

Distribution of arboreal nocturnal mammals in northern Borneo

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Abstract

This study aimed to determine the distribution of arboreal nocturnal mammals in northern Borneo, in particular the Bornean Striped Palm Civet *Arctogalidia stigmatica*, Philippine Slow Loris *Nycticebus menagensis*, Western Tarsier *Cephalopacus bancanus*, Bornean Colugo *Galeopterus borneanus* and Island Palm Civet *Paradoxurus philippinensis*. Nocturnal mammals were surveyed at six sites in northern Borneo of varying habitat types and patterns of disturbance. Standardised point and line transects following predetermined paths were used and mammals searched for with the aid of a thermal imaging camera, a red-filtered head lamp and alternatively, a white light head lamp. With 49% of the observations, *A. stigmatica* (36 individuals/6 sites) was the most common species across the study sites, followed in abundance by *N. menagensis* (16/5), *C. bancanus* (14/3), *G. borneanus* (11/3) and *P. philippinensis* (2/2). The highest arboreal mammal density of 4.4 individuals/km was found at our Kiudang study site in Tutong District. In addition to the five focal arboreal mammals, 20 additional species were observed throughout the study. This study reveals variation in arboreal nocturnal mammal presence with habitat type that is likely influenced by diet preferences, habitat fragmentation, and the level of hunting pressure. Further surveys combined with arboreal camera trapping will be necessary to study the secretive and easily disturbed arboreal nocturnal mammals of Borneo.

Index Terms: arboreal nocturnal mammals, distribution, northern Borneo, red light, thermal imaging

1. Introduction

Mammals play a critical role in balancing the ecosystem as they provide important ecosystem services¹. However, human-induced deforestation, overexploitation, and pollution have led to the destruction and degradation of habitats used by mammals. The decline of wildlife due to the loss of virgin forests is well documented². The International Union for Conservation of Nature (IUCN) has shown that thousands of mammals worldwide have been affected by habitat loss³. Thus, by studying the distribution of mammals, a deeper understanding of the species affected, their long-term survival, conservation needs and zoonotic potential can be assessed⁴. Moreover, by assessing the conservation status of mammals, we could provide efforts and resources for the conservation

or protection of these species. The majority of mammals are nocturnal⁵ and are not well-studied, especially in Brunei Darussalam.

This research focused on arboreal nocturnal mammals. The term arboreal has been ascribed by Reed⁶ to mammals that spend most of their time on trees conducting activities such as eating, socialising and breeding, while nocturnality is defined as being active during the night and sleeping during the day.

Nocturnal surveys were carried out at six sites in northern Borneo chosen to cover a variety of sites with varying degrees of forest degradation from pristine to secondary to fruit farm mosaic. Except for one study site in Sarawak, Malaysia, all sites were located in Brunei Darussalam, a small

country with a 5765 km² land area. Although Brunei Darussalam is the smallest territory on the island, it is a hotspot of biodiversity, featuring high species diversity^{7,8}. An estimated 75% of the country's land area is covered by tropical forests that are composed mainly of old growth forests⁹.

The surveys concentrated on five nocturnal mammal species: the Philippine Slow Loris (*Nycticebus menagensis*), the Bornean Colugo (*Galeopterus borneanus*), the Western Tarsier (*Cephalopacus bancanus*), the Bornean Striped Palm Civet (*Arctogalidia stigmatica*) and the Island Palm Civet (*Paradoxurus philippinensis*). There is inadequate information on the abundance and distribution of arboreal nocturnal mammals in northern Borneo with much of the available data being anecdotal or circumstantial¹⁰. Thus, the aim of this research was to study and record the distribution of the five mentioned focal nocturnal mammal species and to provide baseline data for their conservation and protection.

2. Materials and methods

This nocturnal mammal survey was conducted at five different sites in Brunei Darussalam, within forests, farms and anthropogenically-disturbed habitats, and one site in Sarawak (Malaysia) within the Gunung Mulu National Park (see *Figure 1*).

