
Research Article

Survey on the Small Mammals in Sg. Kangkawat Research Station Imbak Canyon Conservation Areas

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Abstract

Sg. Kangkawat Research Station is a newly established research station in the Imbak Canyon Conservation Area, Sabah which encompasses both primary and secondary forest areas. Limited data is available on the small mammal diversity for this particular area. Therefore, a survey-based study on small mammal diversity was carried out between the 29th September - 8th October 2018 along the established trails within the vicinity areas of this research station. Small mammal trapping was done using traps (mist nets, harp traps, cage traps and pitfall traps) employed randomly along the Nepenthes trail, the Kawang trail, the South Rim trail and the Pelajau trail. This study documented a total of 32 small mammal species i.e. represented by 26 species (15 spp. of new records for ICCA) of volant small mammals (Chiroptera) and 6 species of non-volant small mammals (Rodentia, Scandentia, Insectivora, Carnivora). The total number of specimens recorded was 108. A new distribution record on the Free-tailed Bat, *Chaerephon* cf. *johorensis*, was documented for Sabah and Borneo during this study.

Keywords: Small mammals; Chiroptera; Rodentia; Scandentia; Insectivora; Imbak Canyon Conservation Area; Sabah

Introduction

The background knowledge about the pattern of mammal species richness and community composition in most parts of Borneo Island is still lacking (Bernard et al, 2013). So far, there are at least 271 known mammal species of Borneo with at least 242 species of mammals occupying various types of terrestrial habitat and 63 species of terrestrial mammals that are endemic species of Borneo (Phillipps & Phillipps, 2018). Mammal surveys are important to document patterns of species richness, diversity and compositions in different sites, together with different forest conditions (Bernard et al, 2013). This vital information will facilitate sound decisions related to biodiversity conservation (Bernard et al, 2013).

Few surveys on mammals have been done in Imbak Canyon Conservation Area (ICCA) covering localised areas such as Mt. Kuli research station (Bunya et al., 2012; Matsubayashi et al., 2011; Ong et al., 2013). Extensive mammals' surveys have been done covering the many areas in ICCA and its surrounding secondary logged forests using camera traps (Bernard et al, 2013). Those studies have contributed to the checklist of mammals in ICCA where 45 species of small mammals were documented (Ong et al., 2013). In this study, small mammals refer to small-sized mammals including volant (bats) and non-volant small mammals. There are at least 182 species of small mammals in Borneo (Order Chiroptera - 99; Order Scandentia - 45 spp.; order Rodentia - 29 spp.; order Insectivora - 1 sp.; order Eulipotyphla - 8 spp.) (Phillipps & Phillipps, 2018) and ICCA has recorded approximately 14% of the Borneon species of small mammals (25 spp. - 11 spp. Chiroptera, 10 spp. Rodentia and 4 spp. Scandentia) (Bunya et al., 2012; Matsubayashi et al., 2011; Bernard et al, 2013; Ong et al., 2013).

A survey on small mammals was carried out in the Sg. Kangkawat research station, ICCA from 29 September to 8 October 2018 covering the base camp area and four main sites in Sg. Kangkawat Research Station: Nepenthes trail, Kawang trail, South Rim trail and Pelajau trail. The forest habitat surrounding Nepenthes trail, Kawang trail and South Rim trail are categorized as primary forest and forest areas in Pelajau trail are mainly secondary forest. This study aimed to add the small mammals' inventory data in the ICCA region, specifically to initiate the inventory data in Sg. Kangkawat research station. The assemblages of small mammals in Sg. Kangkawat research station was documented based on four main orders: order Chiroptera, Rodentia, Scandentia, and Insectivora. Data from this study can be used in species monitoring and biodiversity conservation.

Material and Methods

Study area

ICCA is one of the Yayasan Sabah forest management areas located in the central part of Sabah. The ICCA is approximately a 300 km² crescent-shaped elongated valley (Bernard et al, 2013). It can be accessed from the district of Telupid (appx. four hours from Kota Kinabalu) with approximately another four hours journey from Telupid town to ICCA. The ICCA was gazetted as a Class I (Protection) Forest Reserve in 2009, logging activities were totally prohibited in the area ever since. The forest habitats surrounding the fringes of the ICCA are generally heavily disturbed as it had been logged in the past and these areas are located in proximity to some human settlements and plantations (Bernard et al, 2013). However, the interior forests inside the canyon of the ICCA are still relatively pristine. The habitat within that area is mostly covered with lowland dipterocarp rainforest and upper montane forest, including patches of montane heath or “Kerangas” forest (Sugau et al., 2012; Suleiman et al., 2012; Bernard et al, 2013). In Sg. Kangkawat Research Station, there are four established trails used for the present study namely Nepenthes trail, Kawang trail, South Rim trail and Pelajau trail. Nepenthes trail, Kawang trail, and South Rim trail are within the primary forest region. The base camp and Pelajau trail is located within the ICCA buffer zone with medium to heavily disturbed forest habitats surrounding the fringes of ICCA.

