

Methods for sampling and collecting insect pollinators and flower visitors in global mangrove ecosystems: A critical systematic review

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Abstract

Mangrove ecosystems are highly productive coastal habitats that provide essential ecological services and support complex biological interactions. Among these interactions, insect pollination plays a critical role in sustaining mangrove reproduction, maintaining genetic diversity, and enhancing ecosystem resilience. However, research on insect pollinator communities within mangrove ecosystems remains limited. This study synthesizes current scientific knowledge on insect pollination in mangrove systems and proposes a spatially informed methodological framework for investigating insect-mangrove interactions. The research integrates a systematic literature review with proposed ecological field approaches to address knowledge gaps related to pollinator diversity, sampling methodologies, and the ecological dynamics of mangrove pollination networks. A thematic review of peer-reviewed literature published between 2020 and 2025 was conducted using multiple academic databases, with earlier studies included to provide historical context. From 154 retrieved articles, 107 met the inclusion criteria and were analyzed to evaluate established insect sampling techniques in mangrove environments. The proposed framework of this review incorporates Geographic Information Systems (GIS), remote sensing, UAV-based habitat assessment, and structured ecological sampling across two randomly selected 100 m × 100 m plots. Insect pollinators are sampled using both active methods and passive methods, while floral visitation, pollinator behavior, vegetation composition, and environmental variables are recorded. By integrating spatial analysis with standardized sampling protocols, the study provides a baseline for documenting insect assemblages associated with key mangrove species such as *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*. This review supports long-term ecological monitoring and highlights the vulnerability of mangrove pollination networks to climate change, habitat fragmentation, and anthropogenic pressures, thereby contributing to improved biodiversity conservation and mangrove management in Guyana and the neotropics.

Keywords: Insect pollinators; Insect flower visitors; GIS Mapping; Mangrove ecosystems; Active Sampling; Passive Sampling; Insect collection; Insect identification; Insect preservation, Neotropic

1. Introduction

Mangrove ecosystems represent one of the most ecologically complex and productive coastal habitats in the tropics and subtropics, occupying intertidal zones where terrestrial and marine systems intersect. Comprising a specialized assemblage of salt-tolerant trees and shrubs, mangroves have evolved remarkable physiological, morphological, and reproductive adaptations that enable survival under fluctuating salinity, tidal inundation, anoxic soils, and high solar

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exposure. Among these adaptations, pollination strategies are particularly diverse and play a critical role in sustaining mangrove population dynamics, genetic diversity, and long-term ecosystem resilience [21, 28, 137]. Unlike many terrestrial forests where wind pollination dominates, mangrove species exhibit a range of biotic pollination syndromes, often relying heavily on insects for successful reproduction [28, 137]. These interactions position insect pollinators as keystone functional components within mangrove ecosystems.

Globally and regionally, mangrove ecosystems are increasingly threatened by a convergence of anthropogenic pressures. Rapid coastal development driven by tourism expansion, urbanization, agriculture, and aquaculture has resulted in widespread habitat loss and fragmentation. In parallel, pollution from agrochemical runoff, industrial effluents, and improper waste disposal has further degraded mangrove health and productivity [21, 28, 58, 128, 137, 171, 180].

In addition to human-induced disturbances, mangroves are increasingly vulnerable to climate-driven stressors. Sea-level rise, intensified storm surges, and saltwater intrusion are reshaping coastal geomorphology and altering hydrological regimes at local and global scales [92, 128, 129]. These changes affect not only mangrove survival but also the availability and phenology of floral resources that sustain pollinator communities. Further, deforestation for fuelwood and timber extraction continues to account for substantial mangrove loss, with estimates suggesting that approximately 26% of global mangrove cover has already been degraded or destroyed [128, 187]. Collectively, these pressures threaten the integrity of plant–pollinator interactions that underpin mangrove regeneration and ecosystem stability.

Insects and plants are among the biological groups most sensitive to climate variability and extreme weather events. Empirical evidence demonstrates that anthropogenic climate change has affected species distributions, population dynamics, and phenological synchrony across virtually all continents and major taxonomic groups [61, 78, 97]. In mangrove ecosystems, rising temperatures, altered rainfall regimes, increased solar radiation, and shifting tidal patterns influence flowering intensity, nectar production, and pollen viability. These environmental changes, in turn, have direct consequences for insect fertility, feeding behavior, survival, dispersal, and pollination efficiency [61, 97, 169]. Disruptions in these finely tuned ecological relationships can result in reduced reproductive success of mangrove species and long-term declines in forest resilience.

Understanding the structure and dynamics of insect pollinator communities within mangrove ecosystems is therefore critical for biodiversity conservation, ecosystem management, and climate adaptation planning, particularly in tropical coastal regions. Concepts such as species richness, species evenness, functional diversity, and interaction networks provide essential theoretical frameworks for evaluating ecosystem health and resilience. Pollination ecology theory further highlights the dependence of plant reproductive success on the diversity and reliability of pollinator assemblages, especially in ecosystems where flowering phenology is temporally constrained or environmentally sensitive.

Despite the global recognition of mangroves as biodiversity hotspots and critical carbon sinks, methodological research on insect-mangrove interactions remains geographically uneven. Much of the existing literature originates from the Indo-West Pacific region, including studies in India, Bangladesh, Southeast Asia, and Australia, where mangrove pollination ecology has received comparatively greater attention [4, 5, 6, 7, 8, 10, 148, 149, 150]. In contrast, neotropical mangrove systems, remain poorly studied, particularly with respect to insect pollinator diversity, seasonal dynamics, and species-specific pollination strategies. This knowledge gap limits the development of evidence-based conservation and restoration strategies tailored to local ecological conditions.

Within this context, the present review critically examines and synthesizes methodological approaches suitable for investigating insect pollinator diversity among mangrove species. Emphasis is placed on quantitative, non-experimental research designs that allow for the observation and documentation of natural ecological patterns without manipulating environmental variables [35]. Such designs are particularly appropriate for mangrove ecosystems, where experimental manipulation may be logistically challenging, ethically constrained, or ecologically disruptive. By employing systematic field observations, random sampling, and standardized data collection protocols, researchers can generate robust, replicable datasets that accurately reflect real-world ecological conditions [25].

The methodological frameworks reviewed in this paper integrate both active and passive insect sampling techniques, vegetation assessments, spatial mapping, and advanced analytical tools. Diversity indices such as Simpson's Index and Shannon's Index and, measures of species richness and evenness provide quantitative metrics for comparing pollinator communities across mangrove species and environmental gradients [56, 72]. These metrics are not merely descriptive but serve as proxies for ecological stability, interaction strength, and functional redundancy within pollination

networks. In mangrove systems, where a limited number of plant species may support a disproportionately large number of insect taxa, such analytical tools are essential for identifying keystone pollinators and vulnerable interactions.

A defining feature of this methodological review is its emphasis on spatial and temporal rigor. The integration of Geographic Information System (GIS) mapping enables precise delineation of study sites, assessment of mangrove cover, and identification of habitat edges where pollinator activity may be particularly pronounced [3, 37, 106]. Edge effects, environmental gradients, and habitat fragmentation are known to influence insect community composition, making spatially explicit methodologies indispensable for accurate ecological interpretation [53, 143].

Equally important is the recognition that pollinators must be distinguished from mere floral visitors. Methodological approaches that combine behavioral observation, morphological assessment, and ecological context are necessary to identify effective pollinators and quantify their contributions to plant reproduction [101, 198]. This distinction is particularly relevant in mangrove ecosystems, where diverse insect taxa may visit flowers opportunistically without contributing meaningfully to pollen transfer. Failure to differentiate pollinators from non-pollinating visitors can inflate diversity estimates while obscuring functional relationships.

Advances in molecular techniques, particularly DNA barcoding, have further enhanced the accuracy of insect identification in complex ecosystems such as mangroves. Morphological identification alone is often insufficient for resolving cryptic species or immature life stages, especially within highly diverse orders such as Diptera and Hymenoptera. The incorporation of molecular tools complements traditional taxonomy and strengthens the reliability of biodiversity assessments [136, 145, 190]. This methodological integration is especially valuable in understudied regions, where reference collections and taxonomic expertise may be limited.

Beyond its scientific contributions, this methodological review addresses broader conservation and management implications. Effective conservation of mangrove ecosystems requires an understanding not only of tree species composition but also of the ecological processes that sustain regeneration and resilience. Pollination is a foundational ecosystem service, and its disruption can have cascading effects on forest structure, carbon sequestration, and coastal protection. By synthesizing methodological best practices for studying insect pollinators, this review provides a framework for long-term ecological monitoring, habitat restoration, and climate adaptation strategies and comparable tropical coastal systems.

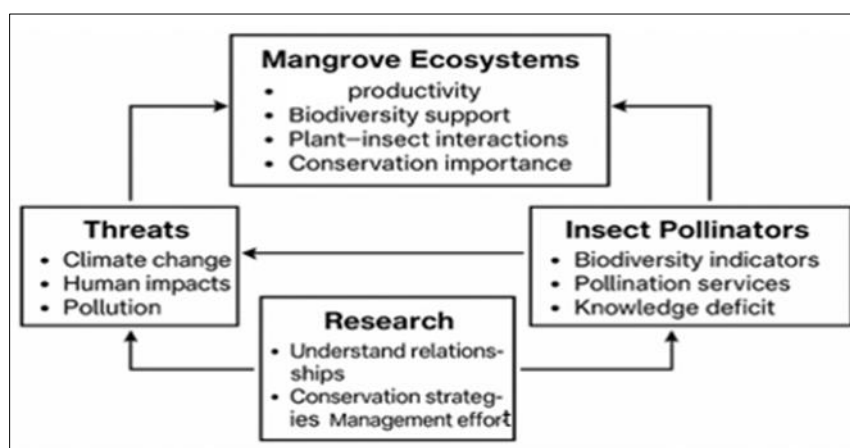


Figure 1 Link between research and studying entomofauna in mangrove ecosystems

This review subsequently outlines the detailed procedures and analytical techniques employed to investigate ecological relationships, highlighting the use of an experimental design appropriate for examining natural variation without manipulating variables [35]. This approach allows for objective and replicable measurement of key ecological indicators across different mangrove species. Using systematic field observations and random sampling, the study minimizes bias and ensures that the findings are generalizable to the broader mangrove landscape [25]. The use of descriptive and inferential statistical analyses, including diversity indices like Simpson's Index and Shannon's Index, supports robust comparisons of insect pollinator communities across environmental gradients. This design is particularly well-suited for ecological research where the goal is not to establish causality, but to document and understand natural distribution patterns and biodiversity dynamics.

By investigating the complex interactions between mangrove species, environmental variables, and insect pollinator communities, this study contributes to a deeper understanding of pollination network stability under the pressures of environmental change and human impact. The findings will not only aid in biodiversity conservation and habitat restoration but also enhance predictive models of ecosystem function in tropical coastal zones.

Despite the critical role of insect pollinators in maintaining mangrove biodiversity and facilitating plant reproduction, there is a notable lack of research on insect-mangrove interactions. In particular, the degree of pollination specialization among neotropical mangrove species remains poorly understood. This gap in local ecological knowledge hinders effective conservation and management strategies (Figure 1). Therefore, it is essential to investigate the relationships between insect visitors and mangrove species to better understand the dynamics of these ecosystems under current and future environmental pressures.

2. Material and methods

2.1. Search Strategy

A systematic thematic review was conducted using search engines to identify globally relevant journal articles published between 2020 and 2025. The search strategy prioritized recent studies focusing on methods to sample insect pollinators in mangroves. Older publications were also incorporated when deemed relevant, particularly if they contributed to identifying existing knowledge gaps within the literature.

The search refinement was guided by thematic keywords, including "insect pollinators," "mangrove," "insect diversity," "insect abundance" and "methods to sample insect pollinators."

2.2. Inclusion Criteria

This review aimed to evaluate existing literature on methods to sample insect pollinators. The selection of articles was based on the following inclusion criteria:

- Relevant and recent journal articles published between 2020 and 2025 to show the context of recent work.
- Publications from before the 2020-2025 timeframe (research conducted between 1962 and 2019) that contained relevant information were reviewed to establish a baseline for this study.
- Work on the methods to identify and sample mangrove species and the abundance of insect pollinators found dwelling among mangroves during flowing periods.
- Articles that focused on different taxonomic classification of insect pollinators found dwelling in mangrove ecosystems.
- Papers written and available in 'English'.

3. Results

Literature was sourced various search engines and open-access databases, including Google Scholar, ResearchGate, Academia, Semantic Scholar, R Discovery, Opub, ScienceDirect, PubMed, SpringerLink, Web of Science, SciSpace, and NPI. The majority of journal articles were freely accessible through these platforms. Access was obtained using their Digital Object Identifier (DOI) via Sci-Hub for articles that were not directly available.

An extensive and comprehensive collection of published literary works was accumulated when the terms were utilized in the search. The results are as follows:

- Insect pollinators of mangroves: 13,900 results.
- Insect abundance among mangroves: 19,100 results.
- Active methods to sample insect pollinators in mangroves: 11,400
- Passive methods to sample insect pollinators in mangroves: 3,020
- Method to sample and identify mangrove species: 184,000
- Taxonomic classification of insect in mangroves: 19,600
- Preservation of insect specimens in mangroves: 16,700

When searching "Google Scholar" for information on methods to sample insect pollinators in mangrove ecosystems, a total of 16,500 results were retrieved. Among the results obtained from the search, a total of 32 were published within

the years 2000-2025, 26 were published between the years 2010-2025, 54 were published within the years 2015-2025 and 83 were published between the years 2020-2025. A total of one hundred fifty-four (154) research articles were accumulated, and one hundred-seven (107) were included in this review.

However, not all papers retrieved for this research focused directly on methods to sample insect pollinators in mangrove ecosystems. Some papers focused on factors affecting insect pollinators, while others documented the interactions of different insect species with various environmental factors. Some papers focused solely on anthropogenic activities affecting specific insect orders, and others examined mitigation, conservation, and management approaches to protect insect pollinators dwelling among mangroves. Some papers focused directly on pollination mechanisms among mangrove species while others examined insect pollinator diversity among mangroves. Information deemed relevant from these papers was used in this review.

4. Investigation Methods

4.1. GIS Mapping

Geographic Information System (GIS) mapping forms the spatial foundation of this study and is employed to characterize the distribution, structure, and extent of mangrove habitats at each study site prior to and throughout field investigations. GIS is usually used to generate high-resolution spatial datasets to guide sampling design, optimize site accessibility, and ensure that ecological surveys adequately capture habitat heterogeneity, with particular emphasis on the periphery of mangrove patches where edge effects and environmental gradients are expected to be most pronounced [3, 37].

High-resolution satellite imagery (e.g., Sentinel-2 MSI, Landsat 8/9 OLI, and where available, commercial platforms such as WorldView or PlanetScope) and orthorectified aerial photographs are acquired to delineate mangrove boundaries and assess canopy structure [106]. These datasets are processed and analyzed using GIS and remote sensing software such as ArcGIS Pro and QGIS, supplemented by ENVI or Google Earth Engine for image preprocessing and classification. Standard preprocessing steps will include atmospheric correction, radiometric normalization, geometric correction, and cloud masking. Vegetation indices (e.g., NDVI, EVI, and mangrove-specific indices) are calculated to enhance discrimination between mangrove stands, adjacent terrestrial vegetation, mudflats, and open water [106].

Supervised and object-based image classification techniques are applied to categorize land cover types, with particular focus on mangrove zonation and patch configuration. Training samples are developed from field-verified locations, and classification accuracy is evaluated using confusion matrices, overall accuracy, and the Kappa coefficient. Mangrove patch metrics, including area, perimeter, edge-to-core ratio, fragmentation indices, and proximity to adjacent habitats, are generated using spatial analysis tools and landscape ecology extensions (e.g., FRAGSTATS or ArcGIS Spatial Analyst) [106].

4.2. Field Validation and Ground-Truthing

Field validation is undertaken to verify the accuracy of remotely sensed mangrove classifications and to refine spatial outputs derived from satellite and UAV imagery. Ground-truthing surveys will involve systematic site visits across all mapped mangrove zones, during which vegetation boundaries, species composition, and structural attributes are recorded using a high-precision handheld Global Positioning System (GPS) receiver. Georeferenced observations are used to generate training and validation datasets for image classification and to assess mapping accuracy through confusion matrices and spatial error analysis [144].

In addition to ground surveys, unmanned aerial vehicles (UAVs) equipped with high-resolution RGB sensors, and where feasible multispectral payloads, are deployed to generate ultra-fine spatial data on canopy structure, flowering tree distribution, and habitat microheterogeneity. UAV-derived orthomosaics and digital surface models have been shown to significantly enhance mangrove mapping accuracy and species-level discrimination when integrated with satellite imagery [191, 192]. These high-resolution datasets will support precise delineation of mangrove edges, canopy gaps, and access routes, and are particularly valuable for identifying localized floral resource patches relevant to pollinator activity.

4.3. GIS-Guided Selection of Ecological Sampling Sites

Spatial analyses are used to stratify each mangrove system into ecologically meaningful units, including seaward fringe zones, interior forest stands, and landward margins. Landscape metrics such as patch area, perimeter-to-area ratios, edge density, and habitat connectivity are calculated within a GIS environment to characterize patch configuration and

fragmentation patterns. Such metrics are essential for understanding spatial controls on biodiversity distribution and for designing robust ecological sampling frameworks [53, 94].

Sampling locations are systematically allocated along mangrove peripheries and across interior gradients to capture transitions in salinity, inundation frequency, vegetation structure, and floral resource availability. Mangrove edges are widely recognized as ecotonal zones exhibiting elevated environmental variability and biological interactions, making them particularly important for studies of insect flower visitors and pollinator assemblages [21]. GIS-guided site selection will therefore ensure that field investigations are spatially representative, ecologically stratified, and explicitly linked to landscape structure.

5. Insect Data

5.1. Overview of Sampling Methods of Insects

Tables 4 and 5 summarize the principal active and passive sampling techniques commonly employed for collecting insects in mangrove ecosystems. Sampling insect communities in mangrove habitats requires a combination of approaches because these environments are structurally complex, tidally influenced, and support a wide range of insect taxa occupying different ecological niches. Active sampling methods involve direct human participation and allow researchers to selectively capture insects associated with mangrove vegetation, flowers, and canopy layers. Techniques such as sweep netting, aerial netting, beat sampling, hand collecting, vacuum sampling, bait stations, and fogging are particularly valuable for documenting floral visitors and pollinators because they enable real-time observation of insect behavior, including nectar feeding, pollen collection, and interspecific interactions. These approaches are especially useful for targeting insects associated with flowering mangrove species such as *Avicennia*, *Rhizophora*, *Sonneratia*, and *Bruguiera*, where pollinator activity often occurs during specific periods of the day.

Active methods (Table 4) are advantageous because they allow targeted sampling of specific insect groups and habitats within the mangrove ecosystem. For example, sweep netting and aerial netting are widely used to capture flying pollinators such as bees, butterflies, and hoverflies visiting mangrove flowers, while beat sampling and hand collection are effective for obtaining less conspicuous insects such as beetles, ants, and hemipterans hidden among foliage or floral structures. Similarly, vacuum sampling provides an efficient method for collecting small and delicate insects that may evade conventional nets, and bait stations help attract insects during periods when floral resources are limited. Although some techniques, such as canopy fogging, are more intensive and require careful ethical and environmental considerations, they can provide valuable insights into arboreal insect diversity and reveal species that are otherwise difficult to sample.

In contrast, passive sampling methods (Table 5) rely on insect movement and behavior rather than direct human capture. Devices such as Malaise traps, pan traps, light traps, pitfall traps, sticky traps, window traps, and emergence traps continuously collect insects over extended periods, providing a broader representation of insect diversity and temporal activity patterns. These traps are particularly useful for monitoring pollinator abundance, seasonal variation, and vertical stratification within mangrove forests. For example, Malaise traps efficiently capture flying Diptera and Hymenoptera, pan traps attract visually oriented pollinators such as bees and flies, and light traps sample nocturnal insects that may participate in twilight pollination. When used collectively, active and passive methods provide complementary datasets, allowing researchers to obtain a more comprehensive understanding of insect diversity, pollinator assemblages, and ecological interactions within mangrove ecosystems.

Table 4 Active Methods of Sampling for Insect Pollinators and Species Sampled in Mangrove Ecosystems

Methods	Description of Method	Keynote	Insect Orders Sampled	Insect Family Sampled	Species Collected	Common name(s)
Sweep netting	Sweep netting is one of the most commonly used active insect sampling techniques in mangrove ecosystems, particularly along forest edges and understory vegetation. It involves sweeping a mesh net through flowering branches and foliage to collect flying and resting insects, especially pollinators like bees (Apidae), wasps (Vespidae), and hoverflies (Syrphidae). This method is particularly effective during daylight hours when pollinators are actively foraging on floral resources. Sweep netting is highly efficient for capturing floral visitors associated with mangrove species such as <i>Avicennia marina</i> , <i>Rhizophora mucronata</i> , and	Common in mangrove wetlands; many adults rest on vegetation and are easily swept.	Diptera (Flies)	Ceratopogonidae	<i>Culicoides peregrinus</i> (Kieffer, 1913)	Haematophagous fly
				Tabanidae	<i>Tabanus striatus</i> (Fabricius, 1787)	Horsefly
				Chironomidae	<i>Chironomus circumdatus</i> (Kieffer, 1916)	Harlequin fly
		Sap-feeders commonly found on mangrove leaves and young shoots.	Hemiptera (True Bugs)	Pyrrhocoridae	<i>Dysdercus cingulatus</i> (Fabricius, 1775)	Red cotton bug
				Pentatomidae	<i>Nezara viridula</i> (Hokkanen, 1986)	Southern green stink bug / Southern green shield bug / Green vegetable bug
				Cicadellidae	<i>Amrasca biguttula</i> (Ishida, 1913)	Cotton Jassid / Two-Spot Cotton Leafhopper
		Herbivores and predators associated with mangrove foliage and detritus.	Coleoptera (Beetles)	Curculionidae	<i>Hypothenemus eruditus</i> (Westwood, 1836)	Dark Beetle
				Chrysomelidae	<i>Altica cyanea</i> (Weber 1801)	Flea Beetle
				Staphylinidae	<i>Paederus fuscipes</i> (Fabricius, 1775)	Rove Beetle
		Important pollinators and predators; frequently	Hymenoptera (Bees, Wasps, Ants)	Apidae	<i>Apis dorsata</i> (Fabricius, 1793)	Giant Honey Bee
				Formicidae	<i>Camponotus compressus</i> (Fabricius, 1787)	Common Black Ants

<i>Sonneratia apetala</i> [5, 7, 10, 148, 149, 150]. In their study of Indian mangrove pollination ecology, Aluri <i>et al.</i> (2012) [7, 10] reported that sweep netting helped reveal a diverse assemblage of bees and flies visiting the flowers of <i>Avicennia</i> species. Similarly, Raju & Ezradanam (2002) [151] used sweep netting in the Godavari mangroves to document insect-flower interactions in <i>Acanthus ilicifolius</i> and <i>Excoecaria agallocha</i>. Ward & Johnson (2005) [193] demonstrated that sweep netting was useful for quantifying visitation rates in fragmented populations of <i>Bruguiera gymnorhiza</i>. This method also complements observational techniques by providing physical specimens for further identification and pollen load analysis.	encountered on flowers and foliage.		Vespidae	<i>Polistes olivaceus</i> (De Geer, 1773)	Yellow oriental paper wasp / Macao paper wasp
	Adults are highly active in mangrove edges and flowering zones.	Lepidoptera (Butterflies & Moths)	Nymphalidae	<i>Danaus chrysippus</i> (Linnaeus, 1758)	Brush-footed butterfly / Plain tiger / African queen / African monarch
				<i>Junonia atlites</i> (Linnaeus, 1763)	Gray pansy / Grey pansy
			Noctuidae	<i>Spodoptera litura</i> (Fabricius, 1775)	Tobacco cutworm / Cotton leafworm
	Herbivorous taxa often abundant in understory vegetation.	Orthoptera (Grasshoppers & Crickets)	Acrididae	<i>Oxya hyla</i> (Serville, 1831)	Spine-kneed Grasshopper
			Pyrgomorphidae	<i>Atractomorpha crenulata</i> (Fabricius, 1793)	Tobacco Grasshopper
			Gryllidae	<i>Gryllus bimaculatus</i> (De Geer, 1773)	Two-spotted cricket / African field cricket / Mediterranean field cricket
	Adults perch on mangrove vegetation and are occasionally captured during sweeping.	Odonata (Dragonflies & Damselflies)	Libellulidae	<i>Orthetrum sabina</i> (Drury, 1773)	Variegated Green Skimmer / Slender skimmer / Green marsh hawk
				<i>Pantala flavescens</i> (Fabricius, 1798)	Globe skimmer / Globe wanderer / Wandering glider
			Coenagrionidae	<i>Ischnura senegalensis</i> (Rambur, 1842)	Common bluetail / Marsh bluetail / Ubiquitous bluetail / African bluetail / Senegal golden dartlet
	Predatory insects associated with	Neuroptera (Lacewings)	Chrysopidae	<i>Chrysoperla carnea</i> (Stephens, 1836)	Common green lacewing

		foliage where prey (aphids, small insects) occur.		Hemerobiidae	<i>Micromus timidus</i> (Hagen, 1853)	Brown lacewing
					<i>Hemerobius pacificus</i> (Banks, 1897)	Pacific brown lacewing
		Mostly Detritivores; occasionally swept from lower vegetation or tree trunks.	Blattodea (Cockroaches & Termites)	Blattidae	<i>Periplaneta americana</i> (Linnaeus, 1758)	American cockroach / Blattid cockroach
					<i>Blatta orientalis</i> (Linnaeus, 1758)	Oriental cockroach / Black beetle / Water bug
				Heterotermitidae	<i>Coptotermes gestroi</i> (Wasmann, 1896)	Asian subterranean termite
		Sit-and-wait predators inhabiting mangrove shrubs.	Mantodea (Mantids)	Mantidae	<i>Tenodera sinensis</i> (Saussure, 1871)	Chinese mantid / Chinese praying mantis
					<i>Hierodula patellifera</i> (Serville, 1838)	Giant Asian mantis / Asian mantis / Indochina mantis / Harabiro Mantis
				Hymenopodidae	<i>Creobroter gemmatus</i> (Stoll, 1813)	Jeweled flower mantis
		Very common on leaves and flowers; efficiently sampled via sweeping.	Thysanoptera (Thrips)	Thripidae	<i>Thrips palmi</i> (Karny, 1925)	Melon thrips
					<i>Frankliniella occidentalis</i> (Pergande, 1895)	Western flower thrip
					<i>Scirtothrips dorsalis</i> (Hood, 1919)	Chilli thrips / Yellow tea thrips
		Associated with bark, lichens, and leaf surfaces in humid mangrove habitats.	Psocodea (Booklice / Barklice)	Liposcelididae	<i>Liposcelis bostrychophila</i> (Badonnel, 1931)	Book lice
				Psocidae	<i>Psocus bipunctatus</i> (Linnaeus, 1761)	Bark lice

