

DIVERSITY AND SPECIES COMPOSITION OF NON-VOLANT SMALL MAMMALS IN CHEMERONG RECREATIONAL FOREST AND KENYIR, TERENGGANU

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Abstract: Malaysia comprises a large number of mammal species, most of which are small mammals. However, the diversity and species composition of non-volant small mammals remains understudied, especially on the east coast of Peninsular Malaysia. This study aims to determine the diversity and species composition of non-volant small mammals in the Chemerong Recreational Forest and Kenyir. 10 sampling sessions with 3,000 sampling efforts were conducted between November 2021 and October 2022 using 100 collapsible wire-mesh live traps. In Chemerong Recreational Forest, 50 individuals were identified from 11 species, which is dominated by *Rattus rattus* (n = 14), followed by *Maxomys whiteheadi* and *Tupaia glis* with nine individuals, respectively. In Kenyir, 62 individuals were captured from nine species, primarily comprising *Sundamys muelleri* (n = 15), *Maxomys rajah* (n = 14), and *Rattus rattus* (n = 13). Results reveal that the diversity and species composition varied between the two study areas. Chemerong Recreational Forest demonstrates a higher diversity of non-volant small mammals, while Kenyir exhibits higher species dominance. This study provides baseline data for further study and conservation efforts for non-volant small mammal species in the region.

Keywords: Diversity, non-volant small mammals, recreational forest, species composition, Terengganu.

Introduction

Malaysia indeed stands out as a biodiversity hotspot (Von Rintelen *et al.*, 2017; Azmir *et al.*, 2022), renowned for its rich variety of flora and fauna. This record includes a diverse array of small mammal species, all weighing below 5 kg when they reach maturity (Bourliere, 1975). In Peninsular Malaysia, there are about 205 small mammal species, which comprise families such as Muridae, Sciuridae, and Scandentia from more than 360 species of mammals (Department of Wildlife and National Parks, 2023). Small mammals can be found in diverse habitats from high montane forests to coastal mangroves and swamp forests (Laurent *et al.*, 2020). Thus, with a huge range of habitats,

they thrive, occupying various niches and being important for the survival of many ecosystems. Note that small mammals are vital as they act as seed dispersal agents, which help maintain forest health and their excrement contains seeds that promote the growth of new trees (Acharya, 2001; Wells & Bagchi, 2005; Zwolak *et al.*, 2010). Additionally, they also act as prey for animals higher up the food chain (Nadchatram, 2008; Chaisiri *et al.*, 2010).

Small mammals can also be discovered in man-made areas such as agricultural land, housing, and urban areas. Notably, certain species have become adaptable in thriving in man-made areas and becoming dominant species.

This includes house rat (*Rattus rattus*), brown rat (*Rattus norvegicus*), and Asian house shrew (*Suncus murinus*) as they are highly adaptable to human habitation and are considered habitat generalists (Rhim *et al.*, 2007; Bernard *et al.*, 2009; Benacer *et al.*, 2013). The study of small mammal diversity in Terengganu, especially in forested areas has received relatively less attention than in other regions. Previous studies have only focused on a few districts such as Hulu Terengganu and several islands within the state (Rahim *et al.*, 2016; Nor Zalipah *et al.*, 2019; Baqi *et al.*, 2021). Past literature has revealed approximately 74 small mammals in Hulu Terengganu and 56 species across Pulau Perhentian Besar and Pulau Perhentian Kecil (Baqi *et al.*, 2021).

Although only a few areas have been studied, a large diversity of small mammals have been reported with about 30% of Malaysia's small mammal species discovered in Terengganu (Rahim *et al.*, 2016). The high diversity of small mammals in Terengganu is related to the relative density of intact forest areas in Terengganu, which provide a suitable habitat for small mammals to thrive (Osman *et al.*, 2022). Remarkably, Terengganu is one of the states in Malaysia and has the largest forest cover after Sabah, Sarawak, and Pahang. More than 95,750 hectares of land in Terengganu are

forested areas, some known as essential tourist hotspots (Terengganu Forestry, 2016). Given the knowledge gaps in their distribution and diversity in Terengganu, this study aims to determine the diversity and species composition of non-volant small mammal species in Chemerong Recreational Forest and Kenyir in Terengganu.

