Preliminary Insights into Nocturnal Beetle Diversity in Mangrove Ecosystems of Kemujan, Karimunjawa Island: Implications for Sustainable Coastal Management

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Abstract. Mangrove ecosystems are critical coastal habitats that provide shoreline protection, carbon sequestration, and essential biodiversity support. Insects, particularly nocturnal beetles, play a key role in pollination, decomposition, and food web dynamics. However, data on nocturnal beetle diversity in mangrove habitats, especially small tropical islands, are scarce, limiting their integration into biodiversity-based management strategies. This study presents the first documented assessment of nocturnal beetles in the mangrove ecosystem of Kemujan, Karimunjawa Island, and provides baseline data for conservation planning. Sampling was conducted in June 2025 at four sites representing different habitat conditions: mangrove interior (S1), roadside near mangrove (S2), mangrove area within Karimunjawa National Park (S3), and coastal tourism site (S4). Light traps were operated for a single night, and the collected specimens were identified to the morphospecies level. The survey yielded 17 individuals representing 7 morphospecies from 7 families: *Phyllobaenus* sp., *Amblycerus* sp., *Ambrosiodmus* sp., *Anacaena novacaledonica*, *Sisenopiras sp., Luciola sp., and Scirtes tibialis*. Species composition varied among sites, with *Anacaena novacaledonica* occurring in multiple locations. The low number of individuals may reflect habitat-specific conditions, artificial lighting influence, or human disturbance. These findings highlight the ecological role of mangroves as habitats for nocturnal beetles, demonstrate the applicability of light trapping as a nondestructive monitoring method, and provide essential baseline information to guide long-term biodiversity assessments, mangrove conservation, and sustainable coastal management in Karimunjawa Island.

Keywords: Night insect, light trap, biodiversity monitoring, shoreline protection, Karimunjawa National Park.

1 Introduction

Mangrove ecosystems are among the most productive and ecologically important coastal habitats in tropical regions. They provide a wide array of ecosystem services, including shoreline stabilization, carbon sequestration, nursery grounds for marine fauna, and support for diverse terrestrial and aquatic biodiversity [1]. Insects constitute

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a major component of mangrove-associated biodiversity, functioning as pollinators, decomposers, predators, and herbivores, thereby contributing to nutrient cycling and overall ecosystem functioning [2,3]. Among these, nocturnal beetles (Order Coleoptera) are particularly important yet understudied in many mangrove systems.

Research on beetle diversity within mangrove forests in Southeast Asia has remained limited, with most studies focusing on flora, crustaceans, or vertebrates [4,5,6]. Small island ecosystems, such as those in the Karimunjawa Archipelago are especially vulnerable to anthropogenic pressures, including tourism, coastal development, and light pollution, which may influence insect community structures [7,8]. Despite these vulnerabilities, baseline data on beetle diversity, particularly nocturnal species, are largely absent from the mangrove habitats of Karimunjawa.

This study presents the first documentation of nocturnal beetle assemblages in the mangrove ecosystems of Kemujan Island, Karimunjawa National Park, Indonesia. Using light-trap sampling across four sites representing different levels of human activity, this research provides essential baseline information for future biodiversity assessment and conservation planning. Understanding beetle presence and distribution in these habitats is crucial for sustainable coastal management, as insect diversity often serves as a sensitive indicator of ecosystem health [9]. The findings aim to fill existing knowledge gaps, support ongoing conservation strategies, and contribute to long-term ecological monitoring in the Karimunjawa archipelago.

2 Materials and Methods

Sampling was carried out in June 2025, during the dry season when nighttime insect activity is generally high in tropical environments [10]. Weather conditions during sampling were favorable, with no rainfall and average nighttime temperatures ranging from 26–28°C. The study was conducted at four sampling sites within the mangrove ecosystems of Kemujan Island, Karimunjawa: roadside near mangrove (S1), a semi-disturbed site located adjacent to a paved road with intermittent vehicular activity; mangrove tourism area (S2), characterized by wooden walkways, visitor traffic, and artificial lighting at night; mangrove area within the National Park (S3) a minimally disturbed zone with restricted access and natural vegetation; and homestay area (S4), a site near residential accommodation with moderate light pollution (Figure 1).

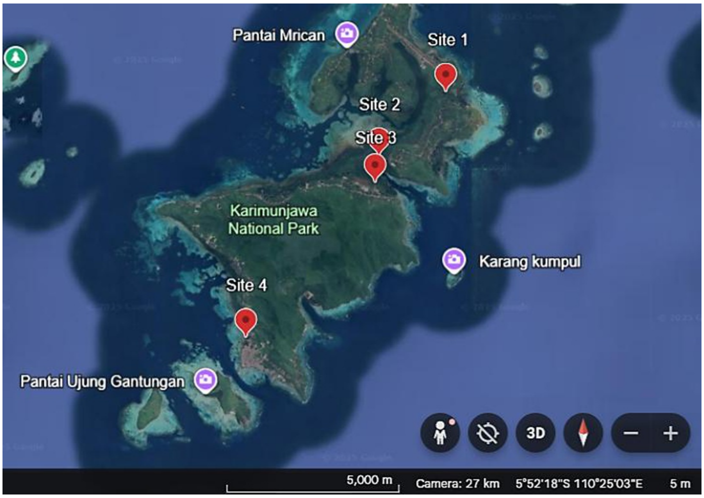

Fig. 1. Sampling sites S1–S4.