				Ectopsocidae	<i>Ectopsocus briggsi</i> (McLachlan, 1899)	Bark fly
Aerial netting	Aerial netting targets fast-moving, free-flying insects such as butterflies (Lepidoptera), bees (Hymenoptera), and dragonflies (Odonata) that forage in open air spaces or above flowering canopies. It is particularly useful in mangrove ecosystems during early morning and late afternoon hours when pollinator activity peaks. This method allows for the selective capture of visible, mobile pollinators that are often missed by passive traps. For example, Upadhyay & Mishra (2010) [183, 184, 185] used aerial netting in the Bhitarkanika Wildlife Sanctuary to sample butterfly species associated with mangrove vegetation, finding that butterflies such as <i>Danaus chrysippus</i> and <i>Catopsilia pyranthe</i> were common visitors to <i>Sonneratia</i> and	Strong diurnal fliers; frequently captured during flower visitation in mangroves.	Lepidoptera (Butterflies & Moths)	Nymphalidae	<i>Hypolimnas bolina</i> (Linnaeus, 1758)	Common Eggfly / Great Eggfly
				Pieridae	<i>Eurema hecabe</i> (Linnaeus, 1758)	Common Grass Yellow
				Erebidae	<i>Utetheisa pulchella</i> (Linnaeus, 1758)	Crimson-speckled flunkey / Crimson-speckled footman / Crimson-speckled moth
		Highly active aerial foragers; key mangrove pollinators and predators.	Hymenoptera (Bees, Wasps, Flying Ants)	Apidae	<i>Trigona iridipennis</i> (Smith, 1854)	Stingless bee
					<i>Xylocopa latipes</i> (Drury, 1773)	Carpenter bee
				Vespidae	<i>Vespa affinis</i> (Linnaeus, 1764)	Lesser banded hornet
		Includes hoverflies and other flower visitors, often netted mid-flight.	Diptera (Flies)	Syrphidae	<i>Eristalinus arvorum</i> (Fabricius, 1787)	Hoverfly / Lagoon fly
				Muscidae	<i>Musca sorbens</i> (Yu, 1971)	Facefly / Dog dong fly / Bazaar fly / Eye-seeking fly
					<i>Stomoxys calcitrans</i> (Linnaeus, 1758)	Stable fly / Barn fly / Biting house fly / Dog fly / Power mower fly
		Strong aerial predators; commonly netted along mangrove creeks and edges.	Odonata (Dragonflies & Damselflies)	Libellulidae	<i>Brachythemis contaminata</i> (Fabricius, 1793)	Ditch jewel / Common amberwing
					<i>Crocothemis servilia</i> (Drury, 1773)	Scarlet skimmer / Ruddy marsh skimmer
				Coenagrionidae	<i>Agriocnemis pygmaea</i> (Rambur, 1842)	Pygmy wisp / Wandering midget / Pygmy dartlet / Wandering wisp

<i>Avicennia</i> lowers. Similarly, Rajesh <i>et al.</i> (2017) [147] reported the utility of aerial netting in capturing butterfly pollinators in the Pichavaram mangroves, where lepidopteran diversity was closely tied to seasonal flowering patterns. Aerial netting is particularly effective in open-canopy species like <i>Sonneratia caseolaris</i> , where larger pollinators such as hawkmoths and butterflies are common [148, 149, 150]. The method enables direct observation of foraging behavior and is often used in combination with sweep netting to capture a broader range of pollinators.	Many species are strong fliers, especially during dusk or dispersal.	Coleoptera (Beetles)	Scarabaeidae	<i>Oryctes rhinoceros</i> (Linnaeus, 1758)	Coconut rhinoceros beetle / Scarabs
				<i>Anomala cupripes</i> (Hope, 1839)	Large green chafer beetle
			Lampyridae	<i>Photinus pyralis</i> (Linnaeus, 1767)	Firefly / Big Dipper Firefly
	Winged morphs are commonly intercepted during flight or dispersal events.	Hemiptera (True Bugs - Winged Formed)	Alydidae	<i>Leptocorisa acuta</i> (Thunberg, 1783)	Paddy bug
				<i>Aphis gossypii</i> (Glover, 1877)	Cotton aphid / Melon aphid / Melon and cotton aphid
			Delphacidae	<i>Nilaparvata lugens</i> (Stål, 1854)	Brown planthopper
	Captured during short-distance flights or disturbance-induced movement.	Orthoptera (Grasshoppers & Crickets)	Acrididae	<i>Locusta migratoria</i> (Linnaeus, 1758)	Migratory locust
				<i>Schistocerca gregaria</i> (Forskål, 1775),	Desert locust
			Gryllidae	<i>Teleogryllus occipitalis</i> (Serville, 1838)	Black field cricket
	Nocturnal or crepuscular fliers; occasionally netted in aerial surveys.	Neuroptera (Lacewings)	Chrysopidae	<i>Chrysopa pallens</i> (Rambur, 1838)	Green lacewing
			Mantispidae	<i>Mantispa japonica</i> (McLachlan, 1875)	Oriental Mantispid / Mantis-fly
			Myrmeleontidae	<i>Distoleon tetragrammicus</i> . (Fabricius, 1798)	Four-spotted antlion
	Captured during nuptial (swarming) flights, especially in humid mangrove climates.	Isoptera (Termites - Alates)	Termitidae	<i>Macrotermes bellicosus</i> (Smeathman, 1781)	War-like termite
				<i>Odontotermes obesus</i> (Rambur, 1842)	Subterranean wood-eating termite

					<i>Nasutitermes corniger</i> (Motschulsky, 1855)	Conehead termite
		Weak but frequent fliers; often collected in aerial sweeps around flowers.	Thysanoptera (Thrips)	Thripidae	<i>Thrips tabaci</i> (Lindeman, 1889)	Onion thrip / Potato thrip / Tobacco thrip / Cotton seedling thrip
					<i>Frankliniella schultzei</i> (Trybom, 1910)	Common blossom thrip / Cotton thrip
				Phlaeothripidae	<i>Haplothrips ganglbaueri</i> (Schmutz, 1913)	Halothrip / Thrip
Beat sampling	Beat sampling is used to dislodge insects from foliage and branches by striking the vegetation with a stick or pole while placing a white cloth or tray underneath to catch the falling specimens. In mangroves, this method is effective for collecting flower-dwelling beetles (e.g., Nitidulidae, Scarabaeidae), ants (Formicidae), and true bugs (Hemiptera), which are often hidden among floral bracts or leaf axils. Although not typically used as a primary method for mobile pollinators,	<i>Eristena mangalis</i> is specifically reported as dominant in mangrove canopy studies	Lepidoptera (Caterpillars & foliage moths)	Crambidae	<i>Eristena mangalis</i> (Murphy, 1989)	Common aquatic moth
				Hyblaeidae	<i>Hyblaea puera</i> (Cramer, 1777)	Teak defoliator / Teak defoliator moth
				Lycaenidae	<i>Arhopala pseudocentaurus</i> (Doubleday, 1847)	Centaur oakblue / Western centaur oakblue
		Common phytophagous insects attached to leaves, easily dislodged by beating.	Hemiptera (Sap-feeders on leaves / stems)	Pseudococcidae	<i>Ferrisia virgata</i> (Cockerell, 1893)	Striped mealybug
				Monophlebidae	<i>Icerya aegyptiaca</i> (Douglas, 1890)	Egyptian fluted scale / Breadfruit mealybug / Egyptian mealybug / Egyptian cottony cushion scale / Egyptian Icerya
				Aleyrodidae	<i>Aleurodicus disperses</i> (Russell, 1965)	Spiralling whitefly
		Monolepta and Ryparida are reported as	Coleoptera (Leaf beetles & canopy dwellers)	Chrysomelidae	<i>Monolepta</i> sp.	Leaf beetle
					<i>Ryparida wallacei</i> (Wallace, 1854)	Wallace's leaf beetle

beat sampling reveals the presence of cryptic or less active flower visitors that contribute to pollination, especially in dense or compact-flowered mangrove species like <i>Bruguiera cylindrica</i> and <i>Ceriops tagal</i> [152, 153]. Adeduntan & Olusola (2015) [1] used beat sampling in Nigerian mangrove forests and found it particularly effective for capturing beetles and spiders associated with flowering branches. Beat sampling also helps capture pollinators resting during non-foraging periods or sheltering from heat and humidity. It is especially valuable in mangrove trees with interlocking canopies that limit visual access.	dominant mangrove herbivores		Scarabaeidae	<i>Adoretus compressus</i> (Weber, 1801)	Rose beetle / Shining leaf chafer / Scarab beetle
	Ants dominate tree canopies in mangroves and are readily dislodged.	Hymenoptera (Arboreal ants & parasitoids)	Formicidae	<i>Oecophylla smaragdina</i> (Fabricius, 1775)	Asian weaver ants / Green ants / Orange gasters / Weaver ant / Green tree ant
				<i>Crematogaster rogenhoferi</i> (Mayr, 1879)	Cocktail ant / Acrobat ant
			Platygastridae	<i>Telenomus podisi</i> (Ashmead, 1893)	Stink bug egg parasitoid / Telenomus wasp / Podisibug
	Often rest on leaves and stems; easily sampled via beating.	Orthoptera (Vegetation-dwelling herbivores)	Acrididae	<i>Valanga nigricornis</i> (Burmeister, 1838)	Javanese grasshopper / Javanese bird grasshopper
				<i>Eyprepocnemis alacris</i> (Serville, 1838)	Short-horned grasshopper
			Tettigoniidae	<i>Conocephalus maculatus</i> (Le Guillou, 1841)	Spotted meadow katydid / Katydid / Bush-cricket
	Classic beat sampling taxa due to camouflage and low mobility.	Phasmatodea (Stick insects - cryptic canopy fauna)	Diapheromeridae	<i>Carausius morosus</i> (Sinéty, 1901)	Indian stick insect / Laboratory stick insect
			Lonchodidae	<i>Necroscia annulipes</i> (Gray, 1835)	Malaysian Green Jewel Stick Insect / Yellow Flying Stick
			Phasmatidae	<i>Phobaeticus serratipes</i> (Gray, 1835)	Giant Malayan Stick-insect / Giant Stick Insect
	Found under bark or foliage, dislodged	Blattodea (Arboreal cockroaches & termites)	Blaberidae	<i>Panchlora nivea</i> (Linnaeus, 1758)	Cuban cockroach / Green banana cockroach / Giant cockroach

		during branch beating.		Kalotermitidae	<i>Neotermes bosei</i> (Snyder, 1933)	Damp wood termite
				Cryptocercidae	<i>Cryptocercus punctulatus</i> (Scudder, 1862)	Brown-hooded cockroach / woodroach
		Sit-and-wait predators resting on branches.	Mantodea (Foliage predators)	Mantidae	<i>Statilia maculata</i> (Thunberg, 1784)	Asian jumping mantis
					<i>Tenodera aridifolia</i> (Stoll, 1813)	Japanese giant mantis / Chinese mantid / Chinese mantis
					<i>Hierodula membranacea</i> (Burmeister, 1838)	Giant Asian Mantis
		Adults and larvae occur on vegetation feeding on soft-bodied insects.	Neuroptera (Foliage predators)	Chrysopidae	<i>Chrysopa basalis</i> (Walker, 1853)	Green lacewing
				Hemerobiidae	<i>Hemerobius stigma</i> (Stephens, 1836)	Marked Brown Lacewing / Brown pine lacewing
				Myrmeleontidae	<i>Myrmeleon formicarius</i> (Linnaeus, 1767)	Antlion / Blackhead antlion / Doodlebug
		Extremely common on mangrove leaves and flowers; dislodged in large numbers.	Thysanoptera (Leaf & flower microfauna)	Phlaeothripidae	<i>Gynaikothrips uzeli</i> (Zimmermann, 1900)	Weeping fig thrip / Cuban laurel thrip
					<i>Haplothrips gowdeyi</i> (Franklin, 1908)	Gold-tipped tubular thrip
				Thripidae	<i>Megalurothrips sjostedti</i> (Trybom, 1908)	African bean thrip / Bean flower thrip
Hand Collecting	Hand collecting is a direct, selective method where	Arboreal ants and nesting bees are easily hand-picked	Hymenoptera (Ants, Bees, Wasps)	Formicidae	<i>Dolichoderus thoracicus</i> (Smith, 1860)	Cocoa black ant / Black cocoa ant

researchers use forceps, aspirators, or containers to pick insects from floral surfaces, trunks, aerial roots, or mudflats. This method is particularly well-suited for collecting large, visible insects such as ants, beetles, and moths that may not respond to baits or nets. In mangrove ecosystems, hand collection is often used in conjunction with visual surveys during specific floral phenophases. Aluri (1990) [4, 8] and Raju <i>et al.</i> (2011) [152, 153] used hand collecting extensively in their studies of <i>Sonneratia</i> and <i>Bruguiera</i> species, observing beetles (e.g., <i>Meligethes spp.</i>) and ants as regular floral visitors. The method enables researchers to collect pollinators while observing behaviors such as nectar feeding, pollen harvesting, or territoriality. Raju (2019) [148, 149, 150] emphasized the importance of hand collection in	from bark, leaves, or nests.				<i>Tetraponera rufonigra</i> (Jerdon, 1851)	Bi-coloured arboreal ant / Bicolored slender ant
			Megachilidae		<i>Megachile disjuncta</i> (Fabricius, 1781)	Disjunct Resin Bee
	Typical cluster-forming, immobile insects on leaves and stems, ideal for hand collection.	Hemiptera (Sap-sucking insects)	Diaspididae		<i>Aonidiella aurantii</i> (Maskell, 1879)	California red scale
			Coccidae		<i>Pulvinaria psidii</i> (Maskell, 1893)	Green shield scale
			Pseudococcidae		<i>Planococcus citri</i> (Risso, 1813)	Citrus mealybug
	Caterpillars are large, visible herbivores commonly picked directly from mangrove leaves.	Lepidoptera (Larvae / Caterpillars)	Erebidae		<i>Anomis flava</i> (Fabricius, 1775)	Cotton semi-looper / Cotton looper
					<i>Bombyx nuda</i> (Fabricius, 1787)	Clearwing tussock moth / Banyan tussock moth
			Notodontidae		<i>Dudusa nobilis</i> (Walker, 1865)	Prominent moth / Puss moth
	Slow-moving beetles on foliage or stems are easily collected manually.	Coleoptera (Beetles)	Chrysomelidae		<i>Aspidimorpha miliaris</i> (Fabricius, 1775)	Asian spotted tortoise beetle / Leaf beetle
					<i>Brontispa longissima</i> (Gestro, 1885)	Coconut hispine beetle / Coconut leaf beetle
			Curculionidae		<i>Sitophilus oryzae</i> (Linnaeus, 1763)	Rice weevil / Lesser grain weevil / Small snout weevil
	Larger individuals often remain stationary, easy to capture by hand.	Orthoptera (Grasshoppers & Crickets)	Pyrgomorphidae		<i>Aularches miliaris</i> (Linnaeus, 1758)	Northern spotted grasshopper / Coffee locust / Ghost grasshopper / Foam grasshopper / Painted grasshopper
			Acrididae		<i>Hieroglyphus banian</i>	Rice grasshopper / Paddy grasshopper

identifying role-specific pollinators, especially in cases where floral morphology excludes many generalist visitors.				(Fabricius, 1798)	
			Gryllidae	<i>Acheta domesticus</i> (Linnaeus, 1758)	House cricket / Common house cricket / True cricket
	Found under bark, wood, or debris, commonly collected manually.	Blattodea (Cockroaches & Termites)	Ectobiidae	<i>Supella longipalpa</i> (Fabricius, 1798)	Brown-banded cockroach / Furniture roach
			Rhinotermitidae	<i>Reticulitermes flavipes</i> (Kollar, 1837)	Eastern subterranean termite
			Kalotermitidae	<i>Kalotermes flavicollis</i> (Fabricius, 1793)	Yellow-necked dry-wood termite
	Slow-moving ambush predators, easy to spot and pick.	Mantodea (Mantids)	Mantidae	<i>Mantis religiosa</i> (Linnaeus, 1758)	European mantis / European praying mantid
			Hymenopodidae	<i>Creobroter pictipennis</i> (Westwood, 1889)	Indian Flower Mantis
			Amelidae	<i>Ameles spallanzania</i> (Rossi, 1792)	European dwarf mantis
	Collected when resting on vegetation or substrates.	Diptera (Flies - resting stages)	Calliphoridae	<i>Lucilia sericata</i> (Meigen, 1826)	Blow fly / Common green bottle fly
			Sarcophagidae	<i>Musca carnaria</i> (Linnaeus, 1758)	Flesh fly / Common Flesh fly
			Culicidae	<i>Culex quinquefasciatus</i> (Say, 1823)	Southern house mosquito
	Occasionally captured when stationary on mangrove vegetation.	Odonata (Perching dragonflies/damselflies)	Libellulidae	<i>Libellula depressa</i> (Linnaeus, 1758)	Broad-bodied Chaser
				<i>Sympetrum sanguineum</i> (Müller, 1764)	Ruddy Darter

		Typically collected using fine tools or aspirators during hand sampling.	Thysanoptera (Thrips)	Calopterygidae	<i>Calopteryx splendens</i> (Harris, 1780)	Banded Demoiselle / Broad-winged damselfly
				Thripidae	<i>Frankliniella fusca</i> (Hinds, 1902)	Tobacco thrip
					<i>Thrips hawaiiensis</i> (Morgan, 1913)	Hawaiian flower thrip
					<i>Scirtothrips citri</i> (Moulton, 1909)	California citrus thrip
Vacuum Sampling	Vacuum sampling involves using battery-powered aspirators or portable insect vacuums to collect small, delicate insects from mangrove flowers or leaves. This method minimizes disturbance to the plants and allows efficient collection of small bees (e.g., Halictidae), flies (e.g., Ceratopogonidae, Dolichopodidae), and thrips (Thysanoptera), which may evade traditional nets. While less commonly reported in mangrove-specific studies, vacuum sampling has been employed in tropical pollination research and is especially useful in habitats where foliage is dense or canopy	Dominant in suction samples due to small size and loose attachment to leaves.	Hemiptera (sap-sucking insects)	Aleyrodidae	<i>Bemisia tabaci</i> (Gennadius, 1889)	Tobacco whitefly / Silverleaf whitefly / Whitefly / Sweet potato whitefly
				Aphididae	<i>Myzus persicae</i> (Sulzer, 1776)	Green peach aphid / Peach-potato aphid
				Cicadellidae	<i>Empoasca fabae</i> (Harris, 1841)	Potato leafhopper
		Easily collected due to weak flight and presence on vegetation surfaces.	Diptera (small flies)	Drosophilidae	<i>Drosophila melanogaster</i> (Meigen, 1830)	Common fruit fly / Vinegar fly / Pomace fly / Banana fly / Fruit fly
				Agromyzidae	<i>Liriomyza sativae</i> (Blanchard, 1938)	Vegetable leaf miner / Serpentine vegetable leaf miner / Tomato leaf miner
				Sciaridae	<i>Bradysia impatiens</i> (Johannsen, 1912)	Black fungus gnat / Dark-winged fungus gnat / Mushroom fly / Mushroom sciarid / Indoor soil gnat
		Larvae are frequently suctioned from leaf surfaces and folds.	Lepidoptera (larval stages)	Plutellidae	<i>Plutella xylostella</i> (Linnaeus, 1758)	Diamondback moth / Cabbage moth
				Noctuidae	<i>Helicoverpa armigera</i> (Hübner, 1808)	Cotton bollworm / Old World bollworm / Tomato fruit borer /

access is limited [99]. In mangroves, vacuum devices are advantageous in low-lying vegetation or when sampling from boats or elevated platforms. They can also be used to capture insects engaged in pollination but not easily observed due to their size or speed. For example, researchers investigating <i>Avicennia officinalis</i> and <i>Aegiceras corniculatum</i> have reported small flies and bees as effective pollinators, which could be more reliably sampled using vacuums [148, 149, 150, 156].						African bollworm / Tobacco budworm
				Crambidae	<i>Cnaphalocrocis medinalis</i> (Guenée, 1854)	Rice leaffolder / Rice leafroller
	Among the most abundant taxa in vacuum sampling datasets.	Thysanoptera (thrips)	Thripidae		<i>Frankliniella tritici</i> (Fitch, 1855)	Eastern flower thrip / Flower thrip
					<i>Thrips imaginis</i> (Bagnall, 1926)	Plague thrip / Australian thrip / Apple blossom thrip
					<i>Caliothrips phaseoli</i> (Hood, 1912)	Bean thrips / South American bean thrip
	Small beetles are easily dislodged and suctioned from foliage.	Coleoptera (small beetles)	Chrysomelidae		<i>Chaetocnema pulicaria</i> (Melsheimer, 1847)	Corn flea beetle / Clover flea beetle
					<i>Phyllotreta cruciferae</i> (Goeze, 1777)	Crucifer flea / Canola flea beetle / Cabbage flea beetle / Rape flea beetle
			Coccinellidae		<i>Hippodamia convergens</i> (Guérin-Méneville, 1842)	Convergent ladybug / Ladybug / Lady beetle
	Includes tiny parasitoids and small arboreal ants commonly captured by suction.	Hymenoptera (parasitoids & small ants)	Trichogrammatidae		<i>Trichogramma chilonis</i> (Ishii, 1941)	Tiny parasitic wasp / Egg parasitoid
			Aphelinidae		<i>Encarsia Formosa</i> (Gahan, 1924)	Encarsia wasp / Greenhouse whitefly parasite / Greenhouse whitefly parasitoid
			Formicidae		<i>Solenopsis geminate</i> (Fabricius, 1804)	Tropical fire ant
	Often collected as larvae and small	Neuroptera (lacewings)	Chrysopidae		<i>Chrysopa rufilabris</i> (Burmeister, 1839)	Red-lipped green lacewing

		adults in canopy vegetation.		Hemerobiidae	<i>Micromus variegatus</i> (Fabricius, 1793)	Brown lacewing / Variegated brown lacewing
					<i>Symphorobius barberi</i> (Banks, 1903)	Barber's brown lacewing
		Mostly juveniles or small-bodied species captured during suction.	Orthoptera (nymphs / small individuals)	Acrididae	<i>Melanoplus differentialis</i> (Thomas, 1865)	Differential grasshopper / Short-horned grasshopper
					<i>Chorthippus brunneus</i> (Thunberg, 1815)	Common field grasshopper
				Tetrigidae	<i>Tetrix subulata</i> (Linnaeus, 1758)	Pygmy grasshoppers / Ground-hopper / Slender ground-hopper
		Common in humid mangrove bark and leaf microhabitats.	Psocodea (barklice/booklice)	Trogiidae	<i>Lepinotus reticulatus</i> (Enderlein, 1904)	Reticulate-winged trogiid / Reticulate-winged booklouse
				Peripsocidae	<i>Peripsocus phaeopterus</i> (Stephens, 1836)	Stout barklice / Stout bark fly
				Ectopsocidae	<i>Ectopsocus meridionalis</i> (Ribaga, 1904)	Outer barklice / Outer bark fly
		Occasionally collected when small individuals occur on vegetation or bark.	Blattodea (small arboreal forms)	Ectobiidae	<i>Blattella germanica</i> (Linnaeus, 1767)	German roach
					<i>Parcoblatta pennsylvanica</i> (De Geer, 1773)	Pennsylvania wood cockroach
				Archotermopsidae	<i>Zootermopsis angusticollis</i> (Hagen, 1858)	Pacific dampwood termite / Pacific coast dampwood termite