The nocturnal mammal study was carried out from February 2019 to February 2020, the time ranging from 20:00 to 01:00 hours, using a combination of set paths and point surveys of 500 m length, along existing paths and roads. At every 100 m along the transect, the surrounding vegetation was scanned at all levels, as far as the eye could see, using a head torch with red filter (Clulite HL13) and a thermal imaging device (FLIR Scout III 640)¹¹. These mammal species were medium-sized, which allowed observers, novice or skilled, to detect and study them easily. Moreover, they were abundant enough to allow comparisons between sites.

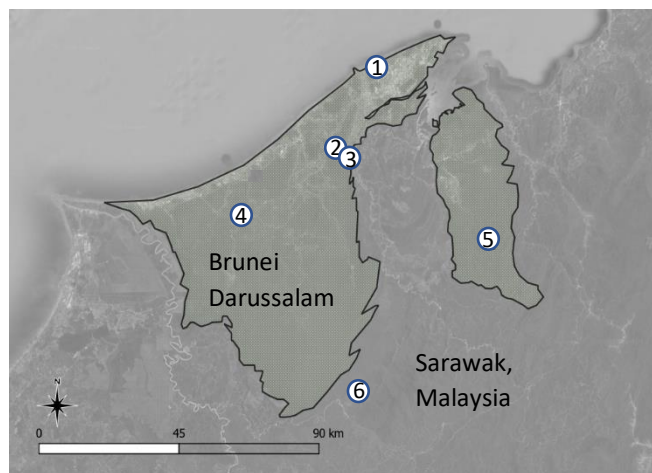


Figure 1. Survey sites for nocturnal mammals in northern Borneo in 2019-2020. 1 = Bukit Shahbandar, a recreational park with natural kerangas forest; 2 = Meriuk Farm Stay, a fruit farm in Kiudang; 3 = Regrowth Primary Forest in Kiudang, a secondary, regenerating forest in Kiudang ; 4 = Kampung Labi, a secondary kerangas forest; 5 = Ulu Temburong National Park, a primary lowland mixed-dipterocarp rainforest. One survey site was located in Sarawak (Malaysia), 6 = Gunung Mulu National Park, a primary lowland mixed-dipterocarp rainforest having experienced high hunting pressure.

3. Results

From the six sites in northern Borneo, a total of 74 individuals belonging to five different species were detected (see *Figure 2*). The highest mammal density of 4.4 individuals/km was found in secondary, regenerating forest in Kiudang followed by the Ulu Temburong National Park with 2.0 individuals/km.

The Bornean Striped Palm Civet (*A. stigmatica*) was observed in all six study sites, with 36 individuals. With 16 individuals recorded in five sites, the Philippine Slow Loris (*N. menagensis*) was the second most common species seen. In contrast, the Bornean Colugo (*G. borneanus*) was recorded in three sites (11 individuals), whereas the Western Tarsier (*C. bancanus*) (9) and Island Palm Civet (*P. philippinensis*) (2) were observed in only two sites (see *Figure 2*).

Other than the five targeted mammals, 20 additional mammals were discovered in the study areas (see *Table 1*). According to the IUCN Red List of Species, three species are defined as

Vulnerable, two as Near Threatened, 14 as Least Concern and one as Data Deficient.

