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Camera-trap insights into wildlife diversity in SFERA@UMS urban forest, Sabah

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Abstract

Urban forest remnants contribute to biodiversity conservation in rapidly developing cities. The Sustainable Forest for Education and Research Area (SFERA@UMS), a 25-ha forest fragment within Universiti Malaysia Sabah, has undergone restoration, but information on its wildlife is limited. We conducted a camera-trap survey from April to September 2023 to document mammals and birds present in the area. Nine camera traps were deployed continuously and periodically relocated, generating 1,620 camera-trap nights. Seven wildlife species were detected, including six mammals and one bird. Long-tailed macaques (*Macaca fascicularis*; Endangered) accounted for the majority of detections, indicating high tolerance to urban disturbance. The confirmed presence of the Critically Endangered Sunda pangolin (*Manis javanica*), along with the Greater mousedeer (*Tragulus napu*) and Asian palm civet (*Paradoxurus hermaphroditus*), highlights the ecological importance of this small forest patch. These results provide baseline data and demonstrate that small forest remnants, such as SFERA@UMS, remain vital refuges for wildlife in Kota Kinabalu.

Kewords: forest management, biodiversity, Sabah Borneo, small forest fragments, urban forest

1 Introduction

In urban environments, forest islands are essential for sustaining the urban landscape through the ecological services they provide (Miller & Hobbs, 2002; Arif et al., 2023). These ecosystem services include microclimate regulation that helps counteract the urban heat island effect, as well as stormwater mitigation and air purification. This forest island, also known as an urban forest, provides fresh air and supports ecological functions in the urban landscape (Soga et al., 2014). As such, biodiversity conservation in urban forest fragments is critical because of the priceless ecosystem services they provide (Aronson et al., 2017). Many wildlife species serve as ecological "gardeners" in urban forests by aiding natural regeneration through seed dispersal and soil interactions, without which our urban forest will surely disappear, bringing very significant disadvantages to urban human societies (Cordeiro et al., 2021). However, urban wildlife often faces challenges due to anthropogenic activities, such as habitat fragmentation, human disturbance and poaching (Haddad et al., 2015; Kang et al., 2015; Sompud et al., 2019; Kodoh et al., 2024). Universiti Malaysia Sabah (UMS) has initiated ongoing reforestation efforts using native tree species in SFERA@UMS (Sustainable Forest and Research Area) to enhance forest structure and ecological resilience. This management intervention aims to improve plant diversity and ultimately support higher wildlife diversity within the campus landscape. However, the extent to which these conservation efforts have supported the persistence of wildlife in this small and fragmented forest remains poorly understood. Therefore, documenting the current status of wildlife in SFERA@UMS is crucial for evaluating its ecological functions and informing future forest management.

SFERA@UMS is a university forest gazetted by the UMS that covers only 25-ha within the main campus (Borneo Post, 2022). It is a valuable area because it serves as a model of sustainable urban forest management, is used for educational and research purposes, and is managed by the Faculty of Tropical Forestry under the UMS Living Lab (Sabah Media, 2023). To date, there has been no comprehensive list of wildlife in this forest reserve which could hinder its management and conservation efforts. A study conducted by Sompud et al. (2023) and Kodoh et al. (2024) reported the presence of a Critically Endangered Sunda pangolin in SFERA. Apart from those recent studies, no prior research has been published on the wildlife

found at SFERA@UMS. Given these knowledge gaps, a systematic assessment using a non-invasive wildlife monitoring tool, i.e. camera trapping, was employed to record wildlife presence in the area.

For this study, we only focus on the fauna, specifically birds and mammals. This article documents the wildlife present in SFERA@UMS and evaluates species diversity. The dearth of information from past studies indicates the importance of this study as baseline data for future management. We postulate that wildlife has very low species diversity because the area is small. This refers to species and area size relationships presented by Preston (1960) and Rosenzweig (1995). Based on the findings of this study, we propose appropriate measures to enhance the diversity of wildlife in the area.