Bait Station	Bait stations use olfactory lures such as fermented fruit (e.g., bananas) or protein-based substances (e.g., fish paste, sugar solutions) to attract specific insect groups, including pollinators. In mangroves, fruit baits are highly effective in attracting butterflies (e.g., Nymphalidae), fruit flies (Tephritidae), and beetles, while protein baits can lure ants and wasps. Actively monitoring bait stations allows researchers to capture visitors on arrival, observe behavior, and avoid predation or specimen loss. Rajesh <i>et al.</i> (2017) [147] used banana bait traps in Pichavaram mangroves and identified several butterfly species with potential pollinator roles. Similarly, Adeduntan & Olusola (2015) [1] recorded beetle diversity using fruit baits in the Niger Delta mangroves. Baiting is particularly	Highly attracted to sugar and protein baits; dominant in mangrove bait studies.	Hymenoptera (Ants)	Formicidae	<i>Anoplolepis gracilipes</i> (Smith, 1857)	Yellow crazy ant / Long-legged ant / Red crazy ant
		Commonly collected using fermenting fruit or protein-based baits.	Diptera (Flies)	Tephritidae	<i>Pheidole megacephala</i> (Fabricius, 1793)	Big-headed ant / African big-headed ant
					<i>Paratrechina longicornis</i> (Latreille, 1802)	Longhorn crazy ant / Black crazy an
				Calliphoridae	<i>Bactrocera dorsalis</i> (Hendel, 1912)	Oriental fruit fly / Fruit fly / Fruit-infesting fly
	Strongly associated with decaying organic matter and carrion baits.	Coleoptera (Beetles)	Nitidulidae	Cleridae	<i>Anastrepha ludens</i> (Loew, 1873)	Mexican fruit fly / Mexfly
					<i>Chrysomya megacephala</i> (Fabricius, 1794)	Oriental latrine fly / Oriental blue fly / Blow fly
				Dermestidae	<i>Carpophilus dimidiatus</i> (Fabricius, 1792).	Cornsap beetle / Corn sap beetle
	Occasionally attracted to plant-based or sugary baits.	Hemiptera (Opportunistic feeders)	Coreidae	Pyrrhocoridae	<i>Necrobia rufipes</i> (De Geer, 1775)	Red-legged ham beetle / Ham beetle / Paper worm (rarely called) / Checkered beetle
					<i>Dermestes maculatus</i> (De Geer, 1774)	Hide beetle / Leather beetle / Skin beetle
				Alydidae	<i>Leptoglossus phyllopus</i> (Linnaeus, 1767)	Leaffooted bug / Eastern leaffooted bug
					<i>Dysdercus koenigii</i> (Fabricius, 1775)	Red cotton bug / Cotton stainer / Red cotton stainer
					<i>Riptortus pedestris</i> (Fabricius, 1775)	Bean bug / Broad headed bug

	effective during times of low floral abundance, when insects seek alternative resources. This method supplements floral visitation data by revealing dietary flexibility and preferences of pollinators in mangrove systems.	Adults often visit fermenting fruit bait in mangrove edges.	Lepidoptera (Adults attracted to fermenting bait)	Nymphalidae	<i>Melanitis leda</i> (Linnaeus, 1758)	Common Evening Brown
		Opportunistic feeders attracted to organic or plant-based bait.	Orthoptera (Occasional scavengers)	Gryllotalpidae	<i>Mycalesis perseus</i> (Fabricius, 1775)	Dingy Bushbrown / Common Bushbrown
					<i>Ariadne merione</i> (Cramer, 1777)	Common Castor
					<i>Gryllotalpa africana</i> (Palisot de Beauvois, 1805)	Mole cricket / African mole cricket
		Typical scavengers and nocturnal bait visitors, especially in coastal habitats.	Dermaptera (Earwigs)	Gryllidae	<i>Brachytrupes membranaceus</i> (Drury, 1773)	African giant cricket / Tobacco cricket
				Tettigoniidae	<i>Ruspolia differens</i> (Serville, 1838)	Katydids / Long-horned grasshoppers / Nsenene (in Uganda) / Senene (in Tanzania)
				Forficulidae	<i>Forficula auricularia</i> (Linnaeus, 1758)	European earwig / Common earwig
		Attracted to cellulose-based bait or decaying wood material.	Isoptera (Termites - wood / bait feeders)	Anisolabididae	<i>Euborellia annulipes</i> (Lucas, 1847)	Ring-legged earwig / Ringlegged earwig / Red-legged earwig
				Labiduridae	<i>Labidura riparia</i> (Pallas, 1773)	Striped earwig / Shore earwig / Tawny earwig / Riparian earwig / Giant earwig
				Rhinotermitidae	<i>Coptotermes formosanus</i> (Shiraki, 1909)	Formosan subterranean termite
				Termitidae	<i>Macrotermes gilvus</i> (Hagen, 1858)	Mound-building termite / Fungus-growing termite
					<i>Nasutitermes ephratae</i> (Holmgren, 1910)	Conehead termite / Nasute termite

		Attracted to organic debris and decaying bait materials.	Blattodea (Cockroaches & Termites)	Blattidae	<i>Periplaneta australasiae</i> (Fabricius, 1775)	Australian cockroach
				Blaberidae	<i>Pycnoscelus surinamensis</i> (Linnaeus, 1758)	Surinam cockroach / Surinam roach / Greenhouse cockroach / Greenhouse roach
				Rhinotermitidae	<i>Heterotermes tenuis</i> (Hagen, 1858)	Subterranean termite / Comején blanco / White ant / White termite
Fogging	Fogging involves the controlled release of a fine insecticide mist into mangrove tree canopies, resulting in the knockdown of insects, which are then collected from sheets placed below. This method provides access to arboreal insect fauna that are otherwise inaccessible, including canopy-dwelling beetles (Scarabaeidae, Cerambycidae), parasitic wasps (Ichneumonidae), and occasional pollinators. Though labor-intensive and subject to ethical and environmental considerations, fogging is one of the few methods capable of providing a	Ants dominate fogging samples due to high canopy abundance.	Hymenoptera (Ants, parasitoids)	Formicidae	<i>Azteca chartifex</i> (Forel, 1896)	Formiga caçarema / Caçarema (Portuguese)
					<i>Cephalotes atratus</i> (Linnaeus, 1758)	Turtle ant / Common giant turtle ant / Gliding ant
					<i>Dolichoderus bispinosus</i> (Olivier, 1792)	Fourmi biépineuse (French)
	Extremely diverse in canopy ecosystems; many are herbivores and predators.	Coleoptera (Beetles)		Chrysomelidae	<i>Cryptocephalus marginatus</i> (Fabricius, 1781)	Cylindrical leaf beetle / Cagoule à bandes (French)
				Buprestidae	<i>Agrilus planipennis</i> (Fairmaire, 1888)	Metallic wood-boring beetles / Jewel beetle / Emerald ash borer
				Coccinellidae	<i>Coccinella septempunctata</i> (Linnaeus, 1758)	Seven-spotted ladybug / Ladybird / Lady beetle / Seven-spotted ladybird
	Abundant on leaf surfaces and stems, easily knocked down by fogging.	Hemiptera (Sap-feeders)		Coccidae	<i>Saissetia coffeae</i> (Walker, 1852)	Soft scaled insect / Hemispherical scale / Coffee brown scale / Helmet scale
				Aleyrodidae	<i>Trialeurodes vaporariorum</i> (Westwood, 1856)	Greenhouse whitefly / Glasshouse whitefly

complete inventory of canopy insect communities. In mangrove settings, portable fogging units have been used to investigate vertical stratification of insect diversity [18, 19, 20]. While fogging is not commonly employed for pollinator research alone, it has the potential to reveal overlooked or nocturnal pollinators in mangrove canopies. Proper permitting, safety precautions, and careful species identification are essential when using this method.			Pseudococcidae	<i>Pseudococcus longispinus</i> (Tozzetti, 1867)	Mealybug / Long-tailed mealybug
	Includes small canopy-associated and resting flies.	Diptera (Canopy flies)	Sciaridae	<i>Sciarahemerobioides</i> (Scopoli, 1763)	Dark-winged fungus gnats / Sciarid fly
			Tephritidae	<i>Ceratitiscapitate</i> (Wiedemann, 1824)	Mediterranean fruit fly / Medfly
			Psychodidae	<i>Phlebotomuspapatasi</i> (Scopoli, 1786)	Sandfly / Moth fly / Sand fly
	Very abundant in fogging samples due to leaf-surface habitat.	Thysanoptera (Thrips)	Thripidae	<i>Hercinothrips femoralis</i> (Reuter, 1891)	Banded greenhouse thrip / Sugar beet thrip
				<i>Selenothrips rubrocinctus</i> (Giard, 1901)	Red-banded thrip / Cacao thrip
				<i>Chaetanaphothrips orchidii</i> (Moulton, 1907)	Orchid thrip / Anthurium thrip
	Larvae and resting adults are commonly dislodged from canopy foliage.	Lepidoptera (Larvae & resting adults)	Erebidae	<i>Euproctis fraterna</i> (Moore, 1883)	Coffee hairy caterpillar / Tussock moth / Hairy caterpillar / Castor hairy caterpillar
				<i>Amatapassalis</i> (Fabricius, 1781)	Sandalwood defoliator / Sandalwood Defoliator Moth / Wasp Moth / Tiger Moth
			Lasiocampidae	<i>Trabalavishnou</i> (Lefèbvre, 1827)	Rose-myrtle lappet moth
Arboreal grasshoppers and katydids are frequent canopy inhabitants.	Orthoptera (Arboreal forms)	Tettigoniidae		<i>Phyllophora speciose</i> (Thunberg, 1815)	Bush cricket / Katydid
				<i>Tettigonia viridissima</i> (Linnaeus, 1758)	Great green bush-cricket

					<i>Acanthopius discoidalis</i> (Walker, 1869)	Armoured bush cricket / Corn cricket / Armoured ground cricket / Armoured katydid
	Extremely abundant in humid mangrove canopies.	Psocodea (Barklice)	Psocidae		<i>Psococerastis gibbosa</i> (Sulzer, 1776)	Large barklouse / Barkfly / Large barkfly
			Lachesillidae		<i>Lachesilla pedicularia</i> (Linnaeus, 1758)	Cosmopolitan grain barklouse / Cosmopolitan grain psocid
			Stenopsocidae		<i>Graphopsocus cruciatus</i> (Linnaeus, 1768)	Narrow barklice / narrow barkfly / F-winged Barklouse / Lizard Bark Louse / Picture-winged Barklouse
	Found in tree cavities, bark, and canopy debris.	Blattodea (Arboreal cockroaches / termites)	Blaberidae		<i>Blaberus discoidalis</i> (Audinet-Serville, 1839)	Discoid cockroach / Discoid roach / West Indian leaf cockroach / False death's head cockroach / Drummer / Haitian cockroach
			Kalotermitidae		<i>Neotermes jouteli</i> (Banks, 1920)	Coastal Florida Dampwood Termite
					<i>Incisitermes minor</i> (Hagen, 1858)	Western drywood termite / Drywood termite
	Predators present in canopy feeding on soft-bodied insects.	Neuroptera (Lacewings)	Chrysopidae		<i>Chrysopa oculata</i> (Say, 1839)	Golden-eyed lacewing
			Hemerobiidae		<i>Hemerobius humulinus</i> (Linnaeus, 1758)	Brown lacewing / Shouldered Brown Lacewing

				Myrmeleontidae	<i>Myrmeleon immaculatus</i> (De Geer, 1773)	Spotless antlion / Pit-trapping antlion / Immaculate antlion
		Cryptic canopy predators occasionally recovered in fogging.	Mantodea (Mantids)	Mantidae	<i>Tenodera angustipennis</i> (Saussure, 1869)	Narrow-winged mantis / Japanese mantis / Narrow-winged mantid / Asian matis
					<i>Hierodula tenuidentata</i> (Saussure, 1869)	Giant Asian Mantis
					<i>Sphodromantis viridis</i> (Forskål, 1775)	Giant African mantis / Bush mantis / African mantis
		Classic cryptic canopy taxa, effectively sampled via fogging.	Phasmatodea (Stick insects)	Phasmatidae	<i>Ramulus artemis</i> (Westwood, 1859)	Vietnamese stick insect / Artemis stick-insect
					<i>Extatosoma tiaratum</i> (Macleay, 1826)	Spiny leaf insect / Giant prickly stick insect / Macleay's spectre/ Australian walking stick
					<i>Sphodromantis viridis</i> (Forskål, 1775)	Giant African mantis / African mantis / Bush mantis / African giant praying mantis

The comparative analysis of active insect sampling methods in mangrove ecosystems reveals that each technique captures distinct components of the insect community, thereby emphasizing the necessity of a multi-method approach to adequately characterize pollinator diversity and associated taxa. Sweep netting and aerial netting are particularly effective for sampling diurnally active and visually conspicuous pollinators, especially within the orders Hymenoptera, Diptera, and Lepidoptera. Sweep netting, conducted along mangrove edges and understory vegetation, consistently captures floral visitors such as bees, wasps, and flies associated with flowering species like *Avicennia marina*, *Rhizophora mucronata*, and *Sonneratia apetala*. Studies have demonstrated that this method is highly efficient for documenting insect-flower interactions and quantifying visitation rates [5, 7, 10, 148, 149, 150, 193]. Similarly, aerial netting complements sweep netting by targeting strong fliers in open canopy spaces, including butterflies and dragonflies, which are often missed by ground-level techniques. Research conducted in mangrove systems such as Bhitarkanika and Pichavaram has shown that aerial netting is particularly useful for capturing lepidopteran pollinators whose activity is closely linked to seasonal flowering patterns [147, 183, 184, 185].

Despite their effectiveness, these methods exhibit inherent biases toward active, diurnal, and larger-bodied insects, thereby underrepresenting cryptic, nocturnal, and small-bodied taxa. To address these limitations, methods such as beat sampling, hand collecting, and vacuum sampling play a crucial role in expanding the detectable insect assemblage. Beat sampling is especially valuable in mangrove ecosystems characterized by dense and interlocking canopies, where it facilitates the collection of concealed or resting insects such as leaf beetles, ants, and sap-feeding Hemiptera. The effectiveness of this method in capturing cryptic taxa has been demonstrated in studies from both Asian and African mangrove systems [1, 152, 153]. Hand collecting further enhances taxonomic resolution by allowing direct observation of insect behavior, including nectar feeding and pollen transfer, thereby enabling the identification of role-specific pollinators [4, 8, 148, 149, 150]. Vacuum sampling, although less commonly reported in mangrove-specific studies, is particularly efficient for collecting small and delicate insects such as thrips, aphids, and minute parasitoids, which are often overlooked by conventional methods [99]. The high abundance of these microfaunal groups highlights their potential, yet underappreciated, role in mangrove pollination systems.

In addition to these active techniques, bait stations provide important insights into the behavioral ecology and resource-use flexibility of insects in mangrove environments. By utilizing fermenting fruit or protein-based attractants, bait stations effectively sample taxa such as ants, flies, and butterflies, particularly during periods of low floral availability. This approach reveals that many insect species exhibit opportunistic feeding behavior and may function as facultative pollinators, shifting between nectar feeding and alternative resources depending on environmental conditions [1, 147]. Such findings underscore the adaptive strategies employed by insects in dynamic mangrove ecosystems, where resource availability can be highly variable.

Fogging represents a unique and powerful method for sampling canopy-dwelling insects, providing access to vertical strata that are otherwise inaccessible through ground-based techniques. This method has been widely used in tropical forest research to assess canopy biodiversity and has demonstrated its applicability in mangrove systems as well [18, 19, 20]. The dominance of arboreal ants and the presence of diverse taxa such as beetles, hemipterans, and psocopterans in fogging samples indicate that a substantial proportion of insect diversity resides within the canopy. This has significant implications for pollination ecology, as it suggests that many potential pollinators or pollination-related taxa may be overlooked in studies that focus solely on understory or ground-level interactions.

Across all sampling methods, certain insect orders, particularly Hymenoptera, Diptera, Coleoptera, and Hemiptera, consistently emerge as dominant components of the mangrove insect community. These groups encompass a wide range of ecological functions, including pollination, herbivory, predation, and decomposition, highlighting the complex trophic interactions that underpin mangrove ecosystems. Secondary groups such as Lepidoptera, Thysanoptera, and Orthoptera further contribute to this diversity, while less frequently sampled orders, including Mantodea, Phasmatodea, and Psocodea, reflect the presence of specialized and cryptic taxa. Collectively, these findings indicate that mangrove pollination systems are embedded within broader ecological networks, where both pollinating and non-pollinating insects play integral roles in maintaining ecosystem function.

In summary, the synthesis of sampling methods presented in Table 4 demonstrates that a comprehensive understanding of insect pollinator diversity in mangrove ecosystems requires the integration of multiple complementary techniques. Each method contributes uniquely to capturing different components of the insect community, thereby reducing sampling bias and enhancing overall biodiversity assessment. Importantly, the inclusion of methods targeting small-bodied, cryptic, and canopy-dwelling insects is essential for accurately characterizing pollination systems and understanding the ecological complexity of mangrove habitats.

Table 5 Passive Methods of Sampling for Insect Pollinators and Species Sampled in Mangrove Ecosystems

Methods	Description of Method	Keynote	Insect Orders Sampled	Insect Family Sampled	Species Collected	Common name(s)
Malaise Traps	Malaise traps are a staple passive sampling technique for capturing flying insects, particularly hymenopterans and dipterans, which are crucial pollinator groups in mangrove ecosystems. These tent-like interception traps exploit the natural flight behavior of insects, channeling them upward into a collecting chamber. In mangrove habitats, they are often set up along edges or natural flight corridors, such as between tree gaps or near flowering canopies. Their passive and continuous sampling over extended periods makes them ideal for tracking temporal changes in pollinator abundance and community structure. For instance, Malaise traps were used by Adeduntan & Olusola (2015) [1] in the Niger Delta mangroves to assess the diurnal distribution of Hymenoptera and Diptera. Similarly, Malaise trapping enabled Kitching <i>et al.</i> (2001) [103] to analyze vertical and seasonal patterns in canopy insects across tropical forests, including mangrove-adjacent sites. In mangrove-specific research, Malaise traps have helped detect fluctuations in bee	Strongly represented in Malaise traps due to continuous flight activity in mangrove corridors.	Diptera (Flies)	Culicidae	<i>Anopheles aquasalis</i> (Curry, 1932)	Coastal malaria vector / Brackish water mosquito
					<i>Culex taeniorhynchus</i> (Wiedemann, 1821)	Black salt marsh mosquito
				Tabanidae	<i>Tabanus occidentalis</i> (Linnaeus, 1758)	Horsefly / Mutucas / Botucas / Mbutú / Colihuacho / Moscas de los caballos (Spanish for horse flies)
	Malaise traps are particularly effective for parasitoid wasps and flying bees.	Hymenoptera (Wasps, Bees, Ant alates)		Ichneumonidae	<i>Ichneumon eumerus</i> (Wesmael, 1857)	Ichneumon fly / Darwin wasp
				Braconidae	<i>Habrobracon hebetor</i> (Say, 1836)	Grain moth parasitoid / Stored product moth parasitoid
				Halictidae	<i>Nomia melanderi</i> (Cockerell, 1906)	Sweat bee / Alkali bee
	Captured during dispersal or short flight movements.	Hemiptera (Flying true bugs)		Lygaeidae	<i>Oncopeltus fasciatus</i> (Dallas, 1852)	Large milkweed bug
				Pentatomidae	<i>Aelia acuminata</i> (Linnaeus, 1758)	Bishop's mitre shield bug / Bishop's Mitre
				Cicadellidae	<i>Cicadella viridis</i> (Linnaeus, 1758)	Leafhopper / Typical leafhopper / Green leafhopper / Cicadelle verte (French) / grüne Zwergzikade (German) / Groene rietcicade (Dutch)
	Intercepted during flight		Coleoptera (Flying beetles)	Cantharidae	<i>Cantharis fusca</i> (Linnaeus, 1758)	Soldier beetle / Dark sailor beetle

and fly populations in response to the flowering cycles of <i>Avicennia marina</i> and <i>Sonneratia caseolaris</i> , thereby contributing to pollination ecology assessments [5, 7, 10, 148, 149, 150]. Their capacity to provide taxonomically and functionally diverse samples make Malaise traps a valuable tool in both short-term surveys and long-term monitoring programs.	between vegetation patches.		Coccinellidae	<i>Harmonia axyridis</i> (Pallas, 1773)	Multicolored Asian lady beetle / Harlequin ladybird / Asian lady beetle / Halloween beetle
			Elateridae	<i>Elater ferrugineus</i> (Linnaeus, 1758)	Click beetle / Rusty red click beetle / European red click beetle
	Mostly moths (nocturnal fliers) captured in Malaise traps.	Lepidoptera (Moths & butterflies)	Noctuidae	<i>Phalaena frugiperda</i> (Smith, 1797)	Fall armyworm / Grass worm / Southern grassworm / Corn leafworm / Budworm
				<i>Heliothis virescens</i> (Fabricius, 1777)	Tobacco budworm / Geranium budworm
			Pieridae	<i>Pieris brassicae</i> (Linnaeus, 1758)	Large white / Large cabbage white / Cabbage butterfly / Large Cabbage White butterfly
	Abundant in humid mangroves; captured during short dispersal flights.	Psocodea (Barklice)	Psocidae	<i>Psocus flavonimbatus</i> (Rostock, 1879)	Bark louse / Bark lice / Bark fly
			Ectopsocidae	<i>Ectopsocus petersi</i> (Smithers, 1978)	Outer bark lice / Peters' barklouse
			Peripsocidae	<i>Peripsocus alboguttatus</i> (Dalman, 1823)	Bark louse / Bark fly / Prickig sorgstövslända (Swedish)
	Occasionally intercepted during flight or disturbance movement.	Orthoptera (Flying / active forms)	Acrididae	<i>Oedaleus senegalensis</i> (Krauss, 1877)	Senegalese grasshopper / Criquet Sénégalais (French)
				<i>Aiolopus thalassinus</i> (Fabricius, 1781)	Slender Green-winged Grasshopper / Long-winged Grasshopper
Tettigoniidae			<i>Phaneroptera falcata</i> (Poda, 1761)	Sickle-bearing bush-cricket / Bush-cricket / Katydid	

		Captured mainly during winged dispersal (alate flights).	Blattodea (Alates & dispersers)	Kalotermitidae	<i>Cryptotermes brevis</i> (Walker, 1853)	West Indian drywood termite / Powderpost termite / West Indian powderpost drywood termite
					<i>Neotermes castaneus</i> (Burmeister, 1839)	Florida dampwood termite / Southern dampwood termite
				Blattidae	<i>Periplaneta fuliginosa</i> (Serville, 1839)	Smokybrown cockroach
		Occasionally intercepted during nocturnal dispersal.	Dermaptera (Earwigs)	Forficulidae	<i>Forficula senegalensis</i> (Serville, 1839)	African Common Earwig
				Spongiphoridae	<i>Labia minor</i> (Linnaeus, 1758)	Lesser earwig
				Chelisochidae	<i>Chelisoches morio</i> (Fabricius, 1775)	Black earwig
		Rare but possible during movement between vegetation layers.	Mantodea (Rare captures)	Mantidae	<i>Miomantis paykullii</i> (Stål, 1871)	Egyptian pygmy mantis / Egyptian praying mantis.
					<i>Sphodromantis lineola</i> (Burmeister, 1838)	African mantis / African praying mantis / Giant African mantis / African lined mantis
				Eremiaphilidae	<i>Iris oratoria</i> (Linnaeus, 1758)	Mediterranean mantis / Iris mantis
		Captured during active predatory flight.	Neuroptera (Lacewings)	Chrysopidae	<i>Chrysoperla externa</i> (Hagen, 1861)	Green lacewing / Green chrysopid
				Hemerobiidae	<i>Hemerobius pini</i> (Stephens, 1836)	Brown lacewing / Pine brown lacewing
					<i>Micromus angulatus</i> (Stephens, 1836)	Biobest's "Micromus-System" / Brown lacewing / Angular brunette lacewing

