

NOTES ON BATS' DIVERSITY IN PARCEL 5 OF SEKAR IMEJ CONSERVATION AREA FROM KIBUNDU, GEROWONG AND MONJUK TRAILS

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ABSTRACT. *The study on bat diversity in Sekar Imej Conservation Area (SICA) was conducted during the Sekar Imej Conservation Area Scientific Expedition from 19 September 2022 to 24 September 2022. Harp traps and mist nets were used to capture bats with placements along forest trails in Kibundu, Gerowong, and Monjuk for six consecutive nights. Species identification was performed on-site through morphological examinations of the forearm, ear, hindfoot, and tail (when available), with measurements recorded in millimeters (mm). Additionally, the bats were weighed in grams and their reproductive stages were noted. The study recorded nine bat species, belonging to four families: Pteropodidae, Rhinolophidae, Hipposideridae, and Vespertilionidae. From the Kibundu trail, Rhinolophus trifoliatus, Kerivoula intermedia and Kerivoula pellucida were collected, while Hipposideros cervinus, Kerivoula papillosa and Balionycteris maculata were recorded at Gerowong trail. At Monjuk trail, five species were recorded: Cynopterus brachyotis, Balionycteris maculata, Rhinolophus borneensis, Hipposideros cervinus and Kerivoula whiteheadi. These results will support the Sekar Imej Estate management in improving and expanding their conservation efforts and management strategies for bats and other wildlife in the landscape.*

KEYWORDS. Bat, diversity, forest trail, plantation, Sekar Imej Conservation Area

INTRODUCTION

Protected areas are viewed as vital boundaries that help conserve remaining species amid Southeast Asia's rapid deforestation (Sodhi et al., 2004; Lee et al., 2007; Fitzherbert et al., 2008). Globally, a total of 18,763,407 km² of parks and protected areas have been designated (Nagendra, 2008). However, concerns have arisen regarding habitat fragmentation and species decline when

human populations live in proximity to these areas (Nagendra, 2008). Specifically, the forests surrounding protected areas, which are intended to function as buffer or transitional zones, often experience significant degradation due to human activity (DeFries *et al.*, 2005; Lee *et al.*, 2007). The loss of habitat in these buffer zones can lead to the formation of isolated protected areas, ultimately diminishing their conservation effectiveness (DeFries *et al.*, 2005; Lee *et al.*, 2007).

As a result, the protection of natural forests within oil palm plantations has become increasingly recognized as essential for biodiversity conservation, particularly as it has become a key factor in the certification process for sustainable oil palm plantations (Fleiss *et al.*, 2020). The Sekar Imej Conservation Area (SICA), which encompasses 2,469 hectares within the Sekar Imej Estate, serves as a prime example of this approach. The conservation area comprises two sections known as Parcel 4 and Parcel 5, bordered by the Paitan and Lingkabau Forest Reserves, and is potentially capable of functioning as a transitional zone. The forest ecosystem within the Sekar Imej Conservation Area is primarily characterized by lowland mixed dipterocarp forest, featuring a structure made up of young regenerating forests, abundant saplings, and a low density of established mixed dipterocarp trees.

MATERIALS AND METHODS

Study sites

Bat sampling was carried out in Parcel 5 of the Sekar Imej Conservation Area (SICA) (see Figure 1). This section of the conservation area is adjacent to the Paitan Forest Reserves. The forest vegetation in Parcel 5 is primarily composed of lowland mixed dipterocarp forest, featuring logged-over areas that are approximately 20 to 30 years old. During the Sekar Imej Conservation Area Scientific Expedition, which took place from September 19 to September 24, 2022, we explored three trails in Parcel 5 for the study of bat diversity: Kibundu, Gerowong, and Monjuk trails.