2 Materials & Methods

2.1 Study area

This study was conducted at SFERA@UMS, located within the UMS main campus in Kota Kinabalu, Sabah. SFERA@UMS lies inside the UMS Hill Forest, which forms part of the larger Sepanggar Hill Forest (Figure 1). Sepanggar Hill covers approximately 2.1 km^2 of remaining forest. Historically, this area comprised secondary forest that local villagers used for small-scale traditional cultivation before UMS was established in 1995 (Sompud, 2025). During campus development, large areas underwent land clearing and were subsequently dominated by *Acacia* spp. as pioneer species (Kodoh et al., 2024). Today, SFERA@UMS consists of a mixture of invasive *Acacia* species and regenerating native pioneer trees across terrain ranging from undulating flats to steep slopes at elevations of 40–180 m above sea level. This land-use history helps explain the current dominance of *Acacia* spp. It highlights the importance of future management to promote the recovery of native species in this urban forest fragment.

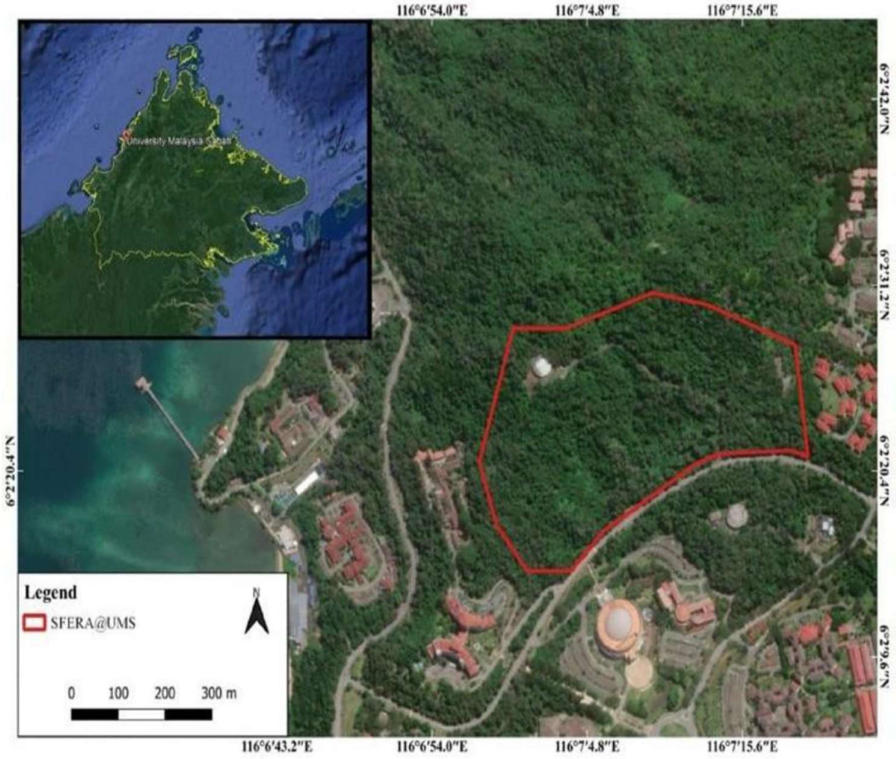

Figure 1: The study site location showing the SFERA@UMS boundary within the UMS Forest with the inset map of Sabah.

SFERA@UMS was gazetted as a university forest in 2022 (Borneo Post, 2022). This area is relevant to the University, as it serves as an educational living laboratory primarily for the Faculty of Tropical Forestry's undergraduate courses. Furthermore, the Faculty's members are also conducting active research in that area. These ongoing research activities include both biotic and abiotic ecological studies such as wildlife monitoring, vegetation dynamics, soil properties, hydrological monitoring, and human–wildlife interactions. Researchers from the Faculty of Tropical Forestry currently undertake multidisciplinary research involving biodiversity conservation, forest rehabilitation, and ecosystem services. As such, SFERA@UMS is very relevant to the educational and conservation work. The soil in SFERA@UMS is classified as Ultisols with sandy clay loam texture. According to Yeoh (2010), the soil in UMS Hill Forest is typical of disturbed secondary forest, ranging from 4-5 pH with moderate organic matter (~2% SOM in the top 0–15 cm), and exhibits bulk density and water content (Yeoh, 2010). A comparative study by Suhaili et al. (2021) shows that upland Bornean tropical forest soils are frequently Gleyic Acrisols or Cambisols. These landscape and ecological characteristics influence the distribution and detectability of wildlife recorded by the camera traps.