		Associated with aquatic mangrove channels; frequently intercepted near water.	Trichoptera (Caddisflies)	Hydropsychidae	<i>Hydropsyche angustipennis</i> (Curtis, 1834)	Net-spinning caddisfly / Tume jõgiehmeslane (Estonian) / Tummaseulakas (Finnish).
					<i>Cheumatopsyche lepida</i> (Pictet, 1834)	Common net-spinning caddisflies / Little Sister Sedge / Pikkuseulakas (Finnish)
				Leptoceridae	<i>Oecetis inconspicua</i> (Walker, 1852)	Leptocère invisible (French) / Long-horned caddisfly / Long horn sedge / Inconspicuous long-horned caddisfly / Plain red-brown long-horned sedge
Pan Traps	Pan traps, also known as color traps, are highly effective passive devices that rely on insect attraction to specific visual cues. Typically composed of brightly colored bowls (e.g., yellow, blue, white) filled with water and surfactant, pan traps are especially efficient in capturing small, visually-oriented pollinators such as halictid bees, syrphid flies, and wasps. In mangroves, where dense understory or tidal conditions can limit other sampling methods, pan traps offer a low-maintenance alternative. Studies by Aluri <i>et al.</i> (2012) [7, 10] and Raju (2019) [148, 149, 150] in the Godavari mangrove forests of India reported that pan traps	Strongly attracted to yellow and blue pan traps; dominant pollinators.	Hymenoptera (Bees, Wasps)	Halictidae	<i>Halictus ligatus</i> (Say, 1837)	Ligated furrow bee / Sweat bee / Ligated gregarious sweat bee
					<i>Lasioglossum albipes</i> (Fabricius, 1781)	Bloomed Furrow Bee / Sweat bee / White-footed sweat bee
				Apidae	<i>Ceratina calcarata</i> (Robertson, 1900)	Spurred ceratina / Spurred small carpenter bee / Wide-legged little carpenter bee / Small carpenter bee
	Mimic bees and are highly responsive to visual floral cues.	Diptera (Flies, especially hoverflies)	Syrphidae		<i>Eristalis tenax</i> (Linnaeus, 1758)	Common Drone Fly / Drone Fly
					<i>Scaeva marginata</i> (Say, 1823)	Margined calligrapher / Margined calligrapher fly
					<i>Syritta pipiens</i> (Linnaeus, 1758)	Thick-legged hoverfly / Common compost fly / compost hoverfly

captured a wide diversity of solitary and social bees visiting <i>Avicennia</i>, <i>Aegiceras</i>, and <i>Excoecaria</i> species. Rajesh <i>et al.</i> (2017) [147] also implemented pan trapping in the Pichavaram mangroves to assess pollinator diversity across seasons and observed consistent captures of Halictidae and Apidae. Pan traps are particularly effective during peak flowering periods when pollinators are highly active and visually responsive. Their quantitative nature also facilitates comparisons across habitats or treatment plots, making them valuable for conservation assessments and restoration monitoring.	Commonly found on flowers and captured in color traps.	Coleoptera (Flower beetles)	Scarabaeidae	<i>Oxythyrea stictica</i> (Linnaeus, 1767)	White-spotted Rose Beetle / White-spotted Rose Chafer / Mediterranean spotted chafer
				<i>Cetonia aurata</i> (Linnaeus, 1758)	Rose chafer / Green rose chafer
			Nitidulidae	<i>Meligethes aeneus</i> (Fabricius, 1775)	Common pollen beetle / Rape pollen beetle / Rape beetle
	Some species visit flowers or are incidentally attracted to colors.	Hemiptera (Plant bugs & flower-associated taxa)	Miridae	<i>Lygus pratensis</i> (Linnaeus, 1758)	Plant bug / Tarnished plant bug / Common green capsid / European tarnished plant bug
			Pentatomidae	<i>Nezara viridula</i> (Linnaeus, 1758)	Southern green stink bug / Green vegetable bug
			Anthocoridae	<i>Orius insidiosus</i> (Say, 1832)	Insidious flower bug / Minute pirate bug
	Occasionally captured when flying low over vegetation.	Lepidoptera (Small moths & butterflies)	Erebidae	<i>Utetheisa ornatrix</i> (Linnaeus, 1758)	Ornate bella moth / Bella moth, Rattlebox moth / Calico moth
			Pieridae	<i>Eurema hecabe</i> (Linnaeus, 1758)	Common grass yellow
			Lycaenidae	<i>Zizeeria karsandra</i> (Moore, 1865)	Dark Grass Blue / Gossamer-winged / Blue butterfly
	Extremely abundant in pan traps due to flower association.	Thysanoptera (Thrips)	Thripidae	<i>Thrips tabaci</i> (Lindeman, 1889)	Onion thrip / Tobacco thrip / Potato thrip / Cotton seedling thrip
				<i>Euthrips occidentalis</i> (Pergande, 1895)	Western flower thrip
			Phlaeothripidae	<i>Haplothrips ganglbaueri</i>	Haplothrip

					(Schmutz, 1913)	
		Occasionally attracted to visual cues or prey presence near traps.	Neuroptera (Lacewings)	Chrysopidae	<i>Chrysoperla carnea</i> (Stephens, 1836)	Common green lacewing
				Hemerobiidae	<i>Hemerobius tasmaniae</i> (Walker, 1860)	Tasmanian brown lacewing / Brown lacewing
					<i>Hemerobius stigma</i> (Stephens, 1836)	Marked brown lacewing / Brown pine lacewing
		Rare; usually accidental captures near vegetation.	Orthoptera (Incidental captures)	Tettigoniidae	<i>Xiphidium strictum</i> (Scudder, 1875)	Straight-lanced meadow katydid
				Acrididae	<i>Locusta migratoria</i> (Linnaeus, 1758)	Migratory locust
				Gryllidae	<i>Gryllus bimaculatus</i> (De Geer, 1773)	Two-spotted cricket / Southern field cricket / African field cricket / Mediterranean field cricket
		Occasionally collected near humid mangrove foliage.	Psocodea (Barklice incidental)	Liposcelididae	<i>Liposcelis bostrychophila</i> (Badonnel, 1931)	Booklouse / Book lice / Psocids / House louse / Banded booklouse
				Myopsocidae	<i>Psocidus quadrisignatus</i> (Banks, 1920)	Barklouse / Bark lice
				Caeciliusidae	<i>Psocus flavidus</i> (Stephens, 1836)	Yellow barklouse / Lizard barklice
Light Traps	Light traps are passive collection tools that exploit insect phototaxis by using artificial light sources, such as ultraviolet (UV) or mercury vapor lamps, to attract nocturnal insects. These traps are commonly used to monitor night-active Lepidoptera and Coleoptera,	Most abundant in light traps due to strong phototaxis.	Lepidoptera (Moths - dominant group)	Noctuidae	<i>Agrotis ipsilon</i> (Hufnagel, 1766)	Black cutworm / Dark sword-grass / Ipsilon dart / Greasy cutworm / Floodplain cutworm
					<i>Noctua litura</i> (Fabricius, 1775)	Tobacco cutworm / Cluster caterpillar / Cotton leafworm / Tropical armyworm / Taro caterpillar

some of which function as pollinators or herbivores of mangrove flora. Although nocturnal pollination is less studied in mangroves compared to diurnal systems, evidence suggests that some moth species visit flowers of <i>Sonneratia alba</i> and <i>Aegiceras corniculatum</i> during twilight hours [4, 8, 156]. In a broader context, light traps have been used in tropical coastal forests, including mangrove areas, to study nocturnal pollinator activity [91]. Adeduntan & Olusola (2015) [1] also reported light trap effectiveness in sampling diverse insect taxa in Nigerian mangroves. The method can complement daytime sampling strategies by capturing additional pollinator guilds, thereby improving the comprehensiveness of community analyses. However, care must be taken to minimize light pollution and non-target mortality in sensitive coastal ecosystems.			Erebidae	<i>Utetheisa pulchella</i> (Linnaeus, 1758)	Crimson-speckled flunkey / Crimson-speckled moth / Crimson-speckled footman
	Many beetles are night-active and attracted to UV light.	Coleoptera (Nocturnal beetles)	Scarabaeidae	<i>Phyllopertha orientalis</i> (Waterhouse, 1875)	Oriental beetle / Asiatic beetle
				<i>Cyclocephala parallela</i> (Casey, 1915)	Southeastern masked chafer
			Lampyridae	<i>Photinus pyralis</i> (Linnaeus, 1767)	Common eastern firefly / Big dipper firefly
	Strongly associated with coastal / mangrove aquatic systems.	Diptera (Flies & mosquitoes)	Ceratopogonidae	<i>Culicoides furens</i> (Poey, 1851)	Little gray punkie / No-see-ums / Biting midges / Sand fly / Punkie
			Chironomidae	<i>Chironomus plumosus</i> (Linnaeus, 1758)	Buzzer midge / Lake midge / Non-biting midge
			Simuliidae	<i>Simulium damnosum</i> (Theobald, 1903)	Blackfly / Black fly
	Frequently captured during nocturnal dispersal flights.	Hemiptera (True bugs)	Delphacidae	<i>Nilaparvata lugens</i> (Stål, 1854)	Brown planthopper (BPH)
				<i>Sogatella furcifera</i> (Horváth, 1899)	White-backed planthopper (WBPG) / Whitebacked planthopper
			Cicadellidae	<i>Nephotettix virescens</i> (Distant, 1908)	Green rice leafhopper
	Parasitoids and some bees/wasps are occasionally attracted to light.	Hymenoptera (Nocturnal / Attracted taxa)	Ichneumonidae	<i>Ophion luteus</i> (Linnaeus, 1758)	Yellow Ophion / Ichneumon wasp
			Apidae	<i>Xylocopa virginica</i> (Linnaeus, 1771)	Eastern carpenter bee / Virginia carpenter bee / Common carpenter bee

				Vespidae	<i>Vespula vulgaris</i> (Linnaeus, 1758)	Common wasp / English wasp / Common yellowjacket
	Nocturnal predators commonly recorded in light traps.	Neuroptera (Lacewings)		Chrysopidae	<i>Chrysopa Formosa</i> (Brauer, 1851)	Aphid lion / Green lacewing / Etelänharsokorento (Finnish) / Fagergulløye (Norwegian Bokmål) / Gap-o-pul-jam-ja-ri (Korean) / Zuidelijke gaasvlieg (Dutch)
				Hemerobiidae	<i>Hemerobius micans</i> (Olivier, 1793)	Brown lacewing
					<i>Wesmaelius subnebulosus</i> (Stephens, 1836)	Misty Brown Lacewing
	Attracted during night activity near vegetation.	Orthoptera (Nocturnal crickets / katydids)		Gryllidae	<i>Teleogryllus oceanicus</i> (Le Guillou, 1841)	Oceanic field cricket / Australian field cricket / Pacific field cricket
					<i>Gryllus campestris</i> (Linnaeus, 1758)	Field cricket / European field cricket / Feldgrille (German) / Veldkrekel (Dutch) / Grillon des champs (French)
				Tettigoniidae	<i>Neoconocephalus triops</i> (Linnaeus, 1758)	Broad-tipped Conehead / Broad-tipped Conehead Katydid
	Nocturnal scavengers occasionally drawn to light.	Dermaptera (Earwigs)		Forficulidae	<i>Doru luteipes</i> (Scudder, 1876)	Green earwig / Predatory earwig / Green forficulid / Common earwig
				Anisolabididae	<i>Euborellia caraibea</i> (Hebard, 1921)	Ring-legged earwig
				Spongiphoridae	<i>Marava arachidis</i> (Yersin, 1860)	Bone-house earwig / Chief earwig / Little earwig

		Especially winged termite alates during dispersal flights.	Blattodea (Cockroaches & termite alates)	Blattidae	<i>Blatta orientalis</i> (Linnaeus, 1758)	Oriental cockroach / Waterbug / Water beetle / Black beetle / Black cockroach
					<i>Shelfordella lateralis</i> (Walker, 1868)	Turkestan cockroach / Red runner cockroach / Rusty red cockroach / Red runner / Lats / Outdoor-dwelling cockroach
				Termitidae	<i>Odontotermes obesus</i> (Rambur, 1842)	Indian white termite / Subterranean termite
		Strongly associated with mangrove tidal channels and estuaries.	Trichoptera (Caddisflies - aquatic link)	Hydropsychidae	<i>Hydropsyche pellucidula</i> (Curtis, 1834)	Net-spinning caddisfly / Caddisfly / Sedge fly
				Rhyacophilidae	<i>Rhyacophila dorsalis</i> (Curtis, 1834)	Sand fly
				Limnephilidae	<i>Limnephilus lunatus</i> (Curtis, 1834)	Cinnamon sedge / Half-moon caddisfly / Crescent cinnamon sedge / Northern casemaker
		Often attracted in large swarms near water bodies at night.	Ephemeroptera (Mayflies)	Baetidae	<i>Baetis rhodani</i> (Pictet, 1843)	Large dark olive / Large dark olive mayfly / Olive mayfly nymph
					<i>Cloeon dipterum</i> (Linnaeus, 1761)	Pond olive / Pond small minnow mayfly
				Ephemeridae	<i>Hexagenia limbata</i> (Serville, 1829)	Giant mayfly / Giant burrowing mayfly / Michigan Hex burrowing mayfly / Hex
		Rare but possible during crepuscular /	Odonata (rare / occasional captures)	Aeshnidae	<i>Anax junius</i> (Drury, 1773)	Common green darner / Green darner / Green darner dragonfly

		nocturnal activity.		Libellulidae	<i>Pantala flavescens</i> (Fabricius, 1798)	Wandering glider / Globe skimmer / Globe wanderer / Typhoon dragonfly / Yellowish-orange dragonfly
				Coenagrionidae	<i>Ischnura elegans</i> (Linden, 1820)	Blue-tailed damselfly / Common bluetail
Pitfall Traps	Pitfall traps are passive ground-level traps designed to capture surface-active arthropods such as ants, beetles, and ground-dwelling wasps. In mangroves, where ground conditions vary with tidal cycles, pitfall traps must be strategically placed on raised roots, mudflats during low tide, or stabilized litter zones. They are particularly useful in studying ant species, some of which function as opportunistic pollinators or defenders of extrafloral nectar sources [5, 7, 10, 152, 153]. For example, in studies of <i>Bruguiera gymnorhiza</i> and <i>Ceriops tagal</i> , pitfall traps captured ant species that were later found to carry pollen on their mandibles and bodies, suggesting potential roles in pollination [148, 149, 150]. In similar ecosystems, ground-dwelling beetles have been documented participating in the pollination of low-lying or ground-accessible flowers. Pitfall trapping also helps quantify foraging behavior and	Typically dominant in pitfall traps due to high ground activity.	Coleoptera (Ground beetles & litter beetles)	Carabidae	Scarites subterraneus (Fabricius, 1775)	Big-headed Ground Beetle / Pedunculate ground beetle
					<i>Carabus melanarius</i> (Illiger, 1798)	Common black ground beetle / Black ground beetle / Strawberry ground beetle / Rain beetle
				Scarabaeidae	<i>Scarabaeus gazella</i> (Fabricius, 1787)	Brown dung beetle / Gazelle scarab
	Ants often represent the highest abundance in mangrove soils.	Hymenoptera (Ants - dominant group)	Formicidae		<i>Camponotus compressus</i> (Fabricius, 1787)	Indian black ant / Common godzilla ant
					<i>Odontomachus bauri</i> (Emery, 1892)	Trap-jaw ant
					<i>Ectatomma ruidum</i> (Roger, 1860)	Foraging ant / Ground dwelling scavenger ant
	Active predators and seed-feeders on soil surface.	Hemiptera (Ground-associated bugs)		Geocoridae	<i>Geocoris punctipes</i> (Say, 1831)	Big-eyed bug
				Lygaeidae	<i>Nysius raphanus</i> (Howard, 1872)	False chinch bug
				Reduviidae	<i>Acanthaspis petax</i> (Stål, 1865)	Ant-snatching assassin bug / Ant Backpack assassin bug / Ant killer / Corpse-carrying assassin bug / Masked hunter

	community composition of non-flying pollinators and integrated with canopy-level methods for a holistic understanding of pollination networks.	Common in leaf litter and muddy substrates.	Orthoptera (Crickets & ground hoppers)	Gryllidae	<i>Acheta assimilis</i> , now more formally known as <i>Gryllus assimilis</i> (Fabricius, 1775)	Jamaican field cricket / Field cricket / Brown silent cricket / Common black field cricket / Grillo negro común (Spanish)
					<i>Gryllus rubens</i> (Scudder, 1902)	Southeastern field cricket / Eastern trilling cricket
				Tetrigidae	<i>Tetrix undulata</i> (Sowerby, 1806)	Common Ground-hopper / Common Groundhopper
		Nocturnal scavengers and predators in mangrove litter.	Dermaptera (Earwigs)	Forficulidae	<i>Doru lineare</i> , formerly known as <i>Forficula linearis</i> (Eschscholtz, 1822)	Linear earwig
				Anisolabididae	<i>Euborellia cincticollis</i> (Gerstaecker, 1883)	African earwig / Red-legged earwig
				Labiduridae	<i>Labidura riparia</i> (Pallas, 1773)	Striped earwig / Shore earwig / Common brown earwig (in Australia)
		Found in decaying wood and soil microhabitats.	Blattodea (Cockroaches & termites)	Blaberidae	<i>Panesthia angustipennis</i> (Illiger, 1801)	Wood cockroach / Orangeback Roach / Orangeback Wood Cockroach
					<i>Blaberus craniifer</i> (Burmeister, 1838)	Death's head cockroach
				Rhinotermitidae	<i>Rhinotermes marginalis</i> (Linnaeus, 1758)	Lower subterranean termite
		Often captured when resting or emerging near ground substrates.	Diptera (Ground-associated flies & larvae)	Scathophagidae	<i>Scathophaga stercoraria</i> (Linnaeus, 1758)	Yellow dung fly / Golden dung fly
				Fanniidae	<i>Fannia canicularis</i> (Linnaeus, 1761)	Little house fly / Lesser house fly

				Sepsidae	<i>Sepsis cynipsea</i> (Linnaeus, 1758)	Dung fly / Black scavenger fly / Ant-mimic fly
		Ground-dwelling larval stages frequently sampled.	Lepidoptera (Larvae / pupae stages)	Noctuidae	<i>Agrotis segetum</i> (Denis & Schiffermüller, 1775)	Turnip moth / Turnip dart / Tobacco cutworm
					<i>Spodoptera exigua</i> (Hübner, 1808)	Beet armyworm / Small mottled willow moth / Asparagus fern caterpillar
					<i>Heliothis armigera</i> (Hübner, 1808)	Cotton bollworm / Old world bollworm / Tomato fruit borer / Tomato grub / Tobacco budworm / Corn earworm / African cotton bollworm
		Occasionally collected from soil or litter surfaces.	Thysanoptera (Thrips - incidental)	Thripidae	<i>Anaphothrips obscurus</i> (Müller, 1776)	Grass thrip / American grass thrip
					<i>Limothrips cerealium</i> (Haliday, 1836)	Grain thrip / Corn thrip / Thunder fly / thunderbug
				Phlaeothripidae	<i>Haplothrips aculeatus</i> (Fabricius, 1803)	Grass thrip
		Found in humid litter layers typical of mangroves.	Psocodea (Barklice - litter-associated)	Psocidae	<i>Psocidus similis</i> (Lienhard, 2013)	Barklice / Bark lice / Barklouse / Psocid
				Lachesillidae	<i>Lachesilla quercus</i> (Kolbe, 1880)	Fateful bark louse
				Ectopsocidae	<i>Ectopsocus briggsi</i> (McLachlan, 1899)	Common barkfly
		Important decomposers in	Isoptera (Termites)	Termitidae	<i>Microcerotermes diversus</i> (Silvestri, 1920)	Microcerotermes termite

		mangrove detritus systems.			<i>Termes formosanus</i> (Shiraki, 1909)	Black-winged subterranean termite / Taiwan soil termite / Black-winged soil termite
				Rhinotermitidae	<i>Reticulitermes speratus</i> (Kolbe, 1885)	Japanese termite / Japanese subterranean termite / Yamato-shiroari (Japan)
Sticky Traps	Sticky traps use adhesive-coated surfaces, often color-coded (e.g., yellow for flies), to passively intercept insects in flight or while perching. These traps are highly effective for capturing small and delicate insects such as thrips, midges, leafhoppers, and tiny bees, many of which act as minor or secondary pollinators in mangrove ecosystems. Deployed at multiple canopy levels or directly on flowering branches, sticky traps help track pollinator visitation frequency and vertical stratification [18, 19, 20]. In mangrove floral canopies, sticky traps have captured Diptera and Thysanoptera suspected to be involved in pollen transfer in compact or closed flowers, such as those of <i>Excoecaria agallocha</i> and <i>Ceriops decandra</i> [152, 153]. Their ability to provide time-integrated data without disturbing the environment makes them useful for comparative studies across tidal zones or flowering periods. However, sticky traps are influenced by humidity and wind	Dominant in sticky traps due to continuous low-level flight activity.	Diptera (Small flies)	Agromyzidae	<i>Oscinis trifolii</i> (Burgess, 1880)	American serpentine leafminer / Celery leafminer / Chrysanthemum leaf miner / Californian leaf miner
				Sciaridae	<i>Bradysia impatiens</i> (Johannsen, 1912)	Black fungus gnat / Dark-winged fungus gnat / Fungus gnat
				Drosophilidae	<i>Drosophila suzukii</i> (Matsumura, 1931)	Spotted wing drosophila / Spotted-wing drosophila / Cherry vinegar fly
		Strongly attracted to yellow sticky traps.	Hemiptera (Sap-feeders)	Aleyrodidae	<i>Bemisia tabaci</i> (Gennadius, 1889)	Silverleaf whitefly / Tobacco whitefly / Sweetpotato whitefly / Cotton whitefly / Cassava whitefly
				Aphididae	<i>Aphis gossypii</i> (Glover, 1877)	Melon aphid / Cotton aphid
				Cicadellidae	<i>Empoasca fabae</i> (Harris, 1841)	Potato leafhopper
		Important for biological control and trophic dynamics.	Hymenoptera (Parasitoids & small wasps)	Aphelinidae	<i>Encarsia formosa</i> (Gahan, 1924)	Encarsia wasp / Encarsia
				Trichogrammatidae	<i>Trichogramma pretiosum</i> (Riley, 1879)	Trichogramma wasp / Moth egg parasitoid

	conditions, requiring careful maintenance and placement.			Braconidae	<i>Aphidius colemani</i> (Viereck, 1912)	Aphid parasitic wasp / Aphid parasitoid wasp
		Among the most abundant taxa in sticky trap samples.	Thysanoptera (Thrips)	Thripidae	<i>Scirtothrips dorsalis</i> (Hood, 1919)	Chilli thrip / Chili thrip
					<i>Physopus schultzei</i> (Trybom, 1910)	Common blossom thrip / Cotton thrip / Tomato thrip / Cotton bud thrip
					<i>Thrips palmi</i> (Karny, 1925)	Melon thrip / Oriental thrip / Southern yellow thrip
		Captured during movement between host plants.	Coleoptera (Small beetles)	Chrysomelidae	<i>Diabrotica undecimpunctata</i> (Mannerheim, 1843)	Spotted cucumber beetle / Southern corn rootworm / 12-spotted cucumber beetle
					<i>Chrysomela cruciferae</i> (Goeze, 1777)	Crucifer flea beetle / Canola flea beetle / Rape flea beetle / Cabbage flea beetle
				Curculionidae	<i>Sitophilus zeamais</i> (Motschulsky, 1855)	Maize weevil / Greater grain weevil
		Mostly small-bodied nocturnal or crepuscular species.	Lepidoptera (Small moths)	Plutellidae	<i>Plutella xylostella</i> (Linnaeus, 1758)	Diamondback moth / Cabbage moth / Cabbage leaf-miner
				Gelechiidae	<i>Phthorimaea absoluta</i> (Meyrick, 1917)	Tomato leafminer / Twirler moth / South American tomato moth / South American tomato pinworm
					<i>Sitotroga cerealella</i> (Olivier, 1789)	Angoumois grain moth / Rice grain moth / French grain moth / Small grain worm
		Associated with humid mangrove	Psocodea (Barklice)	Liposcelididae	<i>Liposcelis decolor</i> (Pearman, 1925)	Booklouse / Booklice

		foliage and bark surfaces.		Ectopsocidae	<i>Ectopsocus meridionalis</i> (Ribaga, 1904)	Outer barklouse / Outer barklice
				Peripsocidae	<i>Psocus phaeopterus</i> (Stephens, 1836)	Medium-sized bark louse / Dysterbrun sorgstövslända (Swedish)
		Captured while searching for prey near vegetation.	Neuroptera (Lacewings)	Chrysopidae	<i>Chrysoperla rufilabris</i> (Burmeister, 1839)	Green lacewing / Red-lipped green lacewing
				Hemerobiidae	<i>Micromus variegatus</i> (Fabricius, 1793)	Brown lacewing / Variegated brown lacewing
					<i>Hemerobius pacificus</i> (Banks, 1897)	Pacific brown lacewing
		Rarely captured; mostly accidental contact with traps.	Orthoptera (Rare incidental captures) /	Gryllidae	<i>Oecanthus pellucens</i> (Scopoli, 1763)	Tree cricket / Italian tree cricket / European tree cricket
				Tettigoniidae	<i>Conocephalus dorsalis</i> (Latreille, 1804)	Short-winged conehead / Eurasian meadow katydid / Kurzflüglige Schwertschrecke (German)
				Gryllotalpidae	<i>Gryllotalpa orientalis</i> (Burmeister, 1838)	Oriental mole cricket / Dōngfāng lóugū (Chinese) / Kera (Japanese) / Ttanggapaji (Korean) / Dal'nevostochnaya medvedka (Russian) / Abdoozdak-e Sharghi (Persian)
Window Traps	Window traps, or flight interception traps, consist of vertical transparent barriers	Strongly represented due to heavy flight	Coleoptera (Dominant group)	Cerambycidae	<i>Xylotrechus colonus</i> (Fabricius, 1775)	Rustic borer / Rustic borer beetle / long-horned beetle

