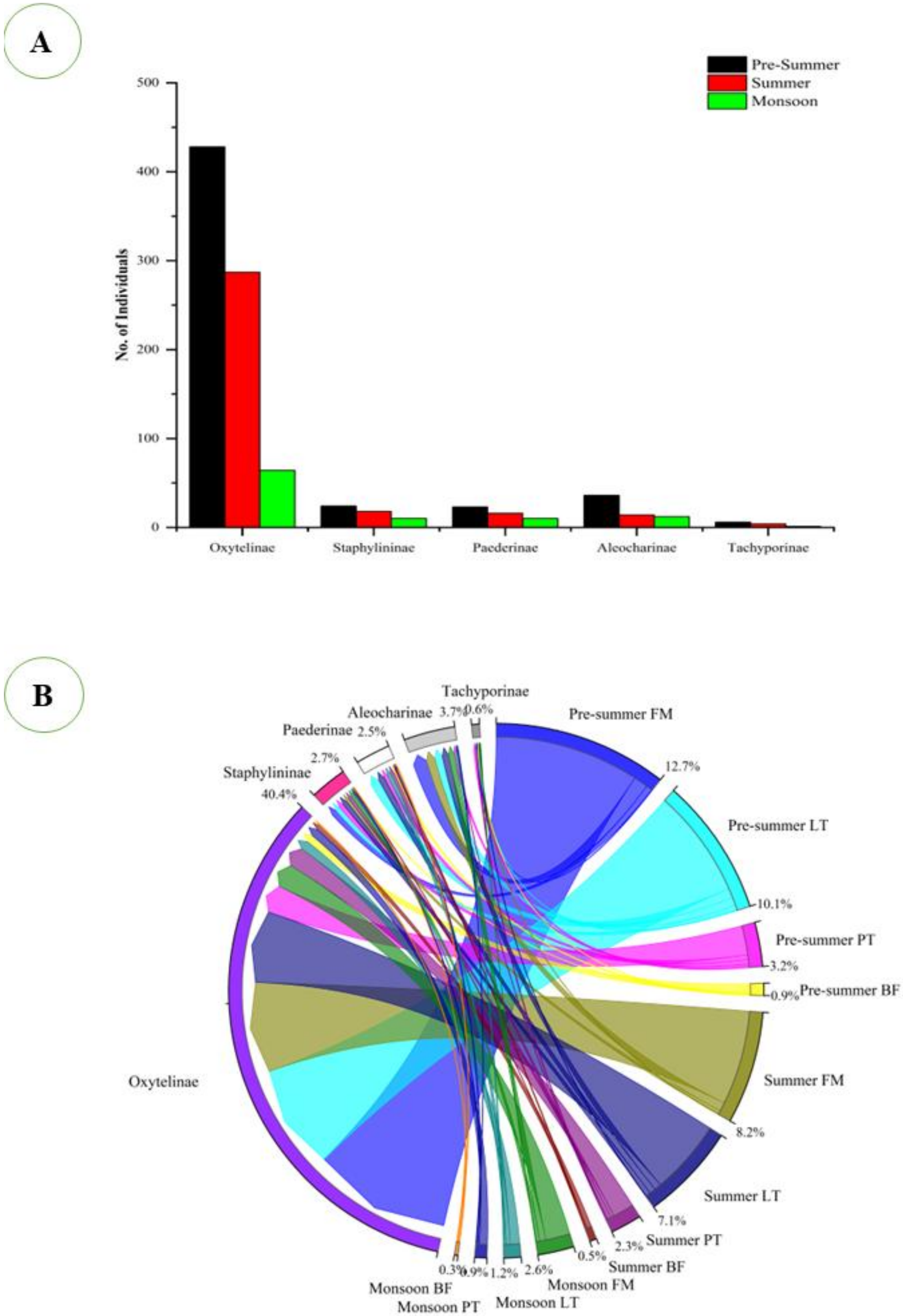

Figure 4. Akalapuzha mangrove coastal ecosystem (A) Diversity, and seasonal variation; (B) correlation between seasonal variation and diversity

organic litter and other decaying habitats. In addition to that, Oxytelinae has a greater ability to adapt to diverse environmental conditions (Lu and Zhon 1995). The presence of Oxytelinae species indicates a stable environmental balance and reflects that the mangrove habitat supports the activity of prey and predator mechanisms in an equilibrium manner (Puspasari *et al*. 2025).