Materials and Methods

Study Area

The study was conducted in two recreational areas in Terengganu: The Chemerong Recreational Forest and Kenyir (Figure 1). The Chemerong Recreational Forest is located in the Pasir Raja Forest Reserve in Dungun. The size of this recreational area is about 292 hectares and about 30 km from the nearest city. The main attractions are the waterfalls and hiking trails to camp at the mountain top. Meanwhile, Kenyir is located in Hulu Terengganu, which is known as the second-largest man-made lake in Southeast Asia (Wahab *et al.*, 2017). It has a total landmass of 38,000 hectares and Kenyir Lake offers many recreational spots around the vast lake area, which are accessible by speed boats and houseboats. Some famous attractions include the Saok and Lasir rivers, many waterfalls, the Kelah Sanctuary, Bewah Cave, and the Belunak hiking trail.

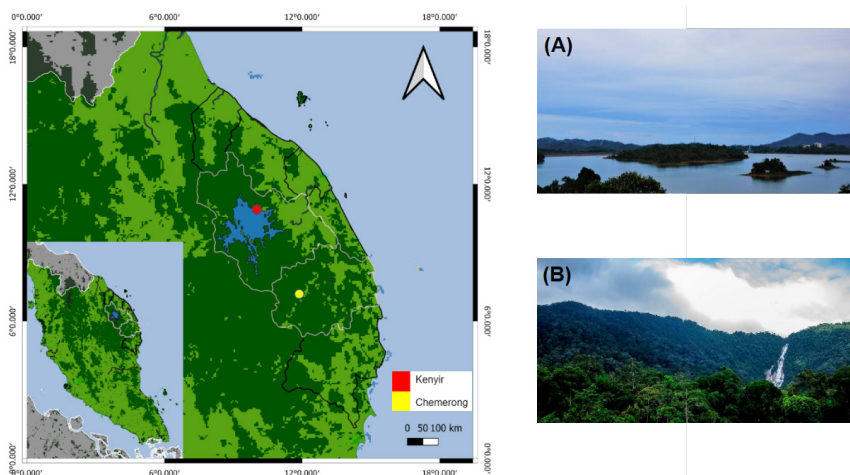


Figure 1: Map showing the location of the study areas in Peninsular Malaysia and within Terengganu state, with aerial view of (A) Kenyir Lake and (B) Chemerong Recreational Forest

Ethical and Permit Approvals

This study was conducted with ethical approval from the UMT Animal Ethics committee (UMT/JKEPHMK/2021/60), permits for entering the study site from the Forestry Department (JH/100Jld.29(76) and PHNT.100/58/2/33Bhg.3(6)), Development Authority of Terengganu Tengah (LKTT:060/1/4/3/5Jld.3-(28)), and also permit to capture animal from the Department of Wildlife and National Park (UMT/JPHLTn.600-6/1/4JLD2(83)/210922).

Animal Trapping

The animal trapping sessions were conducted between May and November 2022 at Chemerong Recreational Forest and Kenyir,

with 10 trapping sessions at each location. Four days and three nights were allocated for each trapping session. A total of 100 wire-mesh live traps with dimensions of 25 cm x 15 cm x 12 cm were used in each trapping session, with a total of 3,000 trapping efforts per session. The traps were randomly deployed along forest trails and river edges with a distance of 10 m between each trap (Figure 2). Ripe bananas, oil palm fruit, and sausages were used as bait and the traps were set late in the evening and checked daily. The bait was replaced each day and traps that managed to capture specimens were brought back to the Universiti Malaysia Terengganu (UMT) laboratory for further morphometric measurements and species identification.



Figure 2: (A) Wire-mesh live traps that were used in each trapping session, (B) traps that were randomly deployed along forest trails and river edges, and (C) captured individuals

Species Identification

Morphometric measurements were obtained for each captured specimen, including head-body length (from nose tip to the anus), tail length (from anus to the tail tip), ear length (from external opening to the tip), hindfoot length

(from the tip of the longest toe to the heel) (Figure 3), and body weight. Note that sex was also recorded for each specimen. All captured animals were identified at the species level based on Francis (2019).