(e.g., plexiglass or mesh) placed perpendicular to known insect flight paths. These passive traps intercept flying insects and direct them into a collecting container below. They are especially effective in capturing medium-to-large insects like beetles, wasps, and even butterflies, which may bypass other trap types. In mangrove settings, window traps placed between tree trunks or above root systems have been used to sample insects moving through dense vegetation or emergent flower canopies. Basset <i>et al.</i> (2003) [18, 19, 20] demonstrated the utility of this method in tropical forests, including mangrove zones, for collecting diverse insect assemblages. In pollination studies, window traps have captured beetles and wasps associated with <i>Excoecaria agallocha</i>, providing insight into lesser-known pollinator pathways [148, 149, 150]. When deployed systematically, they offer insights into diel or seasonal flight patterns of pollinators and are instrumental in identifying species that operate at intermediate canopy levels.	and wood association.		Bostrichidae	<i>Bostrichus capucinus</i> (Linnaeus, 1758)	Capuchin beetle / False powderpost beetle / Auger beetle / Rode houtkever (Dutch) / Kapuzinerkäfer (German)
			Passalidae	<i>Passalus punctiger</i> (Lepeletier & Serville, 1825)	Bess beetle / Bess bug / Patent leather beetle
	Frequently captured due to low-level dispersal flights in mangrove forest understory.	Blattodea (Cockroaches & termite dispersers)	Ectobiidae	<i>Parcoblatta americana</i> (Scudder, 1900)	Western wood cockroach
			Blattidae	<i>Periplaneta australasiae</i> (Fabricius, 1775)	Australian cockroach
			Termitidae	<i>Nasutitermes corniger</i> (Motschulsky, 1855)	Conehead termite / Tree termite
	Captured during horizontal movement through mangrove vegetation corridors.	Diptera (Flying flies)	Asilidae	<i>Asilus sericeus</i> (Say, 1823)	Butterflyhunter / Silky robberfly / Robber fly
			Tipulidae	<i>Tipula paludosa</i> (Meigen, 1830)	European crane fly / Marsh crane fly / Leatherjacket
			Dolichopodidae	<i>Musca plumipes</i> (Scopoli, 1763)	Long-legged fly / Small dolichopid fly
	Includes dispersing alates and active foraging wasps.	Hymenoptera (Wasps & flying ants)	Vespidae	<i>Polistes canadensis</i> (Linnaeus, 1758)	Red paper wasp
			Sphecidae	<i>Sceliphron caementarium</i> (Drury, 1773)	Black-and-yellow mud daube / Yellow-legged mud-dauber wasp
			Formicidae	<i>Atta cephalotes</i> (Linnaeus, 1758)	Leafcutter ant

		Sampled during movement between host plants.	Hemiptera (Flying true bugs)	Coreidae	<i>Leptoglossus phyllopus</i> (Linnaeus, 1767)	Eastern leaf-footed bug
					<i>Coreus marginatus</i> (Linnaeus, 1758)	Dock bug
				Pyrrhocoridae	<i>Pyrrhocoris apterus</i> (Linnaeus, 1758)	Firebug / European firebug / red fire bug
		Less abundant due to avoidance or weak interception efficiency	Lepidoptera (Limited representation)	Noctuidae	<i>Noctua pronuba</i> (Linnaeus, 1758)	Large yellow underwing
					<i>Autographa gamma</i> (Linnaeus, 1758)	Silver Y moth
				Erebidae	<i>Eudocima phalonia</i> (Linnaeus, 1763)	Fruit-piercing moth
		Captured during predatory flight activity.	Neuroptera (Predatory lacewings)	Chrysopidae	<i>Chrysopa oculata</i> (Say, 1839)	Golden-eyed lacewing
				Myrmeleontidae	<i>Myrmeleon immaculatus</i> (De Geer, 1773)	Immaculate antlion / Doodlebug / Pit-trapping antlion / Spotless antlion
				Hemerobiidae	<i>Hemerobius humulinus</i> (Linnaeus, 1758)	Humulin brown lacewing / Brown lacewing / Tuinbruintje (Dutch) / Häivekirkvakorento (Finnish)
		Rare; mostly incidental collisions during movement.	Orthoptera (Occasional captures)	Acrididae	<i>Schistocerca gregaria</i> (Forskål, 1775)	Desert locust / Short-horned grasshopper
				Tettigoniidae	<i>Tettigonia viridissima</i> (Linnaeus, 1758)	Great green bush-cricket
					<i>Neoconocephalus robustus</i> (Scudder, 1862)	Robust conehead / Robust conehead katydid / Crepitating conehead
				Psocidae	<i>Psocus bipunctatus</i>	Barklouse / Barkfly

		Associated with tree bark and humid mangrove surfaces.	Psocodea (Barklice)		(Linnaeus, 1761)	
				Ectopsocidae	<i>Ectopsocus strauchi</i> (Enderlein, 1906)	Outer Barklice
				Lachesillidae	<i>Lachesilla pedicularia</i> (Linnaeus, 1758)	Cosmopolitan grain barklouse / Cosmopolitan grain psocid
		Captured near mangrove waterways and tidal creeks.	Trichoptera (Aquatic-associated insects)	Hydropsychidae	<i>Hydropsyche contubernalis</i> (McLachlan, 1865)	Net-spinning caddisfly
				Leptoceridae	<i>Mystacides azurea</i> (Linnaeus, 1761)	Long-horned caddisfly / Long-horned sedge / Caddisfly
					<i>Mystacides lacustris</i> (Pictet, 1834)	Gevlekt langsprietje (Dutch) / Järvisarvekas (Finnish)
		Associated with aquatic emergence near mangroves.	Ephemeroptera (Mayflies - occasional)	Ephemeridae	<i>Ephemerella danica</i> (Müller, 1764)	Green drake / Green drake mayfly / Common mayfly / Green dun
				Caenidae	<i>Caenis horaria</i> (Linnaeus, 1758)	Small square-gilled mayfly / Angler's Curse
				Baetidae	<i>Baetis muticus</i> (Linnaeus, 1758), now frequently classified as <i>Alainites muticus</i> (Linnaeus, 1758)	Small minnow mayfly / Iron blue / Northern iron blue mayfly / Northern iron blue / Iron blue dun
Emergence Traps	Emergence traps are designed to capture insects emerging from specific substrates, such as mangrove litter, decaying wood, or sediment. These traps typically cover a small patch of	Most abundant due to aquatic larval stages in mangrove sediments.	Diptera (Aquatic / emergent flies - dominant)	Culicidae	<i>Culex quinquefasciatus</i> (Say, 1823)	Southern house mosquito / Brown house mosquito / Tropical house mosquito / Quink
				Chironomidae	<i>Chironomus riparius</i> (Meigen, 1804)	Harlequin fly / Blood worm

habitat and funnel emerging insects into a collection jar. While more commonly used in decomposition studies, emergence traps are increasingly applied in pollination ecology to explore insect life cycles and recruitment in floral zones. In mangrove ecosystems, they are useful for identifying beetles and flies that develop in floral litter or wood and may later visit flowers as adults. For example, studies in Indo-Malayan mangroves have suggested that some saproxylic beetles emerging from decomposing mangrove branches contribute to early morning pollination of <i>Bruguiera</i> species [4, 8, 152, 153]. Emergence traps also help track phenological links between detritus-based larval habitats and adult pollinator activity, offering insights into the trophic coupling of pollination and decomposition processes in mangrove forests.	Common in tidal creeks and brackish mangrove waters.	Trichoptera (Caddisflies)	Tipulidae	<i>Tipula oleracea</i> (Linnaeus, 1758)	Common crane fly / Marsh crane fly / Leatherjacket
			Hydropsychidae	<i>Hydropsyche betteni</i> (Ross, 1938)	Common netspinner / Net-spinning caddisfly / Betten's net-spinning caddisfly
				<i>Cheumatopsyche analis</i> (Banks, 1903)	Little sister net-spinning caddisfly / Little sister sedge
	Emergence linked to water-air interface in mangrove systems.	Ephemeroptera (Mayflies)	Leptoceridae	<i>Oecetis avara</i> (Banks, 1895)	Tan spotted-wing long-horned sedge / Greedy long-horned caddisfly
			Baetidae	<i>Callibaetis fluctuans</i> (Walsh, 1862)	Wavy small minnow mayfly / Speckled duns / Speckle-winged quill
				<i>Centroptilum luteolum</i> (Müller, 1776)	Small spurwing / Small minnow mayfly / Pale watery / Little sky blue / Little sky-blue dun
	Semi-aquatic predators emerging from brackish pools.	Odonata (Dragonflies & damselflies)	Libellulidae	<i>Leptophlebia marginata</i> (Linnaeus, 1767)	Sepia dun
				<i>Orthetrum sabina</i> (Drury, 1770)	Slender skimmer / Green marsh hawk / Green skimmer / Variegated green skimmer/ Sober skimmer / Rhinoceros dragonfly
				<i>Brachythemis contaminata</i> (Fabricius, 1793)	Ditch jewel / Common amberwing / Orange-winged groundling / Asian groundling

				Coenagrionidae	<i>Ischnura senegalensis</i> (Rambur, 1842)	Common bluetail / Tropical bluetail / Marsh bluetail / African bluetail / Senegal golden dartlet
				Dytiscidae	<i>Dytiscus marginalis</i> (Linnaeus, 1758)	Great diving beetle / Great water beetle / Water tiger / Predaceous diving beetles / True water beetles
					<i>Hydrophilus piceus</i> (Linnaeus, 1758)	Great silver water beetle
				Hydrophilidae	<i>Berosus affinis</i> (Brullé, 1835)	Water scavenger beetle
			Hemiptera (Aquatic / semi- aquatic bugs)	Notonectidae	<i>Notonecta glauca</i> (Linnaeus, 1758)	Common backswimmer / Common water-boatman
				Gerridae	<i>Gerris lacustris</i> (Linnaeus, 1758)	Common pond skater / Common water strider
				Nepidae	<i>Ranatra linearis</i> (Linnaeus, 1758)	Water stick insect / Water scorpion
		Emergence from soil and detritus layers.	Lepidoptera (Soil / litter pupation emergence)	Noctuidae	<i>Spodoptera mauritia</i> (Boisduval, 1833)	Lawn armyworm / Paddy swarming caterpillar / Rice swarming caterpillar / Paddy cutworm
					<i>Mythimna separate</i> (Walker, 1865)	Oriental armyworm / Paddy armyworm / Rice ear-cutting caterpillar / Sorghum armyworm / Chinese armyworm /Northern armyworm / Army caterpillar / Cosmopolitan armyworm
				Erebidae	<i>Achaea janata</i> (Linnaeus, 1758)	Castor semi-looper / Croton caterpillar / Castor-oil moth

		Emergence reflects host-parasitoid interactions in mangrove substrates.	Hymenoptera (Parasitoids emerging from hosts)	Braconidae	<i>Cotesia marginiventris</i> (Cresson, 1865)	Braconid wasp / Lepidopteran parasitic wasp
					<i>Diachasmimorpha longicaudata</i> (Ashmead, 1905)	Long-tailed fruit fly parasite
				Pteromalidae	<i>Pteromalus puparum</i> (Linnaeus, 1758)	White butterfly pupal parasitoid wasp
		Emergence linked to decaying mangrove wood.	Blattodea (Termites from wood emergence)	Rhinotermitidae	<i>Coptotermes formosanus</i> (Shiraki, 1909)	Formosan subterranean termite / Super termite
				Termitidae	<i>Macrotermes bellicosus</i> (Smeathman, 1781)	War-like termite / African warlike termite / Mound-building termite / Fungus-growing termite
					<i>Nasutitermes exitiosus</i> (Hill, 1925)	Snouted termite / Gluegun termite
		Emerging from soil and moist substrate layers.	Orthoptera (Litter-associated emergence)	Acrididae	<i>Oxya hyla</i> (Serville, 1831)	Spine-kneed grasshopper / Rice grasshopper / Rice short-horned grasshopper
				Gryllidae	<i>Euscyrtus concinnus</i> (Haan, 1844)	Field cricket / Gryllid
				Tridactylidae	<i>Tridactylus japonicus</i> (Haan, 1842)	Pygmy mole cricket
		Associated with coastal and mangrove detritus zones.	Dermaptera (Earwigs from litter / soil)	Forficulidae	<i>Forficula auricularia</i> (Linnaeus, 1758)	European earwig / Common earwig
				Anisolabididae	<i>Euborellia annulipes</i> (Lucas, 1847)	Ring-legged earwig / Ringlegged earwig
					<i>Anisolabis maritima</i> (Bonelli, 1832)	Maritime earwig / Seaside earwig

The synthesis presented in Table 5 provides a comprehensive, multi-method evaluation of passive insect sampling techniques in mangrove ecosystems, revealing important ecological, methodological, and functional patterns in pollinator assemblages. Collectively, the data demonstrate that passive trapping approaches are not only complementary but also selectively biased toward distinct ecological guilds, thereby reinforcing the need for integrative sampling frameworks in mangrove pollination studies.

A dominant trend across methods is the consistent representation of Diptera and Hymenoptera as primary pollinator groups. Malaise traps, in particular, show strong efficiency in capturing these taxa due to their interception of continuous flight activity along mangrove corridors. The high abundance of Culicidae, Tabanidae, Ichneumonidae, and Halictidae reflects the ecological importance of both nectar-feeding adults and parasitoid guilds. This aligns with the structural complexity of mangrove canopies, where narrow flight pathways enhance interception probability. Moreover, the temporal sensitivity of Malaise traps enables the detection of phenological synchrony between insect activity and flowering cycles of key mangrove taxa such as *Avicennia marina* and *Sonneratia caseolaris*, underscoring their value in long-term ecological monitoring.

Pan traps further refine the understanding of visually mediated pollination by selectively attracting small-bodied, flower-visiting insects. The dominance of Halictidae, Apidae, and Syrphidae highlights the importance of color cues in mangrove pollination systems. Notably, the high capture rates of Thysanoptera indicate that micro-pollinators, often overlooked in traditional surveys, may play a more significant role in pollen transfer within compact mangrove flowers. This suggests a broader functional pollinator spectrum than previously assumed. Light traps expand the temporal scope of sampling by targeting nocturnal taxa, particularly Lepidoptera and certain Coleoptera. The prevalence of noctuid moths supports emerging evidence of crepuscular and nocturnal pollination in mangroves, especially in species with night-blooming or strongly scented flowers. Additionally, the capture of aquatic-associated Diptera and Ephemeroptera highlights the ecological connectivity between mangrove waterways and terrestrial pollination networks. Ground-based methods such as pitfall traps reveal a distinct assemblage dominated by Formicidae and Carabidae, emphasizing the role of ground-dwelling insects in pollination, particularly in species with low-lying or accessible floral structures. The presence of pollen-carrying ants supports the concept of opportunistic or facultative pollination, linking trophic interactions with reproductive ecology. Sticky traps and window traps provide intermediate-scale insights into vertical stratification and flight behavior. Sticky traps are particularly effective for capturing small, weak fliers such as thrips, aphids, and parasitoids, thereby contributing to understanding fine-scale pollination dynamics and trophic interactions. In contrast, window traps preferentially sample larger, stronger fliers such as beetles and wasps, many of which are associated with wood, detritus, or canopy-level resources.

Emergence traps uniquely contribute to this framework by linking larval habitats to adult pollinator populations. The dominance of Diptera, Trichoptera, and Ephemeroptera reflects the strong aquatic influence in mangrove ecosystems, while the presence of saproxylic beetles and parasitoid Hymenoptera highlights the role of detritus and host-mediated emergence. This demonstrates a critical ecological coupling between decomposition processes and pollination services. Overall, Table 5 illustrates that mangrove pollinator communities are highly diverse, functionally complex, and structured across spatial (ground to canopy), temporal (diurnal to nocturnal), and developmental (larval to adult) gradients. No single method captures this complexity in isolation. Therefore, a multi-method passive sampling strategy is essential for accurately characterizing pollinator diversity and ecosystem functioning in mangrove environments. Table 6 outlines the procedures used to execute the various insect sampling and collection methods employed in mangrove ecosystems. Accurate documentation of these procedures is essential in ecological studies because standardized sampling techniques ensure that insect diversity and abundance data are reliable and comparable across different sites and time periods. Mangrove environments present unique challenges for insect sampling due to their dense vegetation, tidal fluctuations, and complex canopy structures. As a result, researchers often apply a combination of carefully structured active and passive sampling techniques to obtain a comprehensive representation of pollinator communities. The procedures summarized in Table 5 describe the equipment preparation, field deployment, sampling duration, specimen preservation, and laboratory identification processes required for each method.

Table 6 Procedures of Executing Methods of Sampling and Collection in Mangroves

Methods	Description of Execution of Sampling Methods and Collection
Active Sampling Methods	
Sweep netting	Sweep netting is one of the most effective and widely used active sampling techniques for collecting insect pollinators in diverse habitats, including mangrove ecosystems. This method is particularly suitable for targeting flying insects such as bees, butterflies, flies, and beetles that are often seen visiting flowers or moving through vegetation. The first step in setting up sweep netting involves the selection and preparation of the appropriate equipment. A standard insect sweep net, preferably with a durable aluminium or fiberglass frame and a fine mesh net bag, is required. The mesh is strong enough to retain small insects yet soft enough to avoid damaging delicate species. Before use, the net is examined for tears and cleaned to prevent contamination between sampling sites [41]. Once the equipment is prepared, the next step is to identify appropriate sampling locations within the mangrove habitat. Areas with abundant flowering vegetation along the forest edge or inner canopy zones are ideal, as they are more likely to host a high abundance and diversity of pollinators. Sampling is generally most effective during peak activity periods for insects, typically in the early morning (8:00 a.m-10:00 a.m.) and late afternoon (15:00 p.m-17:00 p.m.) when environmental conditions such as light, temperature, and humidity are favourable [186]. The actual sweep netting technique is standardized to ensure consistency and comparability across sampling events. A common protocol involves conducting a fixed number of sweeps (e.g., 25 or 50 sweeps) per sampling unit such as a transect or quadrat. Each sweep consists of moving the net in a broad 180-degree arc through the vegetation, ensuring that the rim of the net makes gentle contact with flowers and foliage to dislodge and trap insects. After each sweep, the sampler should move forward one step to cover new ground and avoid sampling the same area repeatedly [135]. At the end of a sweep sequence, the mouth of the net is quickly closed by twisting the handle or net rim to prevent the escape of captured insects. The contents are then carefully transferred to labelled vials containing 70% ethanol, which preserves specimens for later identification and analysis. Labels should include essential metadata such as date, time, location (with GPS coordinates), habitat type, and the target plant species, if applicable. This information is critical for subsequent biodiversity assessments and ecological interpretation [199]. After field collection, specimens are sorted to major insect orders in the field, and detailed identification is conducted in the laboratory using taxonomic keys and entomological guides. Where morphological identification proves insufficient, molecular tools such as DNA barcoding may be employed for precise species determination. Maintaining accurate and complete records of field conditions, sampling efforts, and specimen handling ensures data reliability and scientific integrity. When properly implemented, sweep netting provides a robust and efficient method for inventorying pollinator diversity and understanding their roles in mangrove ecosystems.
Aerial netting	Aerial netting is a highly effective active sampling method widely used for collecting insect pollinators, particularly in diverse and structurally complex habitats like mangroves. This method is especially suited for targeting flying insects such as bees, butterflies, flies, and wasps that may not be easily captured by passive traps. The procedure begins with the selection of an appropriate aerial net. These nets typically feature a lightweight frame and a durable, fine mesh bag that allows for swift movement through the air without harming delicate insects. The net's rim is usually circular, and the handle is sufficiently long to allow the researcher to reach flying insects or those foraging on flowers without disturbing the surrounding vegetation [124]. The next step involves identifying suitable sampling locations within the mangrove habitat. Areas with a high density of flowering plants are ideal, as they tend to attract a greater diversity and abundance of pollinators. Sampling is conducted during periods of peak insect activity, typically in

	the early morning and late afternoon when light, temperature, and humidity conditions are most favourable. Calm weather is essential for effective sampling since strong winds or rain can inhibit insect activity and reduce capture efficiency [182]. During sampling, the researcher moves slowly and deliberately through the selected area, using the net to intercept insects in flight or to capture them while they are feeding on flowers. Insects in flight are approached quietly and swept with a fast but controlled motion of the net in the direction of flight. When targeting insects on flowers, the net is positioned beneath the insect and rapidly lifted to enclose it. Once captured, the net is quickly twisted to prevent the insect from escaping. Specimens are then gently transferred from the net into labelled vials containing 70% ethanol for preservation. Labels must include vital metadata such as the date, time, location (GPS coordinates), plant species visited, and habitat characteristics [140, 199]. All field notes are meticulously recorded, including environmental conditions, floral abundance, and any pollinator behaviours observed. Back in the laboratory, the specimens are sorted by major insect orders and identified using morphological keys and reference guides. For specimens that cannot be confidently identified morphologically, DNA barcoding may be employed to aid in accurate species identification. Proper curation of specimens and data ensures scientific reliability and supports future ecological studies. Aerial netting, when performed systematically, provides valuable insights into the composition, behaviour, and ecological roles of insect pollinators in mangrove ecosystems.
Beat sampling	Beat sampling is a widely used method for collecting foliage-dwelling insect pollinators, especially in structured habitats like mangroves where many insects occupy the canopy or understory vegetation. This method is particularly effective for capturing species from the orders Hymenoptera, Coleoptera, and Hemiptera, which may be otherwise underrepresented in passive sampling approaches. The procedure begins with the preparation of equipment, including a beat sheet (usually a 1-meter square white cloth or tray) and a stick or pole used for striking vegetation. The high contrast of the white sheet allows for easy visualization and collection of insects that fall from branches during the process [27, 133]. The next step is site selection within the mangrove forest. Researchers should focus on areas with dense floral resources or foliage, as these are likely to support high insect activity. Sampling is best conducted during peak activity hours, generally in the morning between 8:00 a.m. and 11:00 a.m. or late afternoon when ambient temperatures and light levels are suitable for insect movement [182]. At each sampling point, the beat sheet is placed on the ground or held beneath a selected plant or branch. The vegetation is then sharply struck several times with the stick to dislodge insects. Care is taken not to damage the plant structure, particularly in fragile mangrove environments. The fallen insects are then quickly collected using aspirators or soft forceps and transferred into labelled vials containing 70% ethanol for preservation [199]. Each specimen vial is labelled with detailed metadata, including GPS coordinates, date, time, mangrove species sampled, and any observational notes about insect behaviour or floral interaction. This information is critical for later analysis and for understanding spatial and temporal variations in pollinator communities. After collection, specimens are sorted by insect order and examined under a stereomicroscope. Identification is conducted using field guides and dichotomous keys; in cases where morphology-based identification is inconclusive, DNA barcoding may be applied to resolve species-level identities [140]. Beat sampling, when standardized and repeated across multiple mangrove microhabitats, provides a comprehensive view of the arthropod pollinator fauna and their ecological associations with native flora.
Hand Collecting	Hand collecting is one of the most targeted and adaptable techniques for collecting insect pollinators in mangrove ecosystems, offering a direct approach to studying species interactions with flowering plants. This method allows researchers to manually collect insects as they actively forage on mangrove flowers, enabling not only species-level identification but also behavioural observations. The process typically begins with field preparation that includes equipping researchers with soft forceps, aspirators, fine brushes, and small vials pre-filled with 70% ethanol for specimen preservation (Grange <i>et al.</i>, 2021). Labels are pre-prepared to record essential metadata including date, time, GPS location, plant species, and observed insect behaviour, ensuring traceability and contextual relevance for each collected specimen [137]. Field sampling is usually conducted during early morning (08:00 a.m.-11:00 a.m.) and late afternoon (15:00 p.m.-17:00 p.m.) when ambient temperature, light conditions, and pollinator activity are optimal [31, 35]. Researchers slowly approach flowering plants to avoid disturbing the