Light traps were used to sample nocturnal beetle diversity (Figure 2). According to established insect sampling protocols in tropical forests, ultraviolet light traps are highly effective for attracting a wide variety of beetle species during nocturnal hours, particularly during the first five hours after sunset, which maximizes species richness and abundance collected [11]. In this study, light traps equipped with ultraviolet light sources were operated for one night at each site. Sampling was performed from dusk until approximately 11 p.m. to optimize collection based on beetle activity peaks. Traps were placed approximately 1.5 meters above ground to optimize capture efficiency and minimize obstruction from vegetation.

Fig. 2. Light trap setup.

Captured specimens were preserved in ethanol and transported to the Laboratory Ecology and Biosystematics, Department of Biology, Universitas Diponegoro. Identification was performed using external morphology under a stereomicroscope, available regional identification keys, and comparison with published taxonomic descriptions [12]. Beetles were categorized into families and morphospecies, which is a widely accepted approach for rapid biodiversity assessments when full taxonomic resolution is not feasible. Data were analyzed descriptively to document species composition and abundance across sites.

3 Result and Discussion

A total of 17 nocturnal beetle individuals representing 7 families and 7 morphospecies were recorded across the four mangrove sites in Kemujan Island. Although overall abundance was low, distinct spatial patterns were evident among sites, reflecting differences in habitat condition, disturbance levels, and ecological preferences of the beetle taxa (Table 1).

Table 1. Composition and abundance of nocturnal beetles collected from four mangrove sites in Kemujan, Karimunjawa.

Site	Family	Species	Number of Individuals
S1 (Roadside near mangrove)	Cleridae	*Phyllobaenus* sp.	1
	Bruchidae	*Amblycerus* sp.	1
	Curculionidae	*Ambrosiodmus* sp.	1
	Hydrophilidae	*Anacaena novacaledonica*	1
S2 (Mangrove tourism area)	Hydrophilidae	*Anacaena novacaledonica*	6
S3 (Mangrove area within National Park)	Oedemeridae	*Sisenopiras* sp.	1
	Lampyridae	*Luciola* sp.	1
	Hydrophilidae	*Anacaena novacaledonica*	1
	Scirtidae	*Scirtes tibialis*	3
S4 (Homestay area)	Hydrophilidae	*Anacaena novacaledonica*	1
Total	7 families	7 morphospecies	17

3.1 Species Composition and Habitat Variation

Species composition differed notably among the sites. The National Park site (S3) recorded the highest morphospecies richness (4 morphospecies), despite a moderate total abundance. This pattern suggests that less-disturbed mangrove habitats support more diverse nocturnal beetle communities, consistent with previous findings that intact mangrove forests harbor higher insect diversity [13].

In contrast, S4 (homestay area) and S2 (tourism area) exhibited lower richness, likely due to anthropogenic pressures such as noise, visitor activity, and artificial lighting. Artificial light at night (ALAN) is well known to disrupt nocturnal insect flight, orientation, and habitat use [14,15], which may contribute to reduced captures at disturbed sites.

3.2 Abundance Patterns: Low Capture Rates and Ecological Drivers

The overall abundance of beetles was low, with only 17 individuals recorded. Several factors may explain this outcome. Mangrove forests are subject to salinity, tidal inundation, and reduced plant species richness, which can limit the diversity and abundance of beetle communities [16]. Insect communities often exhibit strong temporal variation influenced by moon phase, humidity, seasonal changes, and tidal cycles [17]. Disturbed sites may experience reduced insect activity or altered movement patterns due to human presence and artificial lighting [18].

The highest abundance was recorded at S2 (tourism area) due to multiple individuals of *Anacaena novacaledonica*. However, this dominance did not reflect overall richness, indicating that certain generalist taxa may tolerate or even exploit disturbed environments.

3.3 Spatial Distribution of Morphospecies

The spatial occurrence of morphospecies exhibited clear ecological patterns (Figure 3). *Anacaena novacaledonica* (Hydrophilidae) occurred in three of the four sites, confirming its ecological tolerance and broad habitat plasticity. Hydrophilidae are known to thrive in moist and semi-aquatic environments [19,20]. The presence of Cleridae, Bruchidae, Curculionidae in the roadside mangrove site (S1) suggests influence from adjacent terrestrial habitats, indicating an ecotonal effect [21]. Lampyridae (*Luciola* sp.) and Oedemeridae (*Sisenopiras* sp.) were restricted to the protected zone, highlighting sensitivity to human disturbance and potential reliance on intact vegetation structures (S3). Scirtidae (*Scirtes tibialis*) that only detected in S3 aligns showed its preference for moist, detritus-rich vegetation typical of undisturbed mangrove areas.