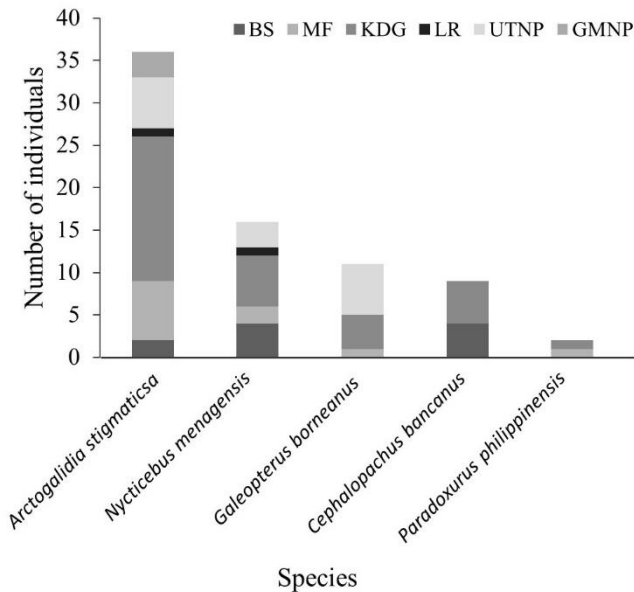


Figure 2. Rank abundance of the five arboreal nocturnal mammal species in all sites of northern Borneo. BS = Bukit Shahbandar; MF = Meriuk Farm Stay; KDG = Regrowth Primary Forest in Kiudang; LR = Labi Road; UTNP = Ulu Temburong National Park; GMNP = Gunung Mulu National Park.

4. Discussion

The Bornean Striped Palm Civet (*A. stigmatica*), a species endemic to the island of Borneo, was found in all six study sites, following the prediction of Duckworth *et al.*¹² that Brunei, and adjacent areas in Sarawak, have highly suitable forest environments for this species. Movement of these arboreal, omnivorous civets is not restricted to the canopy of trees, as they have also been observed on ground level, although rarely.¹³ We observed such behaviour on two occasions only. Using camera traps mounted in trees, Wahyudi and Stuebing¹⁴ and Phillipps¹³ reported more individuals above ground than on the ground. Similar results were obtained by Willcox *et al.*¹⁵ and Duckworth and Nettelbeck¹⁶. This arboreal habit protects the civet from mammal predators, and also provides protection in areas with high human hunting pressure¹³.

Table 1. Additional mammal species recorded from the sites in northern Borneo. Geographical region status on Phillipps' Field Guide to the Mammals of Borneo (2nd ed.) (A = abundant, C = common, E = endemic, S = scarce, U = uncommon). Global conservation status on The IUCN Red List (DD = Data deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable).

Species	Status	IUCN Red List
Carnivora		
<i>Arctictis binturong</i>	S	VU
<i>Hemigalus derbyanus</i>	U	NT
<i>Martes flavigula</i>	S	LC
<i>Prionailurus bengalensis</i>	C	LC
<i>Viverra zangalunga</i>	C	LC
Cetartiodactyla		
<i>Muntiacus muntjak</i>	E	LC
<i>Tragulus kanchil</i>	C	LC
<i>Tragulus nap</i>	C	LC
<i>Sus scrofa</i>	C	LC
Chiroptera		
<i>Pteropus vampyrus</i>	S	NT
Rodentia		
<i>Aeromys tephromelas</i>	-	DD
<i>Leopoldamys sabanus</i>	C	LC
<i>Maxomys tajuddinii</i>	C	LC
<i>Maxomys whiteheadi</i>	C	VU
<i>Petinomys setosus</i>	C	VU
<i>Rattus exulans</i>	A	LC
<i>Sundamys muelleri</i>	C	LC
<i>Thecurus crassispinis</i>	C	LC
<i>Trichys fasciculata</i>	C	LC
Scandentia		
<i>Ptilocercus lowii</i>	S	LC

Another species that we recorded in anthropogenically-disturbed habitats, farmland and forests, at all five study sites in Brunei Darussalam was *Nycticebus menagensis*. Slow lorises are known to show tolerance to many habitat types¹⁷. However, the abundances may differ according to the levels of hunting, remaining natural vegetation and forest cover¹⁸. Slow lorises are highly arboreal, ranging from saplings at eye level to the upper canopy of taller trees¹³. They were seen either foraging, moving, observing or resting above the ground, never on the ground.