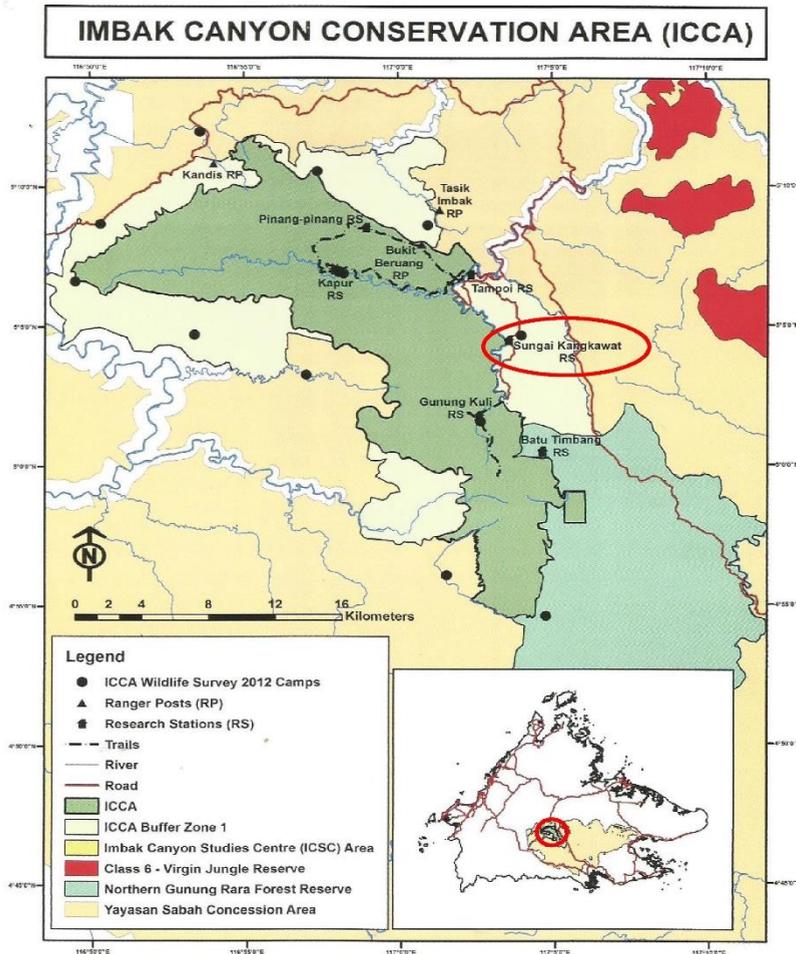


Figure 1. Imbak Canyon Conservation Area (ICCA) in central Sabah, the northern part of Malaysian Borneo.

Field Methods

Samplings of bats were done using five mist nets and four sets of four-bank harp traps for nine trapping nights, employed randomly in Nepenthes trail, Kawang trail, South Rim trail and Pelajau trail. In one sampling point, mist nets and harp traps were deployed with approx. 100m metres interval between points. Both the mist nets and harp-traps were set across trails, narrow pathways in the forest, hill, streams, forest edge and cleared areas in the forest. In addition to

that, double-stacked mist-nets, with a total of six shelves and extending up as canopy mist net for one night in Pelajau trail. It was deployed approx. 15 to 20 metres above the forest floor. Nets and harp-traps were set across trails, narrow pathways in the forest, hill, streams, forest edge and cleared areas in the forest. The nets and harp-traps were used to capture bats that occupy the forest understorey and a canopy mist net was set at the canopy level to capture bats that occupy the canopy flyways. Both nets and traps were checked frequently from 1900 hrs to 2200 hrs, and finally at 0600 hrs in the morning.

Bats were identified in the field following the identification key by Phillipps & Phillipps (2018), Payne, Francis & Phillipps (1985) and Kingston, Lim & Zubaid (2006). The external morphological measurements including sex, Forearm (FA), Ear (E), Tail Ventral (TV) and Hind Foot (HF) of each bat were recorded using a digital calliper in millimetres (mm) and body mass were weighed using spring balance in grams (g). The morphological measurement (mm) of each bat was taken using a digital calliper and weighed (g) using spring balance. Released bats were marked on their right wing using biopsy punch 3mm and some individuals were kept as voucher specimens. Three individuals per species were taken as voucher specimens and preserved in 95% alcohol. Wet specimens were dissected exposing the stomach and intestine before being preserved in 95% alcohol as voucher specimens. The tissue samples such as liver and muscle tissues were minced and preserved into a lysis buffer. Blood samples were collected and ectoparasites found on the specimens were preserved in 70% ethanol. Photographs of selected bats were taken and kept for reference.