3.4 Implications for Monitoring and Conservation

The combined results emphasize the value of mangrove habitats, particularly protected areas for sustaining nocturnal beetle diversity. Light traps proved effective for rapid surveys, yet broader monitoring efforts are needed. Implementing periodic sampling, expanding spatial coverage, and incorporating molecular identification will substantially enhance understanding of beetle assemblages in Karimunjawa.

Given the increasing pressures from tourism and development, incorporating insect diversity indicators into management strategies can strengthen conservation efforts. Nocturnal beetles, sensitive to environmental changes, offer potential as bioindicators for evaluating habitat health. Overall, the study provides critical baseline data for future conservation planning and highlights the need for maintaining habitat integrity within mangrove ecosystems to preserve their ecological functions.

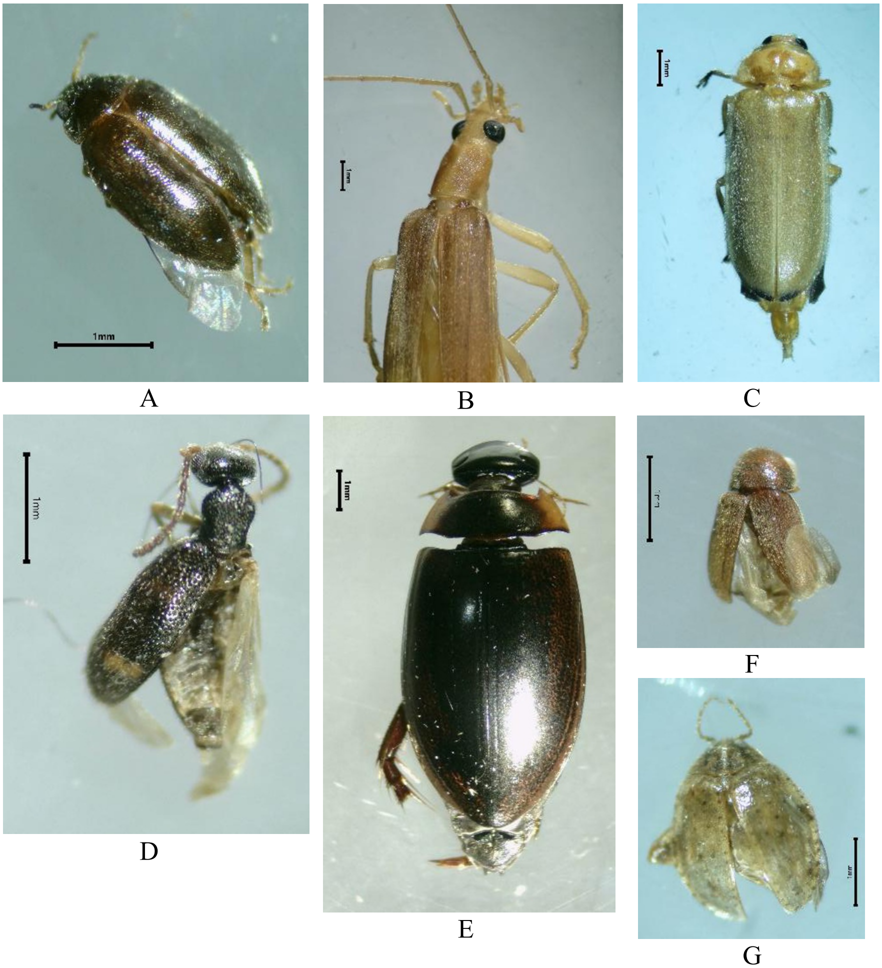

Fig. 3. Beetle speciments. (A) Scirtes tibialis; (B) Sisenopiras sp.; (C) Luciola sp.; (D) Phyllobaenus sp.; (E) Anacaena novacaledonica; (F) Ambrosiodmus sp.; (G) Amblycerus sp.

4 Conclusion

This study presents the first systematic documentation of nocturnal beetle assemblages in the mangrove ecosystems of Kemujan Island, Karimunjawa. Despite the low overall abundance recorded, the findings reveal notable variation in species richness and distribution across sites with differing degrees of human disturbance. The National Park mangrove site (S3) supported the highest morphospecies richness, underscoring the ecological value of undisturbed mangrove forests for sustaining nocturnal insect diversity. In contrast, sites influenced by human activities, particularly tourism areas and residential zones hosted fewer morphospecies, indicating possible effects of habitat modification and artificial lighting.

The repeated detection of Anacaena novacaledonica across multiple habitats demonstrates its ecological tolerance and suggests that certain hydrophilid beetles may serve as useful indicators for monitoring environmental conditions in mangrove ecosystems. The use of light-trap sampling proved effective for rapid nocturnal insect surveys and can be applied to broader biodiversity monitoring programs in coastal habitats.

As mangrove ecosystems face increasing pressures from tourism and coastal development, integrating insect diversity assessments into conservation planning becomes essential. The baseline data generated in this study provide a foundation for future long-term ecological research, including expanded temporal sampling, molecular identification techniques, and comparative studies across additional mangrove sites in the Karimunjawa archipelago and beyond. Strengthening biodiversity monitoring will support sustainable coastal management and enhance conservation strategies for these ecologically critical habitats.

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Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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