In this study, *Galeopterus borneanus* was discovered in farmland and forest sites only. None were recorded in the anthropogenically-disturbed habitats; Bukit Shahbandar and Labi Road. We expected colugos to be spotted in Bukit Shahbandar, reflecting the results of Nasir and Abdullah¹⁹ that colugos are forest-dependent species, but can be found in artificial plantations or gardens¹³. Habitats with trees allow the presence of colugos in a variety of areas including rural places. However, we did not find any colugos in Bukit Shahbandar. Although it is found in a variety of forested habitats, the long-term survival of the Sunda colugo depends on the maintenance of forests with relatively intact canopy cover²⁰. Although mostly forested, in the canopy at Bukit Shahbandar the cover is below 95%. In addition, due to disturbance the area may not supply the colugo's diet preference of fruits, leaves, leaf shoots, flower bud and sap^{21,22}. Another likely reason for their absence at this site is the predation on colugos by raptors, feral cats and long-tailed macaques^{23,24}.

C. bancanus were seen in closely packed trees in Bukit Shahbandar and the Regrowth Kiudang Forest. According to Macdonald²⁵, tarsiers inhabit various habitat types, such as primary, secondary forests and plantations. No detection of tarsiers in other study sites may be due to their small size and posture fixed to the trunk, which make detection difficult¹³. Moreover, based on field observations, tarsiers are difficult to spot as they escape almost immediately upon hearing sounds and when lights are shone on them, they

quickly turn away.

According to Phillips¹³, *Paradoxurus philippinensis* is the most common civet in lowland forested areas. Adem²⁵ also mentioned that the island palm civet can live in a variety of habitat types; ranging from forests, to plantations and to agricultural land and residential areas. Parikesit, Withaningsih and Prastiwi²⁷ concluded that farmland and shrubs are the ideal habitat types for these civets, as there is abundant food. Fruit availability affects space use and spatial distribution of the civets²⁸. Only two observations were recorded in this study: in Meriuk Farm Stay and Regrowth Kiudang Forest. Meriuk Farm Stay is farmland with the highest food availability compared to the rest of the study sites, and many trees were fruiting during the study period. Furthermore, Regrowth Kiudang Forest is an area neighbouring this farmland, which encourages the presence of these civets in overlapping areas.

Overall, Regrowth Kiudang Forest and Ulu Temburong National Park had the highest average encounter rate with 4.45 and 2.0 individuals per km, respectively. The number of animals detected may be influenced by the speed at which the transects were walked²⁹. An increase in encounter rate is obtained with a slower pace. Unfortunately, the speed of walking was not recorded here. But it can be assumed that due to the hilly terrain in the Regrowth Kiudang Forest and Ulu Temburong National Park, more time was spent in walking or hiking through the area, and more mammals were spotted accordingly.

5. Conclusions

The purpose of the study was to establish basic information on the distribution of five mammal species in Brunei Darussalam and the adjacent Mulu National Park in Sarawak, Malaysia. *Arctogalidia stigmatica* was the most common species throughout the study sites, followed in abundance by *N. menagensis*, *C. bancanus* and *G. borneanus*. *P. philippinensis* was the least common mammal in the study sites. There were 20 other mammal species recorded, including one categorised by the IUCN Red List as Data

Deficient and three as Vulnerable. Mammals and their habitats provide ecosystem services and thus their protection and conservation are of fundamental interest.

Acknowledgements

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Appendix 1. Images of the five focus arboreal nocturnal mammals.

a: *Arctogalidia stigmatica*, b: *Cephalopachus bancanus*, c: *Galeopterus borneanus*,
d: *Nycticebus menagensis*, e: *Paradoxurus philippinensis*



Appendix 2. Images of other mammals observed in the study.

a: *Arctictis binturong*, b: *Petinomys setosus*, c: *Rattus exulans*, d: *Aeromys tephromelas*,
e: *Leopoldamys sabanus*, f: *Sundamys muelleri*