	pollinators and use aspirators or brushes to gently capture insects seen actively collecting nectar or pollen. These specimens are then placed directly into labelled vials. Care is taken to minimize damage to both insects and floral parts, especially in protected mangrove environments, where non-destructive sampling is a priority [31, 35, 137]. Once in the laboratory, specimens are sorted to order or family level and then identified to the morpho-species level using entomological keys, regional field guides, or photographic references. Morphological traits such as wing venation, body size, and antennae shape are used for diagnosis [137]. In cases where morphological identification is inconclusive, DNA barcoding may be employed to obtain accurate species-level identification [75, 76, 77]. This method is particularly valuable in biodiverse regions like mangroves, where undocumented or cryptic species may be common. Hand sampling is also highly complementary to passive methods such as pan trapping or malaise trapping, enabling researchers to fill gaps in the pollinator inventory by targeting elusive or behaviourally specific taxa. Overall, hand sampling plays a vital role in developing comprehensive pollinator biodiversity assessments in mangrove ecosystems. It enables both qualitative and quantitative data collection, helping researchers understand not just which species are present, but also how they interact with their floral hosts, thereby informing conservation strategies for pollination services and coastal biodiversity.
Vacuum Sampling	Vacuum sampling is a highly effective method for collecting insect pollinators, especially those that are small, mobile, or difficult to capture using other techniques. This method involves using a motorized vacuum device to suck insects from vegetation or ground surfaces, making it suitable for sampling in complex habitats like mangroves where insect species may be cryptic or dispersed. The equipment required for vacuum sampling typically includes a suction device, commonly referred to as a D-Vac or vacuum insect collector, which consists of a motorized fan connected to a flexible hose. The hose is attached to a collecting head, which is usually fitted with a mesh bag or cloth to capture the insects [44, 46, 48]. For field use, researchers should also prepare vials containing 70% ethanol for insect preservation and have labels on hand to record important metadata such as date, time, GPS coordinates, and habitat descriptions [137]. Site selection is a crucial first step in vacuum sampling. Researchers should target areas of high insect activity, such as flowering mangrove species, as these are the primary habitats for pollinator insects. Sampling is best carried out during peak pollinator activity, typically in the morning (08:00 a.m.-11:00 a.m.) and late afternoon (15:00 p.m.-17:00 p.m.), when temperatures are moderate and wind conditions are calm [31, 35]. It is important to avoid sampling during adverse weather conditions, as this can reduce insect activity and impact the effectiveness of the sampling process. Once a suitable site has been selected, the suction device is carefully positioned near the vegetation or ground surface, and the collecting head is activated to dislodge and collect insects. Researchers should move the suction head systematically over the area to ensure that a diverse range of pollinators is captured without causing damage to the plants [75, 76, 77]. After collection, insects are transferred into vials containing ethanol for preservation, and each vial is labelled with key information to ensure proper record-keeping. In the laboratory, specimens are sorted by taxonomic group, and their identity is determined using morphological keys or field guides [137]. In cases where species identification is challenging, molecular techniques such as DNA barcoding may be used to assist in confirming species identities [75, 76, 77]. This process not only helps in building a comprehensive species inventory but also provides insights into the pollinator community and its ecological role within the mangrove ecosystem. In summary, vacuum sampling is a powerful and efficient tool for collecting insect pollinators in mangroves. It is particularly useful for capturing species that are hard to detect using other methods, and when combined with accurate record-keeping and identification procedures, it can yield valuable data for pollinator conservation and ecosystem management.
Bait Station	Bait station sampling is a useful and targeted method for collecting insect pollinators in mangrove ecosystems, particularly for capturing species that are attracted to specific bait, such as sugary substances or floral scents. This method is commonly used for studying insect visitation patterns and species diversity by utilizing attractants placed in specific locations within the study area. The process begins with selecting appropriate bait substances, such as sugar water, floral nectar, or fruit-based attractants, which are known to attract a wide range of pollinators like bees,

	butterflies, and beetles [81, 84]. Once the bait is prepared, researchers must identify optimal locations within the mangrove ecosystem to place the stations. Typically, these stations are placed in areas with high floral diversity and abundant pollinator activity, ensuring that the bait is accessible to a variety of species [108, 109, 112]. After selecting the appropriate location, researchers set up the bait stations, which are as simple as small containers or dishes filled with the chosen attractant. These stations are placed on the ground, at the base of flowering mangrove species, or slightly elevated to avoid disturbance from ground-dwelling organisms [158, 159]. To enhance the effectiveness of the bait stations, they may be surrounded by protective barriers, such as fine mesh or netting, to prevent non-target organisms, like ants, from accessing the bait [81, 84]. The bait is replenished regularly to maintain its attractiveness, especially in the case of liquid attractants, which may evaporate or be consumed by other animals. Researchers typically leave the bait stations in place for several hours to a day, depending on the study's duration, and record the number and species of pollinators visiting the stations during the sampling period. Once the sampling is complete, the collected insects are captured manually or using small insect traps near the bait stations. Insects are then placed into labelled vials with preservative, typically 70% ethanol, for later identification. Identification is done in the laboratory by sorting the specimens into taxonomic groups (e.g., Hymenoptera, Lepidoptera) based on morphological characteristics such as wing structure, body size, and colour patterns. For more accurate identification, researchers may also use molecular techniques like DNA barcoding [75, 76, 77]. Throughout the process, researchers should maintain accurate records of the sampling conditions, including the time of day, bait type, environmental conditions, and the presence of other floral resources, to ensure that the data are reliable and are compared across different sites and time periods [158, 159]. To summarize, bait station sampling is an effective method for studying insect pollinator visitation patterns in mangrove ecosystems. By using attractants to lure pollinators to specific locations, researchers can gain insights into species composition, pollinator behaviour, and the ecological role of different insect taxa within the mangrove habitat.
Fogging	Fogging is a canopy-based insect sampling method widely employed in forested ecosystems, including mangroves, to collect arboreal insect pollinators that are otherwise difficult to access. This method involves dispersing a fine aerosol of insecticide typically a pyrethroid into the upper canopy using a thermal fogger or ultra-low volume (ULV) fogging machine. The process begins with selecting a suitable site, ideally a patch of mangrove where flowering is active and insect pollinator activity is expected to be high. Sampling is best conducted during early morning or late afternoon hours when wind is minimal, as excessive wind can cause drift and reduce effectiveness [18, 19, 20, 123]. Before fogging, large white plastic sheets or funnel-shaped collecting surfaces are placed on the forest floor beneath the canopy. These sheets serve to capture insects knocked down by the insecticide. The size and configuration of the sheets depend on the target sampling area and canopy structure. Once sheets are laid out and secured, fogging is initiated from the periphery of the sample area, directing the insecticide into the canopy to achieve even dispersal. The fogging usually lasts for 5-10 minutes per plot, after which a waiting period of about 30-45 minutes allows insects to fall from the canopy onto the collecting surfaces [50, 194]. After the waiting period, researchers carefully retrieve insects from the collection sheets using forceps or aspirators. Specimens are then transferred into labelled vials containing 70% ethanol for preservation. Each sample is tagged with detailed metadata including GPS coordinates, time, date, weather conditions, and habitat description. In the laboratory, insects are sorted by order typically focusing on pollinator-rich groups like Hymenoptera, Diptera, Lepidoptera, and Coleoptera and identified using morphological keys and, when needed, molecular tools such as DNA barcoding [18, 19, 20, 123]. Though fogging is effective for sampling a broad spectrum of arboreal insect pollinators, it is non-selective and may impact non-target taxa. Therefore, it is most beneficial when combined with other methods such as sweep netting or malaise traps to gain a more comprehensive picture of pollinator diversity and behaviour in mangrove ecosystems. Ethical and ecological considerations must also be weighed when using insecticides, ensuring minimal disruption to the environment and compliance with local regulations [123].

Passive Sampling Methods	
Malaise Traps	Malaise traps are widely recognized as an effective passive sampling method for collecting flying insect pollinators, especially in biodiverse habitats such as mangroves. These tent-like structures intercept insects in flight, directing them upward toward a collecting container, typically a jar containing 70-95% ethanol or another killing and preservative agent. The step-by-step deployment of malaise traps in mangrove ecosystems involves careful planning to ensure optimal trap placement, minimal environmental disruption, and maximum capture efficiency [118, 178]. The first step in setting up malaise traps is to identify suitable locations within the mangrove forest, ideally near flowering trees or shrubs that attract pollinators. Traps are installed along flight corridors, such as natural clearings or trails, where insects are likely to move [18, 19, 20]. In mangroves, traps are often placed at the interface of land and water, or at different canopy levels, depending on the research focus. Ensuring that the trap entrance is aligned perpendicular to the direction of insect movement increases interception rates [59, 60]. The base of the trap is secured with stakes or tied to roots or trunks, which is particularly important in tidal zones where water levels fluctuate. The collecting bottle at the top of the trap is filled with ethanol and may include a drop of detergent to reduce surface tension and prevent insect escape. Once deployed, traps should remain undisturbed for a set period, commonly 24 to 72 hours or longer, depending on the sampling regime and environmental conditions. During sampling, researchers should monitor the traps daily to ensure they are intact, functioning, and not flooded or obstructed by vegetation. Specimens collected are retrieved periodically and transferred into labelled vials, recording essential data such as date, time, location (using GPS), habitat characteristics, and prevailing weather conditions [105]. In the laboratory, samples are sorted and identified to order or morpho-species levels using dichotomous keys and reference materials. Special attention is given to pollinator-relevant groups such as Hymenoptera (e.g., bees and wasps), Diptera (e.g., syrphid flies), and Lepidoptera (e.g., moths and butterflies). In cases of uncertainty, images are captured for expert identification or molecular techniques like DNA barcoding is used to resolve species-level identity [81]. Malaise trap data contribute significantly to understanding insect pollinator diversity, temporal activity, and spatial distribution, making them invaluable for biodiversity assessments and conservation strategies in mangrove ecosystems [18, 19, 20, 38].
Pan Traps	Pan trapping is a widely used passive sampling technique for surveying insect pollinators, particularly in diverse and structurally complex ecosystems such as mangroves. This method employs shallow, coloured bowls (commonly yellow, blue, and white) filled with a preservative solution to attract and capture visually oriented pollinators like bees, flies, and wasps. The effectiveness of pan traps relies on the contrasting colours, which mimic floral cues and attract pollinators searching for nectar sources [26, 187, 188, 189]. The step-by-step procedure for setting up pan traps begins with selecting appropriate trapping sites within the mangrove habitat. Locations are open enough to allow visibility of the traps while being near flowering vegetation to increase the likelihood of pollinator presence. In tidal mangrove environments, elevated platforms or floating devices may be necessary to stabilize pan traps above water or in areas with fluctuating water levels [141]. Traps are spaced at regular intervals, usually 5 to 10 meters apart to reduce trap interference and ensure spatial coverage. A randomized or transect-based design is often used for statistical robustness [196]. Each pan trap consists of a plastic bowl, typically 15-20 cm in diameter, painted or manufactured in UV-reflective yellow, blue, or white. These colours are selected based on their known attractiveness to different pollinator groups [30, 149]. The bowls are filled with a soapy water solution or a mix of water and propylene glycol to reduce surface tension and preserve captured insects. Adding a small amount of unscented detergent helps ensure insects sink upon contact and are not able to escape. Traps are placed flush with the vegetation or on raised stands to mimic flower height, which enhances sampling efficiency [42, 43]. Traps are usually left in place for 4-8 hours during peak insect activity, often between 08:00 a.m. and 04:00 p.m., or are deployed for a full 24-hour cycle depending on research goals and environmental conditions. After collection, the contents of each bowl are sieved and transferred into

	labelled vials containing 70% ethanol. Field data, including GPS coordinates, date, time, weather conditions, and habitat descriptions, are recorded for each trap. In the laboratory, the specimens are sorted and identified to morpho-species or species level using taxonomic keys and guides. Colour patterns, wing venation, and body morphology are commonly used diagnostic traits. For difficult identifications, molecular tools such as DNA barcoding is employed [81]. Pan trapping provides a standardized and cost-effective method for monitoring pollinator diversity, abundance, and spatial distribution in mangrove ecosystems [159].
Light Traps	Light traps are a valuable method for sampling nocturnal insect pollinators, especially moths and beetles, which are active after sunset in mangrove ecosystems. These traps function by attracting insects using a light source typically UV or LED lights which lures insects toward the trap where they are captured for subsequent identification and analysis. The effectiveness of light traps is well-documented in tropical and subtropical environments, including mangroves, due to their ability to collect a wide array of taxa active during twilight and nighttime [91, 123]. To begin setting up a light trap, an appropriate sampling location must be chosen. Ideal locations are open areas within or adjacent to the mangrove forest where visibility of the light source is unobstructed by dense vegetation. Light traps are placed at least 50 meters apart if deploying multiple traps, to minimize overlap in the attraction range [23]. Setting the traps in elevated positions, such as on poles or tripods, may enhance visibility and increase capture rates, especially for canopy-dwelling insects. The next step involves assembling the trap. A typical light trap setup includes a light source, such as a UV fluorescent bulb or LED light, powered by batteries or a generator, and a collecting apparatus, usually a funnel leading into a container or bag. Below the light source, a white sheet or reflective surface is often placed to maximize light diffusion and increase visual attraction [13, 23]. The collection container may contain a killing or preserving agent like ethanol or a dry chamber lined with mesh or egg cartons to minimize damage to specimens. Traps are set up at dusk and left operational throughout the night, typically from 6:00 p.m. to 6:00 a.m. as most nocturnal pollinators are active during this period. Weather conditions must be recorded, as wind, rain, and moonlight significantly affect insect activity and trap success [131]. After the collection period, specimens are carefully removed and transferred into labeled vials with ethanol for preservation. Each vial must include metadata such as trap location, date, time, temperature, and surrounding flora, to support ecological interpretation. In the laboratory, specimens are sorted and identified to morpho-species or species level, focusing primarily on orders such as Lepidoptera and Coleoptera, which include many nocturnal pollinators. Identification is aided by field guides, dichotomous keys, and, if needed, DNA barcoding for precise taxonomic resolution [81]. Light trapping is particularly effective when combined with other sampling techniques, providing a more comprehensive understanding of insect pollinator communities in mangrove habitats [123].
Pitfall Traps	Pitfall traps are a widely used passive sampling method designed to capture ground-dwelling insects, including pollinators such as certain species of ants and beetles that forage at or near the ground level. While pitfall traps are not as commonly associated with traditional flower-visiting pollinators like bees and butterflies, they are effective in mangrove ecosystems where ground-level floral resources or exposed mudflats may attract ground-active pollinators and their associates [123, 194]. The method is simple, cost-effective, and allows for continuous sampling over extended periods. The procedure for setting up pitfall traps in mangroves begins with selecting suitable sites along the forest floor, ideally in areas adjacent to or beneath flowering mangrove species, fallen logs, and other ground features that attract insect activity. Each pitfall trap typically consists of a plastic cup or container (7-10 cm in diameter and 9-12 cm deep) sunk flush with the ground surface so that insects walking across the substrate fall directly into it [74]. In mangrove environments, it is critical to choose slightly elevated microhabitats or set up traps during low-tide periods to avoid flooding. To preserve captured specimens and deter predation, the cups are partially filled with a preservative solution such as 70% ethanol or a non-toxic alternative like a saturated salt solution with a few drops of detergent to reduce surface tension [110].

	Traps are spaced systematically, often 5 to 10 meters apart depending on the size of the sampling area, and replicated across different microhabitats [123]. To prevent debris or rainwater from entering the traps, a raised rain cover (e.g., a plastic plate or leaf canopy) is suspended above the trap using wire or small sticks. Traps are generally left in the field for 24 to 72 hours, depending on study objectives and environmental conditions. Longer deployment times may increase specimen yield but also risk trap overflow or contamination, especially in dynamic tidal habitats. After collection, trap contents are filtered through a sieve or mesh, and captured insects are preserved in labelled vials containing ethanol. In the laboratory, specimens are sorted, typically to the order or morpho-species level, using stereomicroscopes and identification keys [18, 19, 20]. GPS coordinates, habitat characteristics, date, and environmental data (e.g., temperature, tide stage, and canopy cover) are recorded for each trap location to facilitate spatial analysis and ecological interpretation. Despite their simplicity, pitfall traps can yield valuable insights into the composition and activity patterns of ground-active pollinators and their predators, contributing to a more holistic understanding of pollinator assemblages in complex habitats like mangroves. When used in conjunction with aerial and floral sampling techniques, pitfall traps enhance the completeness of pollinator inventories [194].
Sticky Traps	Sticky traps are a simple yet effective passive method for sampling flying insect pollinators in habitats such as mangroves. These traps use brightly colored surfaces coated with a sticky adhesive to attract and capture insects that come into contact with them. Sticky traps are particularly effective for monitoring insect pollinator activity and diversity, especially for small-bodied species such as certain Diptera (flies) and Hymenoptera (bees and wasps) that are drawn to visual stimuli [159, 187, 188, 189]. The ease of deployment and low cost make sticky traps a popular tool for ecological monitoring in both terrestrial and coastal environments. To set up sticky traps in mangrove ecosystems, the first step involves selecting appropriate trap colours. Yellow is the most commonly used colour because it mimics floral signals and has been shown to be highly attractive to a wide range of pollinators. However, other colours such as blue and white are used in conjunction to increase taxonomic coverage [26]. Sticky traps are purchased commercially or made by coating coloured plastic cards or boards with a non-drying adhesive, such as Tangle-Trap or petroleum jelly. These traps are placed at or slightly above the height of the surrounding mangrove flowers to align with the typical flight paths of foraging pollinators. Next, traps are installed in selected sampling plots within the mangrove forest, ideally near flowering vegetation. Traps are affixed to wooden stakes, suspended from tree branches, or mounted on poles, depending on the structure of the vegetation and tidal conditions. In tidal zones, it is essential to secure traps at a height that avoids submersion during high tide. Sticky traps are spaced at consistent intervals, typically 5-10 meters apart, depending on the study design. It is best to deploy traps during periods of expected high pollinator activity, usually in the morning, and leave them in place for 24 to 48 hours to ensure sufficient capture while minimizing the accumulation of debris [30, 149]. Once the sampling period ends, the traps are carefully removed and stored in protective covers or between sheets of wax paper for transport. Insects are later identified either directly on the sticky surface using a stereomicroscope or, if necessary, carefully removed using a solvent and forceps for further analysis. Morphological identification is done using keys and reference collections, while DNA barcoding is used for species that are difficult to identify morphologically [81]. Researchers must record metadata for each trap including GPS location, date, trap colour, weather conditions, and plant species present, all of which influence insect visitation patterns. Sticky traps offer a non-invasive and standardized approach to monitor pollinator diversity, abundance, and spatial distribution in mangrove ecosystems. When used in combination with other methods such as sweep netting or malaise traps, sticky traps help provide a more complete picture of pollinator communities and their ecological roles [26, 159].
Window Traps	Window traps, also known as flight-intercept traps, are widely used in entomological studies for sampling flying insects, including pollinators, in natural habitats such as mangroves. These traps function by intercepting the flight path of insects with a vertical transparent or semi-transparent barrier, which causes the insects to fall into a collecting container placed below. Setting up window traps in mangrove environments involves a

	series of structured steps to ensure reliable and standardized sampling. First, appropriate sites must be selected typically near flowering trees or along open flyways where pollinators are likely to travel. Once sites are chosen, the trap is constructed using a vertical sheet of clear acrylic, plastic, or mesh mounted between two poles. The base of the trap is fitted with a collecting container filled with a preservative solution such as 70% ethanol or a water-detergent mixture to kill and preserve the insects upon capture [166]. The trap is installed at a height that aligns with the natural flight height of pollinators, generally about 1.5 to 2 meters above ground. It is essential to ensure that the trap is securely anchored to withstand wind or water movement typical of coastal environments. The duration for which the trap remains in place typically ranges from 24 to 72 hours, depending on the objectives of the study and environmental conditions. Once the sampling period concludes, the contents of the collecting container are transferred into labelled vials for transport and further analysis. Each vial is tagged with essential metadata, including the date, time, GPS location, and habitat characteristics. In the lab, the insect specimens are sorted and identified using morphological keys, and in some cases, DNA barcoding may be used for precise identification methods [18, 19, 20, 123, 166]. Window traps are especially advantageous in mangrove studies because they offer a passive, non-attractive means of sampling a broad range of flying insects, minimizing biases that may occur with colour or scent-based traps like pan traps or bait stations. Furthermore, studies have shown that window traps effectively capture a diverse range of taxa, including species that are typically underrepresented in other sampling methods [18, 19, 20, 123, 166]. This makes them a valuable tool for ecological surveys aimed at understanding pollinator diversity and ecosystem health in mangrove habitats.
Emergence Traps	Emergence traps are a specialized method used to capture insects as they transition from their immature to adult stages, providing insights into the breeding and developmental habitats of pollinators within ecosystems like mangroves. This method is particularly useful in detecting pollinators that emerge from specific substrates such as soil, decaying wood, or plant material habitats commonly found in mangrove environments. By capturing insects at the point of emergence, researchers are better able to link pollinators to their larval habitats and life cycles, enhancing ecological understanding [123, 194]. To set up emergence traps in mangroves, the first step involves identifying suitable substrates where insect emergence is likely to occur. These may include decomposing mangrove logs, leaf litter accumulations, sediment surfaces, or pneumatophores (aerial roots) of mangrove species. A variety of trap designs exist, but the most commonly used is the tent-like or dome-shaped emergence trap, which is constructed of fine mesh material supported by a frame that encloses the substrate area. The trap is sealed around the base using soil, sandbags, or waterproof tape to prevent the escape of emerging insects and to avoid intrusion from external sources [18, 19, 20, 40, 42]. Once the trap is set, a collecting head or container is placed at the top or apex of the structure. This container, often fitted with a transparent section to attract insects upward, contains a killing or preserving agent such as 70% ethanol. Insects, upon emergence and guided by light, ascend through the trap and are collected in the container. In mangrove environments where water levels fluctuate, it is critical to elevate traps or place them during low tide to prevent waterlogging or disturbance [123]. Traps are typically left in the field for periods ranging from several days to a few weeks, depending on environmental conditions and study objectives. Frequent checks are needed to ensure that the collection containers are functional and that ethanol levels are maintained. After collection, specimens are transported to the laboratory for sorting and identification. Morphological identification is carried out using field guides and taxonomic keys, while DNA barcoding may be employed for ambiguous specimens [81]. Emergence traps are particularly effective for understanding seasonal and habitat-specific emergence patterns of insects, allowing researchers to correlate life stages with microhabitat features in mangroves. When combined with other active and passive sampling methods such as sweep netting or pan trapping, emergence traps help provide a more comprehensive assessment of pollinator biodiversity [18, 19, 20, 194].

Active sampling methods (Table 6) require direct participation by researchers and allow targeted collection of insects from specific microhabitats such as flowers, foliage, and canopy layers. Techniques including sweep netting, aerial netting, beat sampling, hand collecting, vacuum sampling, bait stations, and fogging are typically performed during peak insect activity periods, particularly in the morning and late afternoon when environmental conditions favor pollinator foraging. These methods involve systematic field procedures, such as standardized sweeping motions, careful interception of flying insects, dislodging arthropods from vegetation, or attracting pollinators using bait. Once captured, specimens are preserved in ethanol and labeled with detailed metadata, including date, time, geographic coordinates, and associated plant species. Such information is crucial for linking insect occurrences with environmental variables and floral resources within the mangrove ecosystem.

Passive sampling methods (Table 6), in contrast, operate continuously without direct human interaction during the sampling period and rely on natural insect movement or behavior. Methods such as Malaise traps, pan traps, light traps, pitfall traps, sticky traps, window traps, and emergence traps are strategically placed within the mangrove habitat to intercept insects over extended time intervals. These traps are particularly useful for capturing a broader range of insect taxa, including nocturnal species, ground-dwelling arthropods, and small flying pollinators that may be overlooked by active methods. After retrieval, specimens collected from these traps undergo similar preservation and identification procedures in the laboratory. By integrating both active and passive sampling approaches, the procedures outlined in Table 5 provide a comprehensive methodological framework for assessing insect pollinator diversity, ecological interactions, and temporal dynamics within mangrove ecosystems.

A critical evaluation of active versus passive sampling methods in mangrove ecosystems reveals that no single approach is universally superior; rather, methodological effectiveness is contingent upon insect behavior, ecological niche, and the taxonomic composition of target groups. Consequently, a synchronized, integrative sampling framework is essential for accurately characterizing insect pollinator diversity and function.

Active sampling methods, such as, sweep netting, aerial netting, beat sampling, hand collecting, vacuum sampling, bait stations, and fogging, are inherently selective and researcher-driven, enabling targeted collection of specific insect orders. For example, sweep and aerial netting are particularly effective for Hymenoptera (bees and wasps), Lepidoptera (butterflies), and Diptera (flies), as these taxa are visually detected during floral visitation. Similarly, beat sampling enhances detection of foliage-associated taxa such as Coleoptera and Hemiptera, which may otherwise be underrepresented. Vacuum sampling further improves capture efficiency for small-bodied or cryptic Diptera and Hymenoptera, while fogging uniquely accesses canopy-dwelling assemblages across multiple order.

The principal advantage of active methods lies in their ability to generate high-quality ecological data, including behavioral observations, plant-pollinator interactions, and temporal activity patterns. This is particularly important in mangrove systems, where pollination ecology is shaped by spatial heterogeneity and tidal influences. However, these methods are labor-intensive, prone to observer bias, and may under-sample less conspicuous or nocturnal taxa. Fogging, while highly comprehensive, introduces ethical and ecological concerns due to its non-selective insecticidal impact.

In contrast, passive sampling methods, including: malaise traps, pan traps, light traps, pitfall traps, sticky traps, window traps, and emergence traps, operate continuously and minimize human interference, thereby reducing sampling bias. Malaise and window traps are highly effective for intercepting flying Diptera and Hymenoptera, while pan traps selectively attract visually oriented pollinators, particularly bees. Light traps complement these approaches by targeting nocturnal Lepidoptera and certain Coleoptera, thereby addressing diel sampling gaps. Pitfall traps extend coverage to ground-active taxa such as ants (Hymenoptera) and beetles (Coleoptera), whereas emergence traps uniquely link insect life stages to mangrove substrates.

Despite their efficiency and standardization, passive methods exhibit inherent biases related to trap design, color attraction, and placement. For instance, pan and sticky traps may over represent small-bodied Diptera while under-sampling larger or behaviorally cautious taxa. Furthermore, passive traps generally lack behavioral context, limiting ecological interpretation.

The choice of sampling method is therefore driven by research objectives. Active methods are preferentially selected when detailed behavioral or interaction-based data are required, particularly for dominant pollinator groups like Hymenoptera and Lepidoptera. Conversely, passive methods are employed for long-term monitoring, biodiversity assessments, and capturing elusive or nocturnal taxa. In mangrove ecosystems, where insect assemblages are vertically and temporally stratified, combining both approaches ensure comprehensive taxonomic coverage and reduces methodological bias.