The sampling of non-volant small mammals was done using metal cage traps and pitfall traps for three days. The dimension of the metal cage traps used was 28cm X 18cm X 14cm and a total of 100 cage traps were deployed in transect line sampling with 5 metres interval between each traps and set along the trails in Nepenthes trail, Kawang trail, South Rim trail and Pelajau trail. Banana and salted fish were used as bait to further increase the effectiveness of the cage traps. Pitfall traps were set up using a 5 X 10 grid design and the dimension of each pitfall trap used was 267mm X 232mm X 232 mm for height, length and width. All the pitfall traps were drilled with holes on the base to allow water to flow through and prevent drowning of animals. Metal fences were set up between each pitfall traps to allow funnelling of animals and maximise the capture rate of the traps. Post sampling procedure for pitfall traps includes refilling of the traps holes to prevent any injury and accidental falling of wildlife in the holes.

Traps were checked and rebaited twice a day at 0900 hours until 1030 hours and 1500 hours until 1700 hours. Captured animals were taken to the camp, anaesthetized and processed. Captured animals were measured morphologically using digital callipers in millimetres (mm) for the Head Body (HB), Tail Ventral (TV), Ear (E) and Hind Foot (HF) measurements. Body mass was weighed using spring balance in grams (g) and species identification was done following Phillipps & Phillipps (2018) and Payne et al. (1985). Marking of individuals was done by applying nail polish on small parts of the fur to document recaptured individuals. Prior to release, photographs were taken for each species representative for future references. Selected individuals were euthanized and preserved as voucher specimens. The conservation status of the small mammals captured in the present study were determined based on the IUCN Red list of globally threatened species (IUCN, 2020).

Data analysis

Sampling saturation was assumed to be met when the observed cumulative number of mammal species reached an approximate asymptote with the cumulative number of individuals captured. Additionally, the sampling saturation was assessed by calculating the sampling completeness ratio (i.e., observed species number/estimated species number) using the mean of four commonly used abundance-based species richness estimators (i.e., ACE, CHAO1, ICE and JACK1) computed using EstimateS Version 9.1.0. (Edwards et al., 2009; Bernard et al, 2013). Here sampling saturation was assumed when the sampling completeness ratio approached one (Bernard et al, 2013).

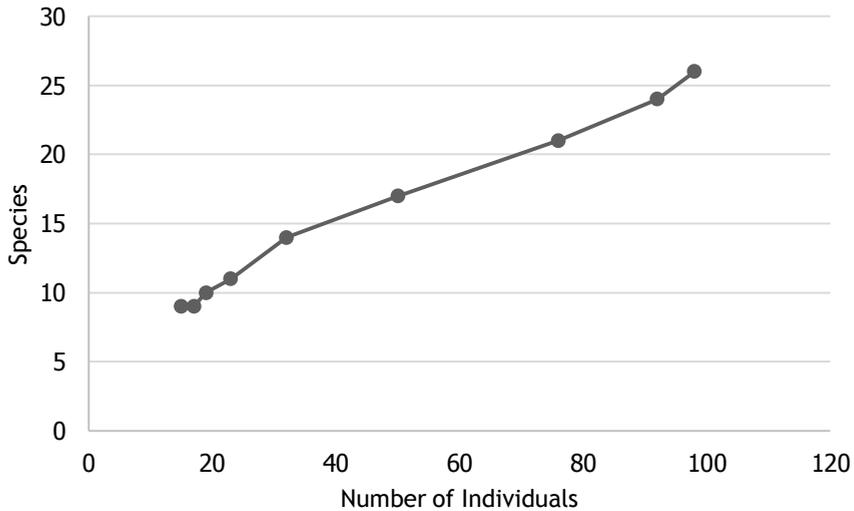
Results

Order Chiroptera: Sampling efforts Species richness and composition

Ninety-eight individuals of Chiroptera (bats) from 26 species representing six families, namely Pteropodidae, Hipposideridae, Molossidae, Nycteridae, Rhinolophidae and Vespertilionidae, were captured in this study. The species accumulation curves for the number of individuals against species of bats recorded in Sg. Kangkawat Research Station showed an increasing pattern (Figure 2). The mean estimated species richness computed with EstimateS was 35.17 (ACE=34.29; CHAO1=31.94; JACK1=36.67; ICE=37.76), which resulted in a sampling completeness ratio of 0.74. From these findings, it is suggested that sampling saturation was moderate and more species are yet to be discovered from longer trapping periods and efforts at different areas in the research station.