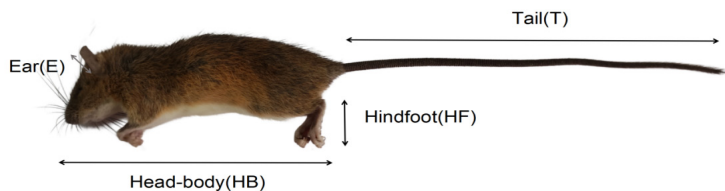


Figure 3: The morphometric measurement: Head-body (HB), tail (T), ear (E), and hindfoot (HF)

Data Analysis

Diversity and abundance of non-volant small mammal species were conducted using multiple approaches, including diversity indices, species rank-abundance, species richness estimator, and rarefaction. The diversity indices that were used for the estimation of diversity are Dominance (D’), Simpson (1-D), Shannon (H’), and Evenness (E’). These analyses were performed using a combination of Paleontological Statistics (PAST) software version 4.11 (Hammer *et al.*, 2001), Interpolation and Extrapolation (iNEXT) online latest version August 2022 (Chao *et al.*, 2014), and Microsoft Excel version 2310.

Results and Discussion

Species Composition of Non-volant Small Mammals

A total number of 112 individuals were caught from both study sites, comprising 12 species from three families, namely Tupaiidae,

Sciuridae, and Muridae (Table 1). Kenyir recorded 62 individuals from nine species and Chemerong Recreational Forest with 50 individuals from 11 species. The most dominant family caught was Muridae with 93 individuals, followed by Tupaiidae with 17 individuals, and Sciuridae with two individuals (Figure 4).

Meanwhile, in Chemerong Recreational Forest, the most common species recorded were *Rattus rattus* with 14 individuals, followed by *Maxomys whiteheadi* with nine individuals. The most dominant species recorded in Kenyir were *Maxomys rajah* and *Sundamys muelleri* with 15 and 14 individuals, respectively (Figure 5). The presence of rare species was also recorded in both sites with one individual each. Chemerong Recreational Forest recorded two species, *Sundamys muelleri* and *Maxomys surifer*, while Kenyir had one species, *Chiropodomys gliroides*.

Table 1: Checklist of non-volant small mammals captured, organised by family, and study site (IUCN = International Union for Conservation of Nature, LC = Least Concern, VU = Vulnerable)

Species	Common Name	IUCN Status	Chemerong Recreational Forest	Kenyir	Total Individual
Order Rodentia					
Family Muridae					
<i>Chiropodomys gliroides</i>	Indomalayan pencil-tailed tree-mouse	LC	3	1	4
<i>Leopoldamys sabanus</i>	Long-tailed giant rat	LC	3	3	6
<i>Leopoldamys ciliatus</i>	Sundaic mountain leopoldamys	LC	0	2	2

<i>Maxomys rajah</i>	Rajah spiny rat	VU	2	15	17
<i>Maxomys surifer</i>	Red spiny rat	LC	1	2	3
<i>Maxomys whiteheadi</i>	Whitehead's spiny rat	VU	9	0	9
<i>Niviventer cremoriventer</i>	Dark-tailed niviventer	LC	4	4	8
<i>Rattus rattus</i>	House rat	LC	14	13	27
<i>Rattus tiomanicus</i>	Malaysian field rat	LC	2	0	2
<i>Sundamys muelleri</i>	Muller's giant sunda rat	LC	1	14	15
Family Sciuridae					
<i>Callosciurus notatus</i>	Plantain squirrel	LC	2	0	2
Order Scandentia					
Family Tupaiidae					
<i>Tupaia glis</i>	Common treeshrew	LC	9	8	17
Total no. of individuals			50	62	112
No. of species			11	9	12
No. of family			3	2	3
Sampling effort			3,000	3,000	6,000
Capture rate (%)			1.7	2.0	1.9