In synthesis, the effectiveness of insect sampling in mangroves depends on methodological complementarity. Active methods provide precision and ecological depth, while passive methods offer breadth and standardization. Their integration is thus critical for robust, unbiased assessments of pollinator diversity, community structure, and ecosystem function.

6. Trends in Publication

Figure 2 illustrate the five-yearly trends in the number of research publications from 1950 to 2025 addressing the topic of “insect pollinators among mangrove species.”

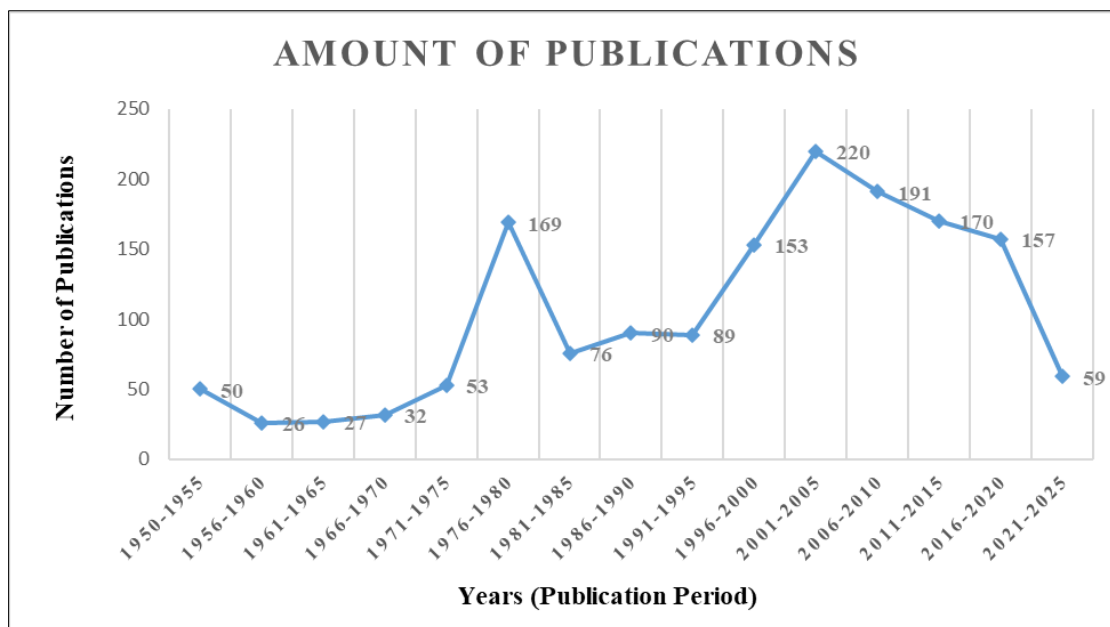


Figure 2 Number of publications on insect pollinators among mangrove species from 1950 to 2025 (five-year interval)

The temporal analysis of publications from 1950 to 2025 reveals a clear evolution in research activity, characterized by distinct phases of emergence, expansion, consolidation, and recent decline.

Between 1950 and 1960, publication output was relatively low, with 50 papers recorded during 1950-1955 followed by a marked decline to 26 papers in 1956-1960. This early period likely reflects the nascent stage of research in the field, limited methodological tools, and lower global scientific attention. From 1961 to 1970, publication numbers remained modest (27-32 papers), indicating slow but steady progress. A noticeable increase occurred during 1971-1975, with publications rising to 53, suggesting growing recognition of the topic and the beginning of more systematic investigations.

A major shift in research intensity is evident from 1976-1980, when publications surged dramatically to 169 papers. This sharp increase represents a turning point, likely driven by advances in research methodologies, improved access to scientific journals, and increased environmental and ecological awareness. Although there was a temporary decline in 1981-1985 (76 papers), publication output stabilized and gradually increased again during 1986-1995 (89-90 papers).

The period from 1996 to 2005 marks the peak phase of scholarly productivity. Publications rose substantially to 153 papers in 1996-2000 and reached their highest level in 2001-2005 with 220 papers. This peak suggests heightened global research interest, possibly influenced by international research programs, interdisciplinary integration, and increased funding opportunities.

Following the peak, a gradual decline is observed from 2006 onwards. Although publication numbers remained relatively high in 2006-2010 (191 papers) and 2011-2015 (170 papers), the downward trend continued into 2016-

2020 (157 papers). This pattern may indicate a maturation of the field, where foundational questions had largely been addressed, leading to more specialized or integrative studies rather than a high volume of new publications.

The most recent interval (2021-2025) shows a pronounced reduction in publication output, with only 59 papers recorded. This decline is interpreted cautiously, as it may reflect incomplete indexing for recent years, publication delays, or shifts in research priorities rather than a true decrease in scientific interest.

Collectively, the dataset of 1,562 publications demonstrates a long-term trend of initial slow growth, followed by rapid expansion and peak productivity in the late 20th and early 21st centuries, and a subsequent stabilization with a recent apparent decline. These trends highlight the dynamic nature of research development over time and underscore how scientific output is influenced by technological advances, funding availability, and broader global research priorities.

7. Conclusion

Mangrove ecosystems represent ecologically complex coastal environments where plant–pollinator interactions play a critical role in sustaining reproductive processes, maintaining genetic diversity, and supporting overall ecosystem stability. This study synthesized contemporary scientific literature on insect pollination in mangrove ecosystems and developed an integrated methodological framework designed to guide future investigations of insect-mangrove interactions. The systematic review of peer-reviewed studies highlighted that, although mangrove pollination has been examined in several tropical regions, substantial knowledge gaps remain regarding pollinator diversity, community composition, and ecological dynamics within neotropical mangrove systems, particularly along the Guyanese coastline.

The findings demonstrate that a comprehensive understanding of mangrove pollination networks requires the integration of spatial technologies with standardized ecological sampling protocols. The proposed methodological framework, incorporating Geographic Information Systems (GIS), remote sensing, UAV-based habitat assessment, and structured field sampling, provides a robust approach for documenting insect pollinator assemblages and evaluating their interactions with dominant mangrove species such as *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*. The combined use of active and passive sampling techniques further enhances the ability to capture a wide spectrum of insect taxa, thereby improving the accuracy and representativeness of biodiversity assessments.

Importantly, the study underscores the ecological sensitivity of mangrove pollination systems to environmental disturbances, including coastal development, habitat fragmentation, climate variability, and other anthropogenic pressures. Disruptions to pollinator communities may compromise mangrove reproductive success and, consequently, the long-term resilience of these coastal ecosystems. Establishing baseline data on pollinator diversity and activity patterns is therefore essential for informing conservation strategies, ecosystem management, and biodiversity monitoring initiatives.

Overall, this research contributes to addressing the regional deficit of scientific information on mangrove pollination ecology by providing both a synthesized body of knowledge and a structured methodological approach for future studies. The framework developed in this study can serve as a foundation for long-term ecological monitoring, facilitate more rigorous assessments of insect pollinator communities, and support evidence-based conservation policies aimed at protecting mangrove ecosystems and the ecological services they provide. Continued interdisciplinary research integrating ecology, spatial analysis, and biodiversity assessment will be crucial for advancing the understanding and sustainable management of mangrove–pollinator interactions in tropical coastal environments.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors certify that this submission is original work and is not under review at any other publication. The authors hereby declare that this manuscript does not have any conflict of interest.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Statement of informed consent

The authors declare that informed consent was obtained from all individual participants included in the study. All work utilized in this study was fully cited and referenced so authors of prior researches are given their due credentials for their work.

Data Availability

Data will be made available on request.

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References

- [1] Adeduntan, S. A., & Olusola, J. A. (2015). Diversity and abundance of insects associated with selected mangrove plants in the Niger Delta, Nigeria. *Journal of Entomology and Zoology Studies*, 3(2), 176–180.
- [2] Alexander, H. M.; Foster, B. L.; Ballantyne IV, F.; Collins, C. D.; Antonovics, J. & Holt, R. D. (2011). Metapopulations and metacommunities: combining spatial and temporal perspectives in plant ecology. *Journal of Ecology*. <https://doi.org/10.1111/j.1365-2745.2011.01917.x>.
- [3] Alongi, D. M. (2002). Present state and future of the world's mangrove forests. *Environmental Conservation*, 29(3), 331–349. <https://doi.org/10.1017/S0376892902000231>.
- [4] Aluri, J. S. R. (1990). Observations on the floral biology of certain mangroves. *Proceedings of the Indian National Science Academy*, 56(4), 367–374.
- [5] Aluri, J. S. R., Subba Rao, P. V. S., & Kumar, R. (2012). Pollination ecology of mangroves: a review. *International Journal of Plant Reproductive Biology*, 4(1), 1–14.
- [6] Aluri, R. J. S. (1990). Observations on the floral biology of some mangroves. *Journal of Palynology*, 26, 187–199.
- [7] Aluri, R. J. S., Subba Rao, P. V. S., Kumar, R., & Mohan, S. R. (2012). Pollination biology of the mangrove species *Avicennia alba* Blume and *A. marina* (Forsk.) Vierh. from Coringa, Andhra Pradesh, India. *Current Science*, 102(8), 1157–1161.
- [8] Aluri, R. J. V. (1990). Observations on the floral biology of certain mangroves. *Proceedings: Animal Sciences*, 99(2), 145–155. <https://doi.org/10.1007/BF03186358>.
- [9] Aluri, R. J., Subba Rao, P. V. S., & Kumar, R. (1994). Pollination ecology of certain mangroves in Godavari estuary. *Proceedings of the Indian National Science Academy B*, 60, 253–260.
- [10] Aluri, R. J., Subba Rao, P. V. S., Kumar, R., & Mohan, S. R. (2012). Pollination ecology of *Avicennia* species (*Avicenniaceae*). *Journal of Threatened Taxa*, 4(3), 2433–2445. <https://doi.org/10.11609/JoTT.o2926.2433-45>.
- [11] American Museum of Natural History. (2024). Mangrove Threats and Solutions. <https://www.amnh.org/explore/videos/biodiversity/mangroves/mangrove-threats>.
- [12] Arizona State University Biodiversity Knowledge Integration Centre [ASUBKIC]. (2025). *Conocarpus erectus*. [Image]. <https://panamabiota.org/stri/taxa/index.php?taxon=63472&clid=71>.

- [13] Axmacher, J. C., Tünte, H., Schrumpf, M., Müller-Hohenstein, K., Lyaruu, H. V. M., & Fiedler, K. (2004). Diverging diversity patterns of vascular plants and geometrid moths during forest regeneration on Mt. Kilimanjaro, Tanzania. *Journal of Biogeography*, 31(6), 895–904. <https://doi.org/10.1111/j.1365-2699.2004.01089.x>.
- [14] Balen, J. van, & McCoy, E. D. (2002). Use of GPS and GIS in ecological field studies. In S. A. Levin (Ed.), *The encyclopedia of biodiversity* (Vol. 3, pp. 403–414). Academic Press.
- [15] Banerjee, D., & Pramanik, A. (2019). Diversity and ecology of thrips (Thysanoptera) in Indian Sundarbans mangroves. *Journal of Entomological Research*, 43(4), 479–488. <https://doi.org/10.5958/0974-4576.2019.00075.4>.
- [16] Banerjee, S., Aditya, G., & Saha, G. K. (2013). Mosquitoes in mangrove wetlands: A study in Indian Sundarbans. *International Journal of Mosquito Research*, 3, 22–28.
- [17] Barraza, L., Ramírez-Amezcu, Y., & Ruíz-Sánchez, E. (2018). Taxonomic identity of mangrove species in the Neotropics. *Systematic Botany*, 43(1), 275–289. <https://doi.org/10.1600/036364418X696939>.
- [18] Basset, Y., Hammond, P. M., Barrios, H., Holloway, J. D., & Miller, S. E. (2003). Vertical stratification of arthropod assemblages. *Annual Review of Entomology*, 48, 89–110.
- [19] Basset, Y., Missa, O., Alonso, A., Miller, S. E., Curletti, G., De Meyer, M., Wagner, T., Lovell, D., & Novotny, V. (2003). Arthropod diversity and community structure in a tropical forest. *Science*, 300(5625), 1692–1694. <https://doi.org/10.1126/science.1084524>.
- [20] Basset, Y., Novotny, V., Miller, S. E., & Kitching, R. L. (2003). *Arthropods of tropical forests: Spatio-temporal dynamics and resource use in the canopy*. Cambridge University Press.
- [21] Bhagarathi, L. K. & Da Silva, P. N. B. (2024). Impacts and implications of anthropogenic activities on mangrove forests: A review. *Magna Scientia Advanced Research and Reviews*, 2024, 11(01), 040–059. eISSN: 2582-9394, DOI: 10.30574/msarr.2024.11.1.0074.
- [22] Borror, D. J., & White, R. E. (1998). *A field guide to insects: America north of Mexico* (Rev. ed.). Houghton Mifflin Harcourt.
- [23] Brehm, G., & Axmacher, J. C. (2006). A comparison of manual and automatic moth sampling methods (Lepidoptera: Arctiidae) in a montane rainforest in southern Ecuador. *Environmental Entomology*, 35(3), 757–764. <https://doi.org/10.1603/0046-225X-35.3.757>.
- [24] Brown, B. V., Borkent, A., Cumming, J. M., et al. (2009). *Manual of Central American Diptera*, Volume 1. NRC Research Press.
- [25] Bryman, A. (2016). *Social research methods* (5th ed.). Oxford University Press.
- [26] Campbell, J. W., & Hanula, J. L. (2007). Efficiency of Malaise traps and colored pan traps for collecting flower-visiting insects from three forested ecosystems. *Journal of Insect Conservation*, 11(4), 399–408. <https://doi.org/10.1007/s10841-006-9048-1>.
- [27] Cary Institute of Ecosystem Studies. (n.d.). Beat sampling. <https://www.caryinstitute.org/eco-inquiry/teaching-materials/biodiversity/beat-sampling>.
- [28] Chatterjee, D. & Remadevi, O. K. (2013). Diversity and ecological role of insect flower visitors in the pollination of *Avicennia officinalis* L. *Current Science*, 105(2), 166–168.
- [29] Chatterjee, T., Sahu, N., Pal, S., et al. (2024). Unveiling the association of mangrove flowering phenology on the dynamics of insect abundance. *Acta Oecologica*, 125, 103112. <https://doi.org/10.1016/j.actao.2024.103112>.
- [30] Chew, K. H., Chong, K. Y., Tan, H. T. W., & Leong, T. M. (2011). An updated checklist of mangrove-associated beetles in Singapore. *Nature in Singapore*, 4, 237–248.
- [31] Chung, A. Y. C., & Mohamed, M. (1993). Insect diversity in Malaysian mangroves. *Journal of Tropical Forest Science*, 5(4), 528–537.
- [32] Conrad, J. (2011). WHITE MANGROVE. [Image]. <https://backyardnature.net/yucatan/white-mv.htm>.
- [33] Cooperative Taxonomic Resources for American Myrtaceae [CoTRAM]. (2025). *Laguncularia racemose*. [Image]. <https://cotram.org/taxa/index.php?taxon=20897&clid=400>.
- [34] Corbet, P. S. (1999). *Dragonflies: Behavior and ecology of Odonata*. Cornell University Press.

- [35] Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed method approaches* (5th ed.). SAGE Publications.
- [36] Cumberlidge, N., et al. (2005). Ecology and distribution of mangrove ants in Kenya. *African Journal of Ecology*, 43, 220–227.
- [37] Dahdouh-Guebas, F., Jayatissa, L. P., Di Nitto, D., Seen, D. L., & Koedam, N. (2005). How effective were mangroves as a defense against the recent tsunami? *Current Biology*, 15(12), R443–R447. <https://doi.org/10.1016/j.cub.2005.06.008>.
- [38] Darling, D. C., & Packer, L. (1988). Effects of trap design on insect capture in malaise traps. *Canadian Entomologist*, 120(8), 787–796. <https://doi.org/10.4039/Ent120787-8>.
- [39] de Souza, A. M., Costa, M. F. & Barbosa, J. C. (2021). Microplastic ingestion by honeybees: A novel concern for pollinator health. *Environmental Pollution*, 289, 117936.
- [40] Debnath, P., Hazra, N., & Bhattacharyya, S. (2021). Diversity and distribution of Diptera in Indian mangrove ecosystems. *Journal of Entomological Research*, 45, 93–104.
- [41] Discover Texas Real Food. (2021). How to use an insect sweep net. <https://discover.texasrealfood.com/homesteaders-toolbox/how-to-use-an-insect-sweep-net>.
- [42] Droege, S., Engler, J. D., Sellers, E., & O'Brien, L. (2010). National protocol framework for the inventory and monitoring of bees. U.S. Geological Survey. <https://pubs.usgs.gov/of/2010/1175/pdf/ofr2010-1175.pdf>.
- [43] Droege, S., Engler, J. D., Sellers, E., & O'Brien, L. (2016). *Bees of Maryland: A field guide*. Maryland Department of Natural Resources.
- [44] D'Souza, D., & Pai, I. K. (2019). Diversity and habitat association of odonates in coastal wetlands of Goa, India. *Journal of Threatened Taxa*, 11(13), 14707–14719.
- [45] Duke, N. C. (1991). A systematic revision of the mangrove genus *Avicennia* (Avicenniaceae) in Australasia. *Australian Systematic Botany*, 4(2), 299–324.
- [46] Duke, N. C. (1992). Mangrove floristics and biogeography. In A. I. Robertson & D. M. Alongi (Eds.), *Tropical Mangrove Ecosystems* (pp. 63–100). American Geophysical Union.
- [47] Duke, N. C., Ball, M. C., & Ellison, J. C. (1998). Factors influencing biodiversity and distributional gradients in mangroves. *Global Ecology and Biogeography Letters*, 7(1), 27–47.
- [48] Duke, N. C., Kovacs, J. M., Griffiths, A. D., Paling, E. I., Hauff, R. D., Hill, D. J. E., Olagoke, A. O., Dale, P. E. R., Mackenzie, J. R., & Wood, A. L. (2021). Mangrove ecosystems: A global biogeographic perspective on the ecology and conservation of the world's most threatened tropical forests. *Global Ecology and Conservation*, 28, e01788. <https://doi.org/10.1016/j.gecco.2021.e01788>.
- [49] Elzinga, C. L., Salzer, D. W., Willoughby, J. W., & Gibbs, J. P. (2001). *Monitoring plant and animal populations*. Blackwell Science.
- [50] Erwin, T. L. (1982). Tropical forests: Their richness in Coleoptera and other arthropod species. *The Coleopterists Bulletin*, 36(1), 74–75.
- [51] Fadamiro, H. Y., & Nwanguma, E. I. (2013). Diversity of insects in mangrove forests in Nigeria. *International Journal of Biological and Chemical Sciences*, 7, 1579–1586.
- [52] Farnsworth, E. J., & Ellison, A. M. (1996). Scale-dependent spatial and temporal variability in biogeography of mangrove root epibiont communities. *Ecological Monographs*, 66(1), 45–66.
- [53] Fatoyinbo, T. E., Simard, M., Washington-Allen, R. A., & Shugart, H. H. (2008). Landscape-scale extent, height, biomass, and carbon estimation of Mozambique's mangrove forests with Landsat ETM+ and Shuttle Radar Topography Mission elevation data. *Journal of Geophysical Research: Biogeosciences*, 113(G2). <https://doi.org/10.1029/2007JG000551>.
- [54] Fernando, E. S. (1995). Mangrove biodiversity: A Southeast Asian perspective. *Asia-Pacific Biodiversity Review*, 1, 1–7.
- [55] Ferrington, L. C. (2008). Global diversity of non-biting midges (Chironomidae; Insecta-Diptera) in freshwater. *Hydrobiologia*, 595, 447–455.
- [56] Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). SAGE Publications.

- [57] Fisher, B. L., & Bolton, B. (2016). *Ants of Africa and Madagascar: A Guide to the Genera*. University of California Press.
- [58] Food and Agriculture Organization of the United Nations [FAO]. (2007). *The world's mangroves 1980–2005*. Chapter 6: North and Central America.
- [59] Fraser, S. E., Dytham, C., & Mayhew, P. J. (2008). The effectiveness and optimization of sampling methods for estimating species richness of Hymenoptera in tropical forests. *Journal of Insect Conservation*, 12, 1–14. <https://doi.org/10.1007/s10841-006-9050-y>.
- [60] Fraser-Smith, S. (2009). Black Mangrove (*Avicennia germinans*). [Image]. https://www.inaturalist.org/guide_taxa/372219.
- [61] Furtak, K. & Wolińska, A. (2023). The impact of extreme weather events as a consequence of climate change on the soil moisture and on the quality of the soil environment and agriculture – A review. *CATENA*, Volume 231, October 2023, 107378.
- [62] Galloni, M., et al. (2020). *Citizen Science Handbook: Life 4 Pollinators*. European Commission LIFE Programme. <https://www.life4pollinators.eu>.
- [63] Ganguly, A., Das, S., & Chakraborty, S. (2020). Pollination biology of mangrove species in Indian Sundarbans: Role of insects and flowering phenology. *Tropical Ecology*, 61(4), 498–509. <https://doi.org/10.1007/s42965-020-00086-6>.
- [64] Gardenia.net. (2025). *Avicennia germinans* (Black Mangrove). [Image]. <https://www.gardenia.net/plant/avicennia-germinans>.
- [65] Gardenia.net. (2025). *Conocarpus-erectus* (Buttonwood). [Image]. <https://www.gardenia.net/plant/conocarpus-erectus>.
- [66] Gardenia.net. (2025). *Laguncularia-racemosa* (White Mangrove). [Image]. <https://www.gardenia.net/plant/laguncularia-racemosa>.
- [67] Gardenia.net. (2025). *Rhizophora mangle* (Red Mangrove). [Image]. <https://www.gardenia.net/plant/rhizophora-mangle>.
- [68] Ghosh, S. K., & Sen-Sarma, P. K. (2003). Insect pollinators of mangroves from Sunderbans, India. *Indian Journal of Forestry*, 26, 39–43.
- [69] Giri, C., Ochieng, E., Tieszen, L. L., Zhu, Z., Singh, A., Loveland, T., ... & Duke, N. (2011). Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography*, 20(1), 154–159. <https://doi.org/10.1111/j.1466-8238.2010.00584.x>.
- [70] Godfray, H. C. J. (1994). *Parasitoids: Behavioral and Evolutionary Ecology*. Princeton University Press.
- [71] Gordon, C. (n.d.). *METEOROLOGY IN GUYANA*. https://cimh.edu.bb/cami/files/met_in_guyana.pdf.
- [72] Gotelli, N. J., & Ellison, A. M. (2013). *A primer of ecological statistics* (2nd ed.). Sinauer Associates.
- [73] Goulet, H., & Huber, J. T. (1993). *Hymenoptera of the World: An Identification Guide to Families*. Agriculture Canada.
- [74] Greenslade, P. J. M. (1973). Sampling ants with pitfall traps: Digging-in effects. *Insectes Sociaux*, 20(4), 343–353. <https://doi.org/10.1007/BF02226937>.
- [75] Gressitt, J. L., & Gressitt, M. K. (1962). An improved Malaise trap. *Pacific Insects*, 4(1), 87–90.
- [76] Guevara, J., & Aviles, J. (2009). Field methods for inventorying insects. *ABC Taxa*, 8, 385–406.
- [77] Gullan, P. J., & Cranston, P. S. (2014). *The Insects: An Outline of Entomology* (5th ed.). Wiley-Blackwell.
- [78] Halsch, C. A.; Shapiro, A. M.; Fordyce, J. A. & Forister, M. L. (2021). Insects and recent climate change. *Biological Sciences*. Vol. 118 (2). e2002543117.
- [79] Hayden, W. J. (2025). *Laguncularia racemosa* - White mangrove. Flower. Family Combretaceae. [Image]. <https://www.pinterest.com/pin/485262928592259326/>.
- [80] Hazra, N., & Das, M. K. (2014). Larval habitats and morphology of midges in estuarine mangroves of eastern India. *Oriental Insects*, 48, 97–106.