2.2 Methods

This study used a camera-trap survey with a systematic-random design to determine station placement within SFERA@UMS (Kodoh et al., 2024). Nine sampling stations were established, each equipped with one camera trap unit (Suntek HC800M or Reconyx Hyperfire). Cameras were configured to capture a burst of three photographs per trigger event and operated continuously for 24 hours to record both diurnal and nocturnal wildlife activity. We applied a 30-minute detection interval, such that any images of the same species at a given station within 30 minutes were considered a single detection (Long et al., 2010; Beirne, 2023). The survey spanned six months from April to September 2023. Each camera remained deployed at a station for approximately 20 days before being systematically relocated to a new station, resulting in a total of 36 sampling points across the study period (9 stations × 4 relocations). The average distance between permanent stations was approximately 300 m to minimize overlapping detection zones, while each relocation was conducted within a 20 × 20 m quadrat surrounding the original station to capture microhabitat variation without compromising spatial independence. The cumulative sampling effort amounted to 1,620 camera-trap nights.

2.2.1 Biodiversity Index

The Shannon-Wiener Diversity Index was used to assess species diversity in SFERA@UMS. The index ranges from 0 (no diversity) to 3 (highest diversity) (Krebs, 1999; Magurran, 2004). This index was selected because it accounts for both species richness and the evenness of individual distribution across species, providing a more balanced representation of ecological diversity in small and heterogeneous habitats (Spellerberg & Fedor, 2003; Mackenzie et al., 2017).

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

H' = Shannon-Wiener
S =total number of species
Pi = proportion of individuals belonging to the ith species
ln = natural logarithm (log base e)

3 Results

Seven species were recorded, including bird and mammals (Table 1). The wildlife included long-tailed macaques (*Macaca fascicularis*, Endangered), based on the IUCN Red List uplisted assessment (2022), forest rats (*Rattus* sp., not evaluated at the species level but most congeners are listed as Least Concern), squirrels (*Callosciurus* sp., taxonomic identification unresolved; most congeners listed as Least Concern), Sunda pangolins (*Manis javanica*, Critically Endangered), Greater mousedeer (*Tragulus napu*, Least Concern), though declining locally, and Asian palm civets (*Paradoxurus hermaphroditus*, Least Concern). The birds recorded were the Greater Coucal (*Centropus sinensis*, Least Concern). All conservation status categories follow the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2024), unless otherwise stated. The presence of both common and threatened species, particularly the Critically Endangered Sunda pangolin and the Endangered long-tailed macaque, demonstrates the role of SFERA@UMS as a key habitat for wildlife in an urbanising landscape.

Table 1: Wildlife recorded in SFERA@UMS

#	Wildlife Type	Species	Number of events
1	Mammal	Long-tailed macaque (*Macaca fascicularis*)	198
2	Mammal	Rat (*Rattus* sp.)	27
3	Mammal	Squirrel (*Callosciurus* sp.)	10
4	Mammal	Sunda pangolin (*Manis javanica*)	3
5	Mammal	Greater mousedeer (*Tragulus napu*)	4
6	Mammal	Asian palm civet (*Paradoxurus hermaphroditus*)	1
7	Bird	Greater coucal (*Centropus sinensis*)	3

The overall detections were dominated by long-tailed macaques, indicating that generalist species remain relatively common in this urban forest patch. In contrast, detections of threatened or less disturbance-tolerant species, such as the Sunda pangolin and greater mousedeer, were rare, reflecting their naturally low encounter rates and vulnerability to habitat fragmentation. The index of diversity shows that there was H' = 0.726 with seven taxa examined for 246 individuals recorded in the study. This value reflects low diversity, as expected for a restricted forest fragment surrounded by extensive anthropogenic land use, consistent with the species–area relationship framework (Chisholm & Foster, 2018) and demonstrated shifts toward generalist-dominated assemblages in urban fragments (Melliger et al., 2018).