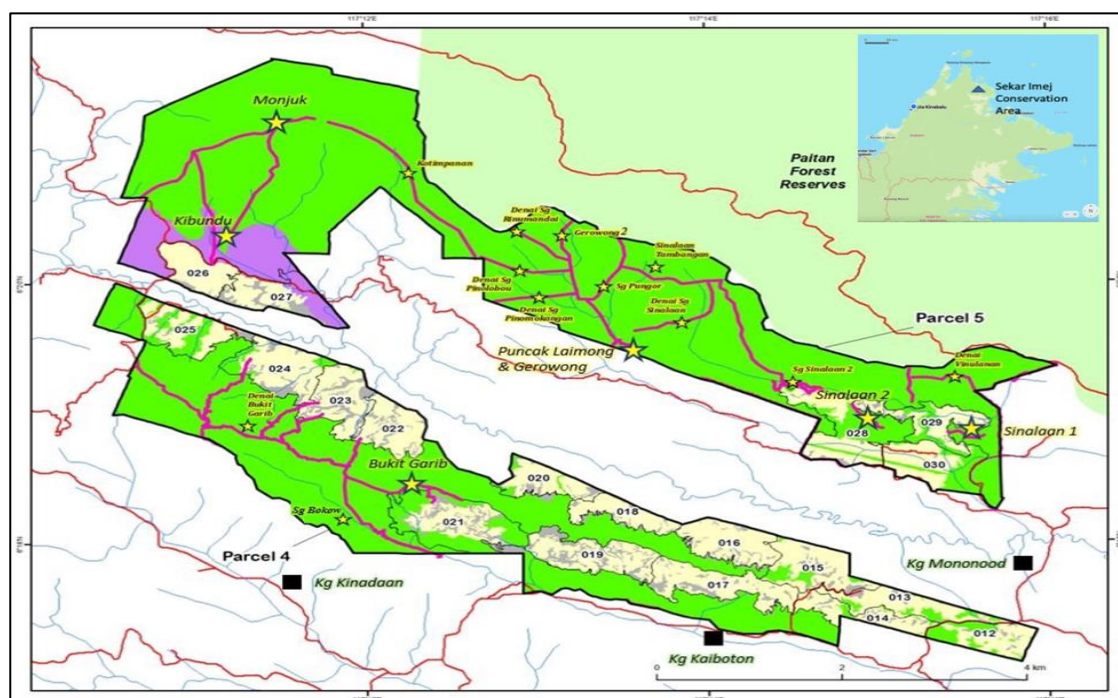


Figure 1 Sekar Imej Conservation Area (SICA), which includes Parcel 4 and Parcel 5

Kibundu trail

The Kibundu trail is situated close to the SICA Field Base Camp and Lot 27 of the planted area, beginning at an elevation of 70 meters above sea level (m a.s.l.) and concluding at Monjuk Peak at 280 m a.s.l. A small stream runs across the trail. The vegetation in the Kibundu area is primarily composed of secondary lowland forest, featuring young regenerating plants and mixed dipterocarps.

Gerowong trail

The Gerowong trail, situated within the Sekar Imej Conservation Area, runs alongside the Gerowong River. We established three sampling locations here: S1 (N06, 19.443; E117 13.615, 63 m a.s.l.), which featured large rock boulders on the riverbed; S2 (N06, 19.516; E117 13.618, 34 m a.s.l.); and S3 (N06, 19.516; E117 13.618, 61 m a.s.l.), both of which were located on a flat sandy riverbed.

Monjuk trail

The Monjuk trail serves as the primary pathway along a ridge that ascends to Monjuk Peak, which is the tallest point in the Sekar Imej Conservation Area. Along this trail, we set up two sampling stations: M1 located at 180 meters above sea level and M2 at 260 meters above sea level. These sampling stations are surrounded by secondary forest vegetation, characterized by a plentiful presence of palms.

Bat Sampling and Handling

We adhered to the sampling protocols outlined by Kingston *et al.* (2003), utilizing a harp trap along with three mist nets set up on-site. However, we made slight adjustments to account for seasonal variations during the sampling process and to minimize lengthy operating hours to prevent any harm to the animals. Bats were collected from 30 minutes before sunset until 4 hours after sunset (5:30 PM to 10:30 PM), with the nets and traps being monitored every 30 minutes. After each collection, the traps were taken down rather than being left unmanned overnight at the locations. Bats were placed into individual cotton bags prior to undergoing morphological examination (Mahyudin *et al.*, 2022).