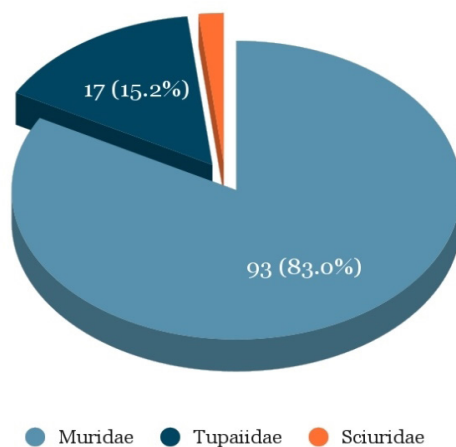


Figure 4: Abundance of non-volant small mammals according to family

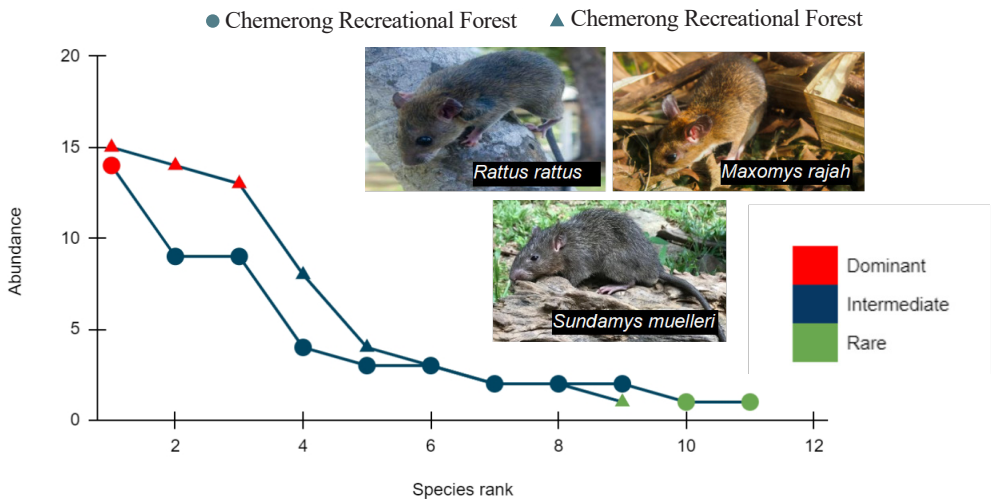


Figure 5: Rank abundance curve of non-volant small mammals captured from Chemerong Recreational Forest and Kenyir

This study revealed that the family Muridae had more than 83%, which resulted in being the most abundant family at both study sites. Out of 12 species captured, 10 species were listed as Least Concern (LC), and two species were listed as Vulnerable (VU) under the IUCN Red List of Threatened Species (IUCN, 2018). Both sampling sites have equal sampling effort; however, the captured rate between both sites varied. Notably, Kenyir has a higher capture rate of 2.0% compared to Chemerong Recreational Forest with 1.7% (Table 1). The high abundance was expected as Muridae is known to be the most abundant rodent family with more than 120 genera (William-Dee *et al.*, 2019; Department of Wildlife and National Parks, 2023). Consequently, the nature of the study sites contributed to the high species abundance, as forest habitats are known to have high abundance compared to urban and suburban areas (Rhim *et al.*, 2007; Bernard *et al.*, 2009; Benacer *et al.*, 2013). The complexity of forest habitats creates more niches for many species to cohabitate rather than generalist species reported in urban and suburban areas.

Furthermore, trapping methods by deploying cage traps on the forest floor have been demonstrated to capture more individuals

from the family Muridae compared to other rodent families. The theory revolves around the feeding behaviour of each family. Members of the family Muridae, mostly comprised of rats and mice are known to prefer foraging on the forest floor as they are not excellent climbers. They typically forage for seeds and fruits on bushes and insects crawl on the ground (Wolton, 1985; Corbalán & Debandi, 2006). While most of the family Muridae are known to be nocturnal, both families, Tupaiidae and Sciuridae have similar characteristics, which are diurnal and known to be active in the morning and before dusk (Gould, 1978; Kwartalnov, 2022). Furthermore, these two families are known for their adapting to climb trees and canopy (Wells *et al.*, 2006). They have strong hind legs and slender bodies that help them to move from one branch to another. They also prefer eating fruits and seeds, foraging mostly on the trees and rarely going to the ground (Corlett, 2017).