4 Discussion

The forest in SFERA@UMS is generally classified as disturbed secondary forest, and therefore our findings are consistent with the broader understanding that small and fragmented forest patches tend to support lower wildlife diversity (Haddad et al., 2015). Be as it may, we are pleasantly surprised that SFERA@UMS harbours other wildlife taxa we did not expect to find there. The discovery of the Sunda pangolin is not new to us, as this has been reported by Sompud et al. (2023). Four events of greater mousedeer were recorded in the vicinity of SFERA@UMS. Through this study, we also discovered that our forest gives refuge to the Asian palm civet. This has not been recorded before in the UMS Hill forest, let alone the SFERA@UMS. These findings collectively demonstrate that SFERA@UMS still retains certain habitat structures to support both generalist and conservation-priority species despite ongoing anthropogenic pressures.

These observations highlight that even small urban forest remnants can retain functional ecological roles, provided that sufficient vegetation structure and reduced human disturbance are maintained. The documented species assemblage, though limited in richness, comprises ecologically important frugivores and insectivores that may continue to contribute to natural regeneration processes within the campus landscape. SFERA@UMS covers only 25-ha and is relatively small; however, because it is surrounded by the UMS hill forest, it remains a highly significant area. It hosts not only the Critically Endangered Sunda pangolin but also other charismatic wildlife such as the greater mousedeer and the Asian palm civet. SFERA@UMS contributes to maintaining healthy planting stock for native and plantation species with ecological and silvicultural value, consistent with prior work highlighting the importance of managing disease risks in *Acacia mangium* plantations in Sabah (Maid & Ratnam, 2014). In addition, it supports biodiversity conservation in urban forests by providing essential refuge for various fauna.

While home garden systems in Kota Kinabalu have also been shown to contribute to urban biodiversity and ecological services (Kodoh et al., 2023), SFERA@UMS demonstrates these values at a larger ecological scale as a forest ecosystem that provides refuge for wildlife and essential ecosystem services. Furthermore, there is an ongoing effort to protect the environment, raise environmental awareness, and provide long-term education. A reforestation program using native trees has been implemented within that area, which UMS policies support, thereby enhancing the local habitat and, in turn, promoting plant diversity and supporting wildlife. Therefore, even marginal forest remnants, such as SFERA@UMS, can contribute meaningfully to maintaining wildlife presence in fast-urbanising landscapes such as Kota Kinabalu. This highlights the importance of retaining and enhancing small green refugia across Malaysian cities.

One limitation of this study is its relatively short six-month sampling period. Although the sampling effort was sufficient to document the key wildlife species present in this 25-ha urban forest, a longer monitoring period is recommended to capture potential seasonal variation in species occurrence and activity patterns (Zwerts et al., 2021). Extended sampling would strengthen the reliability of baseline data and help detect less common or transient species. Long-term monitoring of wildlife in SFERA@UMS should be maintained, as there may be additional species of high conservation value residing within the area. Logistical challenges faced in this study included camera traps being damaged by wildlife, particularly long-tailed macaques which often tamper with or dislodge the devices out of curiosity. Additional causes of camera trap failure were theft and high humidity, which can lead to battery corrosion and malfunctioning of electronic components (Meek et al., 2019; Zwerts et al., 2021). Future studies may incorporate additional detection tools such as acoustic monitoring, insect surveys, and vegetation assessments to provide a more holistic understanding of ecosystem recovery in the area.

5 Conclusion

SFERA@UMS supports notable wildlife of conservation value within an urban landscape. The confirmed presence of the Sunda pangolin and new records of the greater mousedeer and Asian palm civet demonstrate that even a small forest fragment can still provide important refuge for priority fauna. Therefore, continued protection and potential expansion of this forest reserve remain essential for maintaining biodiversity and enhancing urban ecosystem health.

Acknowledgement
This study has strictly adhered to all the ethical conduct set by the Sabah Biodiversity Council (SaBC) under permit number JKM/MBS.1000-2/13JLD.265.

Conflict of interest
The authors declare that there is no conflict of interest during the conduct of this research and in the completion of it.

Authors' contribution
JS: Supervision & writing, Funding acquisition. **ER:** Data curation. **MM:** Review & editing. **NAB:** Validations, Investigations.

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