- [81] Hebert, P. D. N., Cywinska, A., Ball, S. L., & deWaard, J. R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society B: Biological Sciences*, 270(1512), 313–321. <https://doi.org/10.1098/rspb.2002.2218>.
- [82] Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A. L., & Totland, Ø. (2009). How does climate warming affect plant-pollinator interactions? *Ecology Letters*, 12(2), 184–195. <https://doi.org/10.1111/j.1461-0248.2008.01269.x>.
- [83] Hölldobler, B., & Wilson, E. O. (1990). *The Ants*. Harvard University Press.
- [84] Husch, B., Beers, T. W., & Kershaw, J. A. (2003). *Forest mensuration* (4th ed.). John Wiley & Sons.
- [85] Hydrometeorological Service of Guyana [HYDROMET]. (2024). *Weather in Guyana*. <https://www.adventurelife.com/guyana/articles/weather-in-guyana>.
- [86] Hydrometeorological Service of Guyana [HYDROMET]. (n.d.). *Climate of Guyana*. Ministry of Agriculture. <http://hydromet.gov.gy/>.
- [87] iNaturalist Network. (2009). Black Mangrove (*Avicennia germinans*). [Image]. https://www.inaturalist.org/guide_taxa/528628.
- [88] iNaturalist Network. (2009). Laguncularia-racemosa (White Mangrove). [Image]. <https://www.inaturalist.org/taxa/62854-Laguncularia-racemosa>.
- [89] iNaturalist Network. (2025). Black Mangrove (*Avicennia germinans*). [Image]. <https://www.inaturalist.org/taxa/62853-Avicennia-germinans>.
- [90] iNaturalist Network. (2025). Conocarpus erectus (Buttonwood). [Image]. <https://www.inaturalist.org/taxa/62864-Conocarpus>.
- [91] Intachat, J., & Woiwod, I. P. (1999). Trap design for monitoring moth biodiversity in tropical rainforests. *Bulletin of Entomological Research*, 89(2), 153–163. <https://doi.org/10.1017/S0007485399000297>.
- [92] International Panel on Climate Change [IPCC]. (2007). *Synthesis Report*. Pachauri, R. K. & A. Reisinger, eds. 104.
- [93] Islam, M.; Gottlieb, A., Maher, M., Scher, J. & Redford, A. (2024). Combretaceae. [Image]. https://idtools.org/seed_families/index.cfm?packageID=2246&entityID=57794.
- [94] Jamieson, M. A., Burkle, L. A., Manson, J. S., Runyon, J. B., Trowbridge, A. M. & Zientek, J. (2017). Global change effects on plant-insect interactions: The role of phytochemistry. *Current Opinion in Insect Science*, 23, 70–75. <https://doi.org/10.1016/j.cois.2017.07.009>.
- [95] Jensen, J. R. (2007). *Remote sensing of the environment: An Earth resource perspective* (2nd ed.). Pearson Prentice Hall.
- [96] Jones, C. & Smith, P. (2021). Effects of climate change on mangrove pollination. *Climate Change Journal*, 34(2), 78–89.
- [97] Karthik, S.; Reddy, M. M. S. & Yashaswini, G. (2022). Climate Change and Its Potential Impacts on Insect-Plant Interactions, Chapters, in: Stuart Arthur Harris (ed.), *The Nature, Causes, Effects and Mitigation of Climate Change on the Environment*, IntechOpen.
- [98] Kaufmann, T., & Maschwitz, U. (2006). Pollination of *Sonneratia alba* (Sonneratiaceae) by moths in Peninsular Malaysia. *Blumea*, 51, 135–139.
- [99] Kearns, C. A., & Inouye, D. W. (1993). *Techniques for pollination biologists*. University Press of Colorado.
- [100] Kerr, J. T., Pindar, A., Galpern, P., Packer, L., Potts, S. G., Roberts, S. M. & Rasmont, P. (2015). Climate change impacts on bumblebees converge across continents. *Science*, 349(6244), 177–180.
- [101] Kevan, P. G., & Baker, H. G. (1983). Insects as flower visitors and pollinators. *Annual Review of Entomology*, 28, 407–453. <https://doi.org/10.1146/annurev.en.28.010183.002203>.
- [102] King, C., Ballantyne, G., & Willmer, P. G. (2013). Why flower visitation is a poor proxy for pollination: Measuring single-visit pollen deposition, with implications for pollination networks and conservation. *Methods in Ecology and Evolution*, 4(9), 811–818. <https://doi.org/10.1111/2041-210X.12074>.
- [103] Kitching, R. L., Orr, A. G., Thalib, L., Mitchell, H., Hopkins, M. S., & Graham, A. W. (2001). Moth assemblages as indicators of environmental quality in remnants of upland Australian rain forest. *Journal of Applied Ecology*, 37(2), 284–297. <https://doi.org/10.1046/j.1365-2664.2000.00504.x>.

- [104] Kovacs, J. M., Wang, J., & Blanco-Correa, M. (2004). Mapping disturbances in a mangrove forest using multi-date Landsat TM imagery. *Environmental Management*, 33(6), 777–791.
- [105] Krell, F.-T. (2004). Parataxonomy vs. taxonomy in biodiversity studies – pitfalls and applicability of ‘morphospecies’ sorting. *Biodiversity and Conservation*, 13, 795–812. <https://doi.org/10.1023/B:BIOC.0000011727.23539.1f>.
- [106] Kuenzer, C., Bluemel, A., Gebhardt, S., Quoc, T. V., & Dech, S. (2011). Remote sensing of mangrove ecosystems: A review. *Remote Sensing*, 3(5), 878–928. <https://doi.org/10.3390/rs3050878>.
- [107] Kumar, P., Debnath, H. S., & Singh, S. K. (2016). Assessment of mangrove cover using geospatial technology: A case study from Andaman Islands, India. *Journal of Coastal Conservation*, 20, 371–379. <https://doi.org/10.1007/s11852-016-0446-1>.
- [108] Lienhard, C., & Smithers, C. N. (2002). Psocoptera (Insecta): World catalogue and bibliography. *Muséum d'histoire naturelle*.
- [109] Lohman, D. J., Peggie, D., Pierce, N. E., & Meier, R. (2006). Phylogeography and genetic diversity of a widespread Old-World butterfly, *Elymnias hypermnestra* (Lepidoptera: Nymphalidae). *Biological Journal of the Linnean Society*, 88(3), 459–477.
- [110] Lövei, G. L., & Sunderland, K. D. (1996). Ecology and behavior of ground beetles (Coleoptera: Carabidae). *Annual Review of Entomology*, 41, 231–256. <https://doi.org/10.1146/annurev.en.41.010196.001311>.
- [111] Lugo, A. E., & Snedaker, S. C. (1974). The ecology of mangroves. *Annual Review of Ecology and Systematics*, 5, 39–64.
- [112] Luis, A., Bandeira, S. O., & Hatton, J. (2016). Arthropod community structure in Zambezi Delta mangroves. *Wetlands Ecology and Management*, 24, 167–179.
- [113] Machado, A. B., Xavier, D. C., & Silva, J. F. (2019). Moth fauna of a Brazilian mangrove forest: Composition and habitat associations. *Neotropical Entomology*, 48(5), 732–740.
- [114] Mangroves. (2025). *Rhizophora mangle*. [Image]. http://www.mangrove.at/rhizophora-mangle_red-mangrove.html.
- [115] Marshall, S. A. (2012). *Flies: The Natural History and Diversity of Diptera*. Firefly Books.
- [116] Martinez, S. (2025). *Black Mangrove (Avicennia germinans)*. [Image]. https://www.inaturalist.org/guide_taxa/528628.
- [117] Mathis, W. N., & Zatwarnicki, T. (1995). World catalog of shore flies (Diptera: Ephydriidae). *Memoirs of Entomology, International*.
- [118] Matthews, R. W., & Matthews, J. R. (1983). *Insect behavior*. John Wiley & Sons.
- [119] McAlpine, J. F., Peterson, B. V., Shewell, G. E., et al. (1981). *Manual of Nearctic Diptera, Volume 1. Agriculture Canada*.
- [120] Memmott, J., Craze, P. G., Waser, N. M. & Price, M. V. (2007). Global warming and the disruption of plant-pollinator interactions. *Ecology Letters*, 10(8), 710–717. <https://doi.org/10.1111/j.1461-0248.2007.01061.x>.
- [121] Mensah, A., & Oduro, W. (2023). Nonparametric assessment of mangrove ecosystem in the context of coastal resilience in Ghana. *Journal of Coastal Research*, 39(3), 545–556. <https://doi.org/10.2112/JCOASTRES-D-22-00089.1>.
- [122] Michener, C. D. (2007). *The Bees of the World* (2nd ed.). Johns Hopkins University Press.
- [123] Missa, O., Basset, Y., Alonso, A., Miller, S. E., Curletti, G., De Meyer, M., Wagner, T., Lovell, D., & Laponce, M. (2009). Monitoring arthropods in a tropical forest: A comparison of methods and temporal sampling. *Biodiversity and Conservation*, 18(2), 413–431. <https://doi.org/10.1007/s10531-008-9490-3>.
- [124] Mississippi Entomological Museum. (n.d.). *Insect nets - Collecting methods*. Mississippi State University. <https://mississippientomologicalmuseum.org.msstate.edu/collecting.preparation.methods/Insect.nets.htm>.
- [125] Mockford, E. L. (1993). *North American Psocoptera (Insecta)*. Flora & Fauna Handbook No. 10. Sandhill Crane Press.
- [126] Moritz, G., Morris, D. C., & Mound, L. A. (2001). *ThripsID: An interactive identification and information system for thrips*. CSIRO Publishing.

- [127] Mound, L. A., & Marullo, R. (1996). *The Thrips of Central and South America: An Introduction* (Insecta: Thysanoptera). Associated Publishers.
- [128] National Agricultural Research & Extension Institute [NAREI]. (2014). Mangrove Restoration Project. <https://narei.org.gy/mangrove/>.
- [129] National Research Council [NRC]. (2011). *Climate stabilization targets: emissions, concentrations and impacts over decades to Millennia*. Washington DC: National Academies Press. 298.
- [130] New, T. R., & Thornton, I. W. B. (1988). The ecology of bark lice in tropical forests. *Annual Review of Entomology*, 33, 227–247.
- [131] Nowinszky, L. (2004). Nocturnal illumination and night flying insects. *Applied Ecology and Environmental Research*, 2(1), 17–52. https://doi.org/10.15666/aeer/0201_017052.
- [132] Noyes, J. S. (2019). Universal Chalcidoidea Database. Natural History Museum, London. Retrieved from: <http://www.nhm.ac.uk/chalcidoidea>.
- [133] Open Oregon State. (n.d.). Entomology 311 Lab Manual: Chapter 1. <https://open.oregonstate.edu/entomology-lab-manual/chapter/chapter-1/>.
- [134] Osei, D., & Asare, E. (2023). Floristic inventory and diversity assessment at two locations along the shores of Cape Coast, Ghana. *Journal of Ecology and Environment*, 47, Article 9. <https://doi.org/10.1186/s41610-023-00265-3>.
- [135] PacMOSSI Consortium. (2021). Standard operating procedure for performing sweep net sampling of vegetation. James Cook University. https://pacmossi.org/carbon/assets/2022/01/PacMOSSI-SOP_Sweep-net-collections-vegetation.pdf.
- [136] Panda, M., Lele, N., Samal, R. N., Dalai, D., Parida, S. P., & Murthy, T. V. R. (2019). Insect flower visitors and their role in mangrove pollination: A study from the east coast of India. *Journal of Tropical Forestry and Environment*, 9(2), 78–92. ISSN 2235-9370 Print/ISSN 2235-9362. <https://doi.org/10.31357/jtfe.v9i2.4538>.
- [137] Panda, S., & Mishra, R. (2019). Insect flower visitors and their role in mangrove pollination: A study from east coast of India. *Journal of Tropical Forestry and Environment*, 9(2), 1–10.
- [138] Polidoro, B. A., Carpenter, K. E., Collins, L., et al. (2010). The loss of species: Mangrove extinction risk and geographic areas of global concern. *PLoS ONE*, 5(4), e10095. <https://doi.org/10.1371/journal.pone.0010095>.
- [139] Primack, R. B., & Tomlinson, P. B. (1980). Variation in tropical forest breeding systems. *Biotropica*, 12(3), 229–231. <https://doi.org/10.2307/2387969>.
- [140] Purdue University Extension. (2008). *Catching insects with a net*. Purdue University. https://extension.entm.purdue.edu/4hyouth/pdf/Make_Net.pdf.
- [141] Quicke, D. L. J. (2015). *The Braconid and Ichneumonid Parasitoid Wasps: Biology, Systematics, Evolution and Ecology*. Wiley-Blackwell.
- [142] Rader, R., Howlett, B. G., Cunningham, S. A., Westcott, D. A., Newstrom-Lloyd, L. E., Walker, M. K., Teulon, D. A. J., & Edwards, W. (2009). Alternative pollinator taxa are equally efficient but not as effective as the honeybee in a mass flowering crop. *Journal of Applied Ecology*, 46(5), 1080–1087. <https://doi.org/10.1111/j.1365-2664.2009.01700.x>.
- [143] Rahman, M. M., Islam, M. A., Rahman, M. A., Rahman, M. A., & Asaduzzaman, M. (2013). Remote sensing and GIS based area estimation and mapping of mangrove ecosystems in the Sundarbans, Bangladesh. *Journal of Forest Science*, 59(7), 289–297. <https://doi.org/10.17221/24/2013-JFS>.
- [144] Rahman, M. M., Mallick, D., Miah, M. M. U., & Hossain, M. A. (2019). Improved assessment of mangrove forests in Sundarbans East Wildlife Sanctuary using WorldView-2 and TanDEM-X high resolution imagery. *Remote Sensing in Ecology and Conservation*, 5(2), 129–140. <https://doi.org/10.1002/rse2.105>.
- [145] Rahman, M. M., Rahman, M. M., & Ghosh, A. K. (2020). Pollinator diversity and their floral interactions in the mangrove ecosystems of Bangladesh. *Asian Journal of Conservation Biology*, 9(1), 50–59. <https://doi.org/10.53562/ajcb.rg2020.018>.
- [146] Rajendran, N., & Kathiresan, K. (2004). Mangrove insect herbivory in Pichavaram estuary, southeast India. *Wetlands Ecology and Management*, 12, 39–45.

- [147] Rajesh, G., Swamy, K. S. K., & Rajagopal, T. (2017). Butterfly diversity and their host plants in Pichavaram mangrove forest, Tamil Nadu, India. *Journal of Threatened Taxa*, 9(8), 10535–10540. <https://doi.org/10.11609/jott.2863.9.8.10535-10540>.
- [148] Raju, A. J. S. (2019). Pollination biology of mangroves. In S. Bahadur, R. Tandon, A. Tandon & J. R. Sharma (Eds.), *Pollination biology–Volume 2: Pollination and reproductive ecology of plants* (pp. 143–160). Springer. https://doi.org/10.1007/978-981-13-6225-6_6.
- [149] Raju, A. J. S. (2019). Reproductive ecology of mangrove flora: Conservation and management perspectives. In Q. Lai & M. Y. Leong (Eds.), *Mangroves: Ecology, biodiversity and management* (pp. 77–110). Nova Science Publishers.
- [150] Raju, A. J. S. (2019). Reproductive ecology of mangrove plants: Conservation and management. *Transylvanian Review of Systematical and Ecological Research*, 21(1), 23–48.
- [151] Raju, A. J. S., & Ezradanam, V. (2002). Pollination ecology and fruiting behaviour in a mangrove associate *Acanthus ilicifolius* L. (Acanthaceae). *Wetlands Ecology and Management*, 10, 25–33. <https://doi.org/10.1023/A:1014348621431>.
- [152] Raju, A. J. S., Kumar, R., & Mohan, S. R. (2011). Pollination ecology of *Bruguiera cylindrica* (L.) Blume (Rhizophoraceae), a viviparous mangrove species. *Journal of Threatened Taxa*, 3(5), 1742–1750. <https://doi.org/10.11609/JoTT.o2584.1742-50>.
- [153] Raju, A. J. S., Rao, S. P., & Kumar, R. (2011). Pollination ecology of certain mangrove plants. *Journal of Threatened Taxa*, 3(11), 2245–2257.
- [154] Ramaraju, K., Suresh, S., & Suganthi, A. (2010). Parasitic wasps in Indian mangroves: Preliminary notes. *Hexapoda*, 17, 51–56.
- [155] Rasmussen, C., & Cameron, S. A. (2010). Global stingless bee phylogeny supports ancient divergence and vicariance between Neotropical and Indo-Australian faunas. *Molecular Phylogenetics and Evolution*, 56, 245–255.
- [156] Reddy, C. S., Aluri, J. S. R., & Raju, V. S. (1995). Observations on the floral biology of some mangrove species from the Godavari estuary, east coast of India. *Journal of Indian Botanical Society*, 74, 41–45.
- [157] Rey, J. R., O'Connell, S. M., & O'Meara, G. F. (2006). Mosquito production from mangrove forests in Florida. *Journal of the American Mosquito Control Association*, 22, 517–525.
- [158] Riley, N. D. (1980). *Insects in Colour*. Blandford Press.
- [159] Rodríguez, J. P., & Paredes, A. (2015). Grasshopper diversity and habitat associations in mangrove and adjacent areas of the Pacific coast of Colombia. *Revista de Biología Tropical*, 63(2), 455–464.
- [160] Sæther, O. A. (1980). Glossary of chironomid morphology terminology (Diptera: Chironomidae). *Entomologica Scandinavica Supplement*, 14, 1–51.
- [161] Sakagami, S. F., Fukuda, H., & Zicsi, A. (1983). Insect pollinators of mangroves in Sarawak, Malaysia. *Journal of the Faculty of Science, Hokkaido University*, 23, 111–121.
- [162] Sakai, S. (2002). General flowering in lowland mixed dipterocarp forests of Southeast Asia. *Biological Journal of the Linnean Society*, 75, 233–247.
- [163] Sánchez-Bayo, F. & Wyckhuys, K. A. G. (2019). Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation*, 232, 8–27.
- [164] Sathe, T. V., & Jadhav, A. D. (2001). Entomofauna of mangrove ecosystem in Maharashtra. *Zoos' Print Journal*, 16, 503–504.
- [165] Schauff, M. E. (Ed.). (2001). *Collecting and preserving insects and mites: Techniques and tools* (USDA Miscellaneous Publication No. 1443). United States Department of Agriculture.
- [166] Shi, X., Fu, D., Xiao, H., Hodgson, J. A., Yan, D., & Zou, Y. (2022). Comparison between window traps and pan traps in monitoring flower-visiting insects in agricultural fields. *Bulletin of Entomological Research*, 112(5), 691–696. <https://doi.org/10.1017/S0007485322000104>.
- [167] Singh, A. K., Ghosh, S., & Debnath, M. (2020). DNA barcoding in pollinator insects: An approach to assess mangrove biodiversity. *International Journal of Zoological Studies*, 5(6), 01–07. <https://doi.org/10.22271/zoological.2020.v5.i6a.623>.

- [168] Sivaperuman, C., & Jayson, E. A. (2010). Insect fauna of mangrove ecosystem in Andaman and Nicobar Islands, India. Faunal Diversity of Mangrove Ecosystem in India, ZSI Publication.
- [169] Skendžić, S.; Zovko, M.; Živković, I. P.; Lešić, V. & Lemić, D. (2021). The Impact of Climate Change on Agricultural Insect Pests. *Insects* 12 (5):440. DOI: 10.3390/insects12050440. PMID: 34066138; PMCID: PMC8150874.
- [170] Southwood, T. R. E., & Henderson, P. A. (2000). *Ecological methods* (3rd ed.). Blackwell Science.
- [171] Spalding, M.; Blasco, F. & Field, C. (1997). *World Mangrove Atlas*. Okinawa, Japan: The International Society for Mangrove Ecosystems: 178 pp.
- [172] Stewart, A. B.; Diller, C.; Dudash, M. R. & Fenster, C. B. (2022). Pollination-precision hypothesis: support from native honey bees and nectar bats. *New Phytologist*. 235: 1307–1309. <https://doi.org/10.1111/nph.18050>.
- [173] Subba Reddi, C. & Raju, A. J. S. (1997). Reproductive biology of three mangrove plant species. *Indian Journal of Forestry*, 20(2), 153–157.
- [174] Subramanian, K. A. (2005). *Dragonflies and Damselflies of Peninsular India — A Field Guide*. E-books, Indian Academy of Sciences.
- [175] Sundararaj, R., & Hiremath, I. G. (2000). Insect fauna of mangroves from Karnataka, India. *Journal of the Bombay Natural History Society*, 97, 195–197.
- [176] Thompson, F. C., & Rotheray, G. E. (1998). Family Syrphidae. In L. Papp & B. Darvas (Eds.), *Contributions to a Manual of Palaearctic Diptera*, Vol. 3 (pp. 81–139). Science Herald.
- [177] Tomlinson, P. B. (1986). *The Botany of Mangroves*. Cambridge University Press.
- [178] Townes, H. (1972). A light-weight Malaise trap. *Entomological News*, 83, 239–247.
- [179] Triplehorn, C. A., & Johnson, N. F. (2005). *Borror and DeLong's introduction to the study of insects* (7th ed.). Brooks Cole.
- [180] United Nations Framework Convention on Climate Change [UNFCCC]. (2022). A threat and a solution – tourism's role in mangrove protection. <https://climatechampions.unfccc.int/a-threat-and-a-solution-tourisms-role-in-mangrove-protection/>.
- [181] University of Georgia Extension. (2022). *Insect Identification Guide: Great Southeast Pollinator Census*. <https://gsepc.org>.
- [182] University of Wyoming. (2019). Assessing bumble bee diversity, distribution, and status for the Michigan Natural Features Inventory. <https://mnfi.anr.msu.edu/reports/MNFI-Report-2019-33.pdf>.
- [183] Upadhyay, V. P., & Mishra, P. K. (2010). Diversity of butterflies in mangrove ecosystem of Bhitarkanika Wildlife Sanctuary, Odisha, India. *World Journal of Zoology*, 5(4), 266–270.
- [184] Upadhyay, V. P., & Mishra, P. K. (2010). Phenology of mangrove tree species on Orissa coast, India. *Tropical Ecology*, 51(2), 289–295.
- [185] Upadhyay, V. P., & Mishra, P. K. (2010). Pollination ecology of *Avicennia marina* L. in mangrove forests of Odisha, India. *Research Journal of Agriculture and Biological Sciences*, 6(5), 655–661.
- [186] UT Crops. (2023). Sweep net sampling. University of Tennessee. <https://utcrops.com/cotton/insects-and-mites/sweep-net-sampling/>.
- [187] Valiela I., J. L. Bowen, J. K. York. (2001). Mangrove forests: One of the world's threatened major tropical environments. *BioScience* 51: 807–815.
- [188] Van der Niet, T.; Peakall, R. & Johnson, S. D. (2014). Pollinator-driven ecological speciation in plants: new evidence and future perspectives. *Ann Bot.* 113 (2): 199-211. Doi: 10.1093/aob/mct290. PMID: 24418954; PMCID: PMC3890394.
- [189] Vandermeer, J. H. (1972). Niche Theory. *Annual Review of Ecology and Systematics*, 3, 107-132. <http://www.jstor.org/stable/2096844>.
- [190] Wahab, R. A. A., Ang, Y., & Meier, R. (2021). Mangroves are an overlooked hotspot of insect diversity despite low plant diversity. *BMC Biology*, 19(1), 202. <https://doi.org/10.1186/s12915-021-01088-z>.
- [191] Wang, L., Sousa, W. P., Gong, P., & Biging, G. S. (2014). Mangrove species identification: Comparing WorldView-2 with aerial photographs. *Remote Sensing*, 6(7), 6064–6088. <https://doi.org/10.3390/rs6076064>.

- [192] Wang, L., Sousa, W. P., Gong, P., & Biging, G. S. (2015). Object-based approach for multi-scale mangrove composition mapping using multi-resolution image datasets. *Remote Sensing*, 7(4), 4753–4783. <https://doi.org/10.3390/rs70404753>.
- [193] Ward, M., & Johnson, S. D. (2005). Pollen limitation and demographic structure in small fragmented populations of *Bruguiera gymnorrhiza* (Rhizophoraceae). *Biological Conservation*, 123(1), 135–142. <https://doi.org/10.1016/j.biocon.2004.11.006>.
- [194] Wardhaugh, C. W., Stork, N. E., & Edwards, W. (2012). Feeding guild structure of beetles on Australian tropical rainforest trees reflects canopy microhabitat distributions. *Journal of Animal Ecology*, 81(5), 1086–1094. <https://doi.org/10.1111/j.1365-2656.2012.01987.x>.
- [195] Weisschr. (2020). Roots of white mangrove shrubs, *Laguncularia racemosa*. [Image]. <https://www.istockphoto.com/photo/roots-of-white-mangrove-shrubs-laguncularia-racemosa-in-the-gambia-gm1254876488-366938320>.
- [196] Westphal, C., Bommarco, R., Carré, G., Lamborn, E., Morison, N., Petanidou, T., Potts, S. G., Roberts, S. P. M., Szentgyörgyi, H., Tscheulin, T., Vaissière, B. E., Woysciechowski, M., Biesmeijer, J. C., Kunin, W. E., Settele, J., & Steffan-Dewenter, I. (2008). Measuring bee diversity in different European habitats and biogeographical regions. *Ecological Monographs*, 78(4), 653–671. <https://doi.org/10.1890/07-1292.1>.
- [197] Wicomb, K. (2011). *Avicennia germinans*. [Image]. <https://www.flickr.com/photos/36838058@N03/5880059430>.
- [198] Willmer, P. (2011). *Pollination and floral ecology*. Princeton University Press.
- [199] Xerces Society. (2019). Beneficial insect scouting guide. <https://xerces.org/sites/default/files/publications/19-061.pdf>.
- [200] Xie, Z.; Wang, Y.; Cao, J.; Wang, J. & An, J. (2021). Ecological resilience of pollination in the face of pollinator decline: Content, mechanism and perspective. *Biodiversity Science* 29 (7): 980-994. DOI: 10.17520/biods.2020470.
- [201] Yoshizawa, K. (2005). Morphology of Psocodea. In *Psocoptera (Insecta: Psocodea)*. *Zoological Science*, 22(2), 133–1.

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