Table 1. Observed and estimated species and sampling efficiency (%) of the bat communities (N = 100) in the Sg. Kangkawat Research Station, ICCA.

	Observed species	ACE	CHAO1	JACK1	ICE
Total	26	34.29 (75.82)	31.94 (81.40)	36.67 (70.90)	37.76 (68.86)

**Figure 2.** Species accumulation curves based on the number of individuals against species of bats recorded in Sg. Kangkawat Research Station.

Six species of small fruit bats and 20 species of insectivorous bats were recorded during this study. Species from family Rhinolophidae and Hipposideridae were the recorded highest number of individuals in Sg. Kangkawat research station. Species *Hipposideros cervinus* recorded the highest relative abundance with 14 individuals (14.29%). This was followed by *Rhinolophus acuminatus* (11.22%), *Rhinolophus sedulus* (9.18%), *Balionycteris maculata* (8.16%), *Rhinolophus creaghi* (7.14%), *Cynopterus brachyotis* (6.12%), *Myotis ridleyi* (5.10%), *Rhinolopus borneensis* (4.08%), *Hipposideros ater* (4.08%), *Hipposideros diaderma* (4.08%), *Kerivoula intermedia* (4.08%), *Cheiromeles torquatus* (3.06%), *Hipposideros dyacorum* (2.04%), *Kerivoula papillosa* (2.04%), *Kerivoula pellucida* (2.04%), and *Macroglossus minimus* (2.04%). Nine species with 1.02%

relative abundance were *Chaerephon* cf. *johorensis*, *Cynopterus minutus*, *Dyacopterus spadiceus*, *Kerivoula hardwickii*, *Kerivoula minuta*, *Megaerops ecaudatus*, *Nycteris tragata*, *Rhinolophus philippinensis* and *Rhinolophus trifoliatus*.

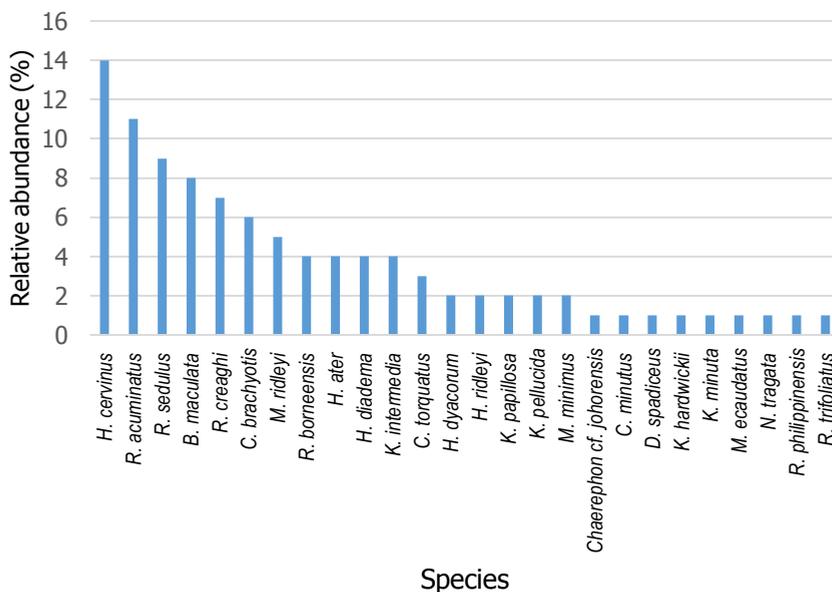


Figure 3. Relative abundance of bats in Sg. Kangkawat Research Station.

In this study, two species of vulnerable bats were recorded namely *Chaerephon* cf. *johorensis* and *Hipposideros ridleyi* (IUCN Red List - Vulnerable, VU). Meanwhile, seven species of bats recorded in this study were listed as Nearly Threatened (NT) species (*Dyacopterus spadiceus*, *Cynopterus minutus*, *Nycteris tragata*, *Kerivoula intermedia*, *Kerivoula minuta*, *Kerivoula pellucida*, and *Myotis ridleyi*). Most of bats (18 species) recorded in this study are listed as Least Concern (LC) in the IUCN Red List. One endemic species of bat, *Rhinolophus borneensis*, was recorded in this study. In comparison with the survey done by Bunya et al. (2012), this study recorded 15 new records of bats species for ICCA, namely *Cynopterus minutus*, *Chaerephon* cf. *johorensis*, *