Aleocharinae was the second most abundant subfamily, supporting the general nature of the prevalence of free-living communities (Basak and Pal 2006). The mangrove ecosystem itself serves as a shelter for a diverse array of insects, with the Aleocharinae playing a significant role as a natural predator (Puspasari *et al.* 2025). Staphylininae was the third abundant subfamily. The presence of cow dung, decaying fruits, and bark of dead trees in the site could be related to the high abundance of Staphylininae in the samples. Staphylinidae beetles concentrate in fallen decomposing fruits, the bark of fallen decaying trees, drifted plant materials on banks of rivers and lakes, and cattle dung, carrions, nests of vertebrate animals. The Staphylinidae play a crucial role in agroecosystems as a natural pest control agent and as an indicator of environmental changes (Puspasari *et al.* 2025). This explains the reason for the abundance of Staphylininae in the study site. Paederinae was the fourth abundant subfamily. Both larvae and adults are predatory on other insects. Predatory nature and its adaptation to a moist environment are well-documented facts (Bohac 1985; Puspasari *et al.* 2025). This supports the reason that Paederinae is most abundant during the monsoon season. The Lowest abundance of Tachyporinae could be related to their fast-moving nature (Campbell 1975) and the possibility of escape during sample collection. The reasons for the community distribution of these beetles could not be explained due to the lack of ecological and biological works. The variations in the diversity of Staphylinidae beetles are related to factors such as sunlight, temperature, vegetation structure, and microclimate variations (Arenhardt 2024).

In the case of seasonal variation analysis, the highest rove beetle diversity was observed in the summer season and followed by pre-summer and monsoon. The summer conditions provided optimum temperature for flying and dispersion of rove beetles (Stasiov *et al.* 2021). The flotation method is effective for the collection of rove beetles, followed by the light trap and pitfall trap. However, the studies of Guseva (2020) suggested that the pitfall trap is the best method for collecting the rove beetles in an agricultural field. The collection method of rove beetles may vary based on environmental factors; therefore, proper systematic studies are required to understand the insect collection trap in different ecosystems.

There are no proper studies related to the rove beetle diversity in the mangrove ecosystem, specifically in India. The studies of Stasiov *et al.* (2021) proved that rove beetle diversity in wetlands directly correlated with the plant diversity, cover of vegetation layers, area, age or forest, thickness of litter layer, physical and chemical properties of soil and leaf litter (conductivity, pH, P, N, H, C) and anthropogenic factors. The study confirmed that species richness correlated with plant diversity and the vegetation layer. There is no major taxonomic work on rove beetles from India after the efforts of Cameron (1930–1939), and no revision based on the modern classification. These severely affect the identification of new taxa and understanding the role of rove beetles in an ecosystem. Our studies mainly highlight the diversity of rove beetles and the impact of different collection methods. This study provides a basic understanding of rove beetle diversity in the mangrove ecosystem, and more systematic studies are needed to understand the role of rove beetles in the mangrove ecosystem and the impact of anthropogenic factors.

In conclusion, the locality of Akalapuzha boasts a rich diversity and abundance of Staphylinidae, which aligns with the availability of their preferred microhabitat, characterized by a moist and organic-rich environment. The studied Staphylinidae beetles belonging to five subfamilies viz. Oxytelinae, Staphylininae, Paederinae, Aleocharinae, and Tachyporinae. Seasonally based, species evenness analysis confirmed that the highest and significant species evenness was observed in monsoon and followed by pre-summer and summer. In the case of diversity analysis, the highest diversity was observed in the summer season, followed by the pre-summer and then the monsoon. Among all the different insect collection methods, the flotation method is the most suitable for collecting rove beetles, regardless of seasonal variations, and is followed by light traps, pitfall traps, and Berlese funnel traps. This higher abundance of Staphylinidae in mangroves is mainly due to the presence of a moist, organic-rich microhabitat preference and the availability of food sources in the form of decaying organic matter.

Conflict of Interest

The author (s) declare no conflict of interest.

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