Species Identification

The body weight of the bats was recorded in grams (g), while measurements for forearm length (FA), tibia (Tb), hindfoot (HF), ear and tragus (E-Tr), and tail (T) were taken in millimeters (mm) for species identification. Species classification was conducted in accordance with the methods of Payne *et al.* (2007), Francis (2008), and Philipps and Philipps (2016). We also assessed the age of each bat—juvenile, subadult, or adult—by examining the level of ossification in the epiphyses (Korine and Pinshow, 2004) and the color of their fur. Additionally, the reproductive stage was recorded for female bats (Korine and Pinshow, 2004).

Data Analysis

Species diversity and species distribution update

Species diversity was characterized by the species checklist generated in this study. The distribution of bats captured in the Sekar Imej Conservation Area (SICA) has been revised in light of previous findings by other researchers and specifically pertains to records from Sabah.

Foraging strategy and conservation status

We determined their guild structure based on foraging habits, following the approach of Struebig *et al.* (2006). The captured bats were categorized according to their conservation status as outlined in

the IUCN Red List of Threatened Species and the Sabah Wildlife Enactment (1997) (Sukiman, 2019; Mahyudin *et al.*, 2022). The Sabah Wildlife Conservation Enactment of 1997 was utilized to assess conservation status at the national level, while the IUCN Red List provided the basis for determining the conservation status of each species reported internationally (Mahyudin *et al.*, 2022).

RESULTS AND DISCUSSION

Species Diversity

This study identified nine bat species present at Parcel 5 of the Sekar Imej Conservation Area (SICA). The recorded species include: *Balionycteris maculata*, *Cynopterus brachyotis*, *Rhinolophus trifoliatus*, *Rhinolophus borneensis*, *Hipposideros cervinus*, *Kerivoula intermedia*, *Kerivoula pellucida*, *Kerivoula papillosa*, and *Kerivoula whiteheadi* (Table 1). The species assemblages in SICA consisted of four species from the Vespertilionidae family, two from Pteropodidae, one from Hipposideridae, and two from Rhinolophidae. These findings closely resemble typical palaeotropical bat assemblages, predominantly composed of insectivorous species from the families Hipposideridae, Rhinolophidae, and Vespertilionidae, particularly the subfamilies Kerivoulinae and Murininae (Struebig *et al.*, 2012). The absence of Murininae species from our SICA bat checklist does not necessarily indicate that these species are completely absent from the area (Suyanto and Struebig, 2007). Expanding the surveys may lead to the discovery of additional species. Moreover, external factors such as weather conditions and trap placement may impact the sampling effort (Sedlock *et al.*, 2008; Bansa *et al.*, 2020).

In this study, bat sampling efforts were constrained by rainy nights. To achieve better species coverage, it is essential to sample both sub-canopy and canopy levels to prevent bias in bat sampling (Bansa *et al.*, 2020). Implementing long-term monitoring, which involves sampling year-round during both wet and dry seasons, and utilizing a variety of sampling techniques—such as canopy nets and bat detectors (Bansa *et al.*, 2020)—across different locations within SICA, will improve our understanding of bat diversity in the area.

Table 1: Species diversity in Parcel 5, Sekar Imej Conservation Area, Sandakan

Family	Species	Common name
Pteropodidae	<i>Balionycteris maculata</i>	Spotted-winged Fruit Bat
	<i>Cynopterus brachyotis</i>	Sunda Short nosed Fruit Bat
Rhinolophidae	<i>Rhinolophus trifoliatus</i>	Trefoil Horseshoe Bat
	<i>Rhinolophus borneensis</i>	Bornean Horseshoe Bat
Hipposideridae	<i>Hipposideros cervinus</i>	Fawn Roundleaf Bat
Vespertilionidae	<i>Kerivoula intermedia</i>	Small Woolly Bat
	<i>Kerivoula pellucida</i>	Clear-winged Woolly Bat
	<i>Kerivoula papillosa</i>	Papillose Woolly Bat
	<i>Kerivoula whiteheadi</i>	Whitehead's Woolly Bat

Bat Species Distribution Notes

Although all the species were recorded for the first time in the Sekar Imej Conservation Area, they have been previously documented in other regions of Sabah.

Family Rhinolophidae

Members of the Rhinolophidae family, specifically *Rhinolophus trifolius* (Trefoil Horseshoe Bat; Figure 2(a)), were captured in the Sekar Imej Conservation Area and are considered common in primary forests of the lowlands (Payne *et al.* 2007). This species is recognized as forest dependent. In Sabah, sightings of this bat have been recorded in various locations, including Trus Madi (Payne *et al.* 2007), Maliau Basin (Mahyudin *et al.* 2010), Sungai Rawog (Amat *et al.* 2019), Crocker Range (Yoh *et al.* 2020), and Imbak Canyon (Senawi *et al.* 2020). A male individual of this species was captured at the Kibundu trail, near a small tributary that runs alongside the trail, in an area dominated by succession species, particularly palms and *Calamus spp.*

An adult male *Rhinolophus borneensis* (Bornean Horseshoe Bat; Figure 2(b)) was caught at sampling Station 1 of the Monjuk trail (M1) in a harp trap set in an open area on the ridge of Monjuk. This species has also been reported in Sabah from locations such as Maliau Basin (Mahyudin *et al.* 2010), Imbak Canyon (Yasuma and Andau, 2000; Bansa *et al.* 2020; Senawi *et al.* 2020), and is known to be common in several cave systems across Sabah, including Gomantong, Madai, Sukau, Sapulut, and Gunung Kinabalu (Abdullah *et al.* 2007; Payne *et al.* 2007; Yasuma and Andau, 2000). Additionally, it has been documented in the Crocker Range (Yasuma and Andau 2000; Yoh *et al.* 2020), as well as in Danum Valley, Sapagaya, Sepilok, Tabin, and Ulu Tomani (Yasuma and Andau 2000).



Figure 2: The two bat species from the Rhinolophidae family that were captured in the Sekar Imej Conservation Area (SICA), a) *Rhinolophus trifolius*; b) *Rhinolophus borneensis* (Photo credit: Nurul 'Ain Elias and Ummu 'Atiyyah Mohamed Talhah)

Family Vespertilionidae, subfamily Kerivoulinae

In the subfamily Kerivoulinae, we documented four species: *Kerivoula intermedia* and *Kerivoula pellucida* were recorded at the Kibundu trail, while *Kerivoula papillosa* was found along the Gerowong trail and *Kerivoula whiteheadi* at the Monjuk trail. All these species have a strong association with primary lowland forests, although *K. intermedia* (Small Woolly Bat; Figure 3(a)) is

also known to inhabit secondary forests (Payne *et al.* 2007). The distribution of *K. intermedia* in Sabah has been observed in locations such as Sepilok, Tabin, Witt Range (Payne *et al.* 2007), Sungai Rawog (Amat *et al.* 2019), Imbak Canyon (Bansa *et al.* 2020), and Crocker Range (Yoh *et al.* 2020). During this study, a female individual was captured at the Kibundu trail with early pregnancy status, while a male was captured in a harp trap set in an open area dominated by Tarap trees and ferns at the same location.

K. pellucida (Clear-winged Woolly Bat; Figure 3(b)) has been previously recorded from various locations across Sabah (Payne *et al.* 2007), including Sungai Rawog (Amat *et al.* 2019), Crocker Range (Yoh *et al.* 2020), and Imbak Canyon (Bansa *et al.* 2020; Senawi *et al.* 2020). In this study, a female *K. pellucida* in the late stage of lactation was captured at the Kibundu trail over a small tributary, along with an adult male recorded at sampling station M2 in a harp trap. Additionally, a female *K. papillosa* (Figure 3(c)) at the post-lactating stage was caught at S3 along the Gerowong trail in a harp trap set 50 meters from the Gerowong River, which is surrounded by secondary lowland forest. Previously, *K. papillosa* has been documented in Danum Valley, Gomantong, Madai, Sepilok, and Tabin (Payne *et al.* 2007), Imbak Canyon (Bansa *et al.* 2020; Senawi *et al.* 2020), and Crocker Range (Yoh *et al.* 2020). An adult male *K. papillosa* was also captured in a harp trap at M2 of the Monjuk trail, which is covered by secondary forest vegetation. Furthermore, a male *K. whiteheadi* (Whitehead's Woolly Bat; Figure (d)) was captured in the harp trap at sampling station M1 on the Monjuk trail. This species was previously reported by Payne *et al.* (2007) in Lower Kinabatangan, and Struebig *et al.* (2006) proposed that the genus *Kerivoula* could serve as an indicator for assessing forest disturbance, particularly for *K. papillosa*, as it is found to be less common in disturbed forests compared to natural ones.



Figure 3: The four bat species from the Vespertilionidae family and Kerivoulinae subfamily that were captured in the Sekar Imej Conservation Area (SICA), a) *K. intermedia*; b) *K. pellucida*; c) *K. papillosa*; d) *K. whiteheadi*. (Photo credit: Nurul 'Ain Elias and Ummu 'Atiyyah Mohamed Talhah)

Family Hipposideridae

Regarding the hipposiderids, a group of *Hipposideros cervinus*, comprising five females and one male (Figure 4), was captured in a harp trap. Among the females, three were observed to be in the post-lactating stage, while two were non-reproductive at sampling station M2 along the Monjuk trail. This species has also been observed at the Gerowong trail, specifically at a rock shelter adjacent to the Gerowong River (S1), where a distinct separation was noted between male and female colonies, positioned 50 meters apart. Additionally, *Hipposideros cervinus* was located at S3, which features a flat sandy riverbed along the Gerowong River. Known as the Fawn Roundleaf Bat, this species is commonly found in cave areas and has a broad distribution throughout Borneo (Suyanto & Struebig, 2007). Its presence has been documented in multiple sites including Batu Punggol, Baturong, the Crocker Range, Danum Valley, Gomantong, Gunung Kinabalu, Maliau Basin, Pulau Mantanani, Pun Batu, Sepilok, Sukau, and Tabin (Yasuma & Andau, 2000; Abdullah et al. 2007), as well as Pulau Balambangan and Pulau Banggi (Nor, 1996; Mahyudin et al. 2018), Imbak Canyon (Bansa et al., 2020; Senawi et al. 2020), and the Crocker Range (Yoh et al. 2020), along with Madai and Batu Supu (Mahyudin et al. 2022a; Mahyudin et al. 2022b).



Figure 4: *Hipposideros cervinus* from the Hipposideridae family that was captured in the Sekar Imej Conservation Area (SICA) (Photo credit: Nurul 'Ain Elias and Ummu 'Atiyyah Mohamed Talhah)

Family Pteropodidae

An intriguing sighting involved a pteropodid that flew between the trees at sampling station S2 along the Gerowong trail, where we captured a single *Balionycteris maculata* (Spotted-winged Fruit Bat) at sampling station S3 during the trapping session. The female *B. maculata* was captured while in the lactating stage. This species has also been observed at the Monjuk trail, specifically at sampling station M2, where three females were captured. Among these, two females were in the post-lactating stage and were caught in mist nets, while the other was captured in a harp trap. *B. maculata* is the

smallest fruit bat and is commonly found in the forest understory. It has been recorded in various forest types, including mangrove, primary, and secondary forests (Philipps and Philipps, 2016). The distribution of *B. maculata* includes scattered records from Kota Kinabalu, Sepilok, Madai, and Tawau (Payne et al. 2007), as well as from Imbak Canyon (Hassan, 2016; Bansa et al. 2020; Senawi et al. 2020) and the Crocker Range (Yoh et al. 2020).

Another fruit bat species recorded in the Sekar Imej Conservation Area is the Sunda Short-nosed Fruit Bat (*Cynopterus brachyotis*) (Figure 5(b)). At sampling station M2 along the Monjuk trail, we captured two adult males and a juvenile female of *C. brachyotis* using a mist net set in an open area surrounded by palms and shrubs. The Sunda Short-nosed Fruit Bat (*C. brachyotis*) is among the most common and widely distributed fruit bats (Payne et al. 2007). This species thrives in various landscape matrices, including orchards, oil palm plantations, secondary forests, as well as coastal and mangrove environments (Philipps and Philipps, 2016). Previous records for this species include Pulau Balambangan (Nor, 1996), Imbak Canyon (Bansa et al. 2020), Crocker Range (Yoh et al. 2020), Gomantong (Abdullah et al. 2007), and Madai (Mahyudin et al. 2022a).



Figure 5: The four bat species from the Vespertilionidae family and Kerivoulinae subfamily that were captured in the Sekar Imej Conservation Area (SICA), a) *Balionycteris maculata* b) *Cynopterus brachyot*. (Photo credit: Nurul 'Ain Elias and Ummu 'Atiyyah Mohamed Talhah)

Foraging Strategy and Conservation Status

In terms of feeding guilds, insectivorous bats accounted for 88% of the species assemblages, which included six species categorized as narrow-space insectivores (Table 2). Additionally, *Hipposideros cervinus* was classified as both edge-gap and narrow-space insectivores. Meanwhile, the pteropodid *Balionycteris maculata* was designated as a narrow-space (understorey) frugivore/nectarivore, and *Cynopterus brachyotis* was classified as a below-canopy frugivore (Struebig et al. 2006). The assignment of each species to its respective feeding guild is influenced by habitat type and foraging behavior (Denzinger and Schnitzler, 2013). It is noteworthy that all bat species recorded from Parcel 5 of the Sekar Imej Conservation Area (SICA) are not protected under the Sabah Wildlife Conservation Enactment (1997). However, several species have been identified with high conservation value according to the IUCN Red List of Threatened Species, including *Rhinolophus trifoliatus*, *Kerivoula intermedia*, and *Kerivoula pellucida*, which are classified as Near Threatened.

The IUCN conservation status of the bats in SICA underscores the necessity for further exploratory research, as much about these species remains unknown. Additionally, the Sabah Wildlife Conservation Enactment (1997) highlights the implications of data scarcity, as none of the species listed are afforded protection under the enactment (Mahyudin *et al.*, 2022a). The bat species currently protected by the Sabah Wildlife Conservation Enactment (1997) are endemic to Borneo and the Malay Peninsula and have a limited distribution range within the Sundaic region (Mahyudin *et al.*, 2022a).

Table 2: Conservation status and foraging behaviours of bats in Sekar Imej Conservation Area

Species	Sabah Wildlife Conservation Enactment (1997)	IUCN Red List of Conservation Status	Foraging strategy
<i>Balionycteris maculata</i>	Not Protected	Least Concern	Nf
<i>Cynopterus brachyotis</i>	Not Protected	Least Concern	Bf
<i>Rhinolophus trifolius</i>	Not Protected	Near threatened	Ni
<i>Rhinolophus borneensis</i>	Not Protected	Least Concern	
<i>Hipposideros cervinus</i>	Not Protected	Least Concern	E/Ni
<i>Kerivoula intermedia</i>	Not Protected	Near threatened	Ni
<i>Kerivoula pellucida</i>	Not Protected	Near threatened	Ni
<i>Kerivoula papillosa</i>	Not Protected	Least Concern	Ni
<i>Kerivoula whiteheadi</i>	Not Protected	Least Concern	

*Note: Nf indicated narrow space (understorey) frugivore/ nectarivore; Bf indicated below canopy frugivore; Ei indicated insectivores foraging at the edges or open spaces; E/Ni indicated Insectivores foraging at the edge/open/narrow spaces, and Ni indicated insectivores foraging at narrow spaces.

CONCLUSION

All bats captured in the Sekar Imej Conservation Area (SICA) represent new distribution records, suggesting that bat diversity in Sabah is still underrepresented and requires further survey efforts. However, existing references for bat species in Sabah do not provide accurate distribution data. The presence of several rare species with significant conservation status underscores the importance of the Sekar Imej Conservation Area ecosystem for sustaining bat diversity in the interior regions of Sabah. This highlights the urgency of improving the protection and conservation of bats in Sabah by revising and remapping their conservation status in the Sabah Wildlife Conservation Enactment of 1997. These findings will aid in the management of the Sekar Imej Estate, allowing for enhanced conservation efforts and management strategies in the landscape that support a variety of matrices for bats and other wildlife.

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