The dominant species identified in this study contrasts with those discovered in a previous study conducted in the Sekayu Recreational Forest (Shafie *et al.*, 2021). The earlier study revealed that the Sekayu Recreational Forest was dominated by *Rattus tiomanicus*, while this study indicated that Chemerong

Recreational Forest and Kenyir were dominated by *Rattus rattus* and *Sundamys muelleri*, respectively. These differences in dominant species are probably due to the microhabitat differences between the habitats. The Sekayu Recreational Forest is surrounded by oil palm plantations, orchards, and human settlements. In comparison, while Chemerong Recreational Forest shares similar surroundings, it is located more profoundly in the forest area and near a mountain. In contrast, Kenyir is distinct from the other two sites, with large water bodies and being known as the biggest man-made lake in Southeast Asia (Wahab *et al.*, 2017). The differences in dominant species are closely related to the animal's ecology and adaptability to human-dominated areas (Rahim *et al.*, 2007; Bernard *et al.*, 2009; Benacer *et al.*, 2013). Moreover, *Rattus rattus* can be discovered predominantly in human settlements, where it has adapted to rely on humans for food. Although the Sekayu Recreational Forest is near human settlements, the sampling point for the study was further from houses. The Sekayu Recreational Forest is surrounded by grassy habitats, oil palm plantations, and abandoned wood structures that are known to be the primary habitat for *Rattus tiomanicus* (Saufi *et al.*, 2020), explaining its dominance there. On the other hand, *Sundamys*

muelleri is known to inhabit areas near water bodies, such as Kenyir, since this species is a strong swimmer (Pimsai *et al.*, 2014).

Diversity Indices of Non-volant Small Mammals

Of these four indices, three suggested that Chemerong Recreational Forest has higher diversity values, while Kenyir has a higher value for Dominance (D'). This indicates that Chemerong Recreational Forest has higher diversity, while Kenyir has higher dominance (Table 2). Figure 6 summarises the individual-based rarefaction curve of both study sites, depicting that Chemerong Recreational Forest has higher diversity compared to Kenyir. The curve was extrapolated (dotted line) until it reached asymptomatic. Consequently, the individual-based rarefaction and extrapolation curves suggest that both study areas nearly achieve asymptote (Chao *et al.*, 2014). The asymptote line on the graph provides a general indication that the data collected is sufficient to represent the study sites (Chao *et al.*, 2009). Therefore, the extrapolated value was used to estimate the number of individuals in the study sites, which is visualised as a dotted line on the graph. This line indicates that the graph achieves an asymptote when the number of individuals is doubled to 100.

Table 2: Diversity indices of Chemerong Recreational Forest and Kenyir

	Chemerong Recreational Forest	Kenyir
No. of species	11	9
No. of individuals	50	62
Dominance (D')	0.1453	0.1655
Simpson (1-D)	0.8547	0.8345
Shannon (H')	2.156	1.947
Evenness (E')	0.7853	0.7787

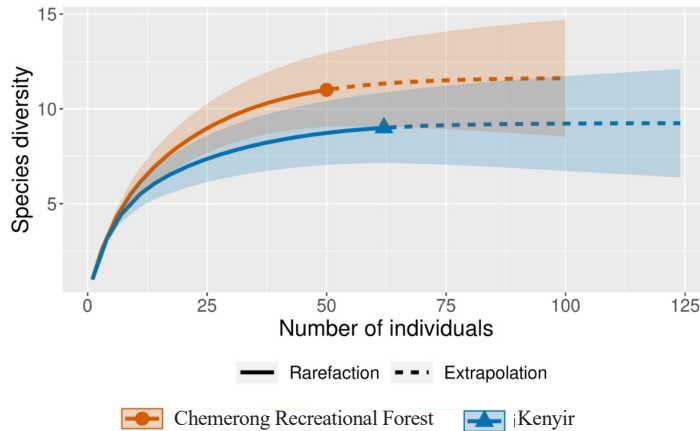


Figure 6: Extrapolated individual-based rarefaction curve for Chemerong Recreational Forest and Kenyir

Conclusions

In conclusion, this study provides valuable information about the diversity and species composition of non-volant small mammals in Chemerong Recreational Forest and Kenyir, Terengganu. Our results illustrate that Chemerong Recreational Forest has higher diversity, while Kenyir has higher species dominance. Despite these differences, both study areas have similar small mammal species. This study also provides baseline data for further study and conservation efforts for non-volant small mammal species in the region. Therefore, further studies in multiple forested areas are recommended to enhance understanding of diversity and species composition on the east coast of Peninsular Malaysia.

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Conflict of Interest Statement

The author states that they do not have a conflict of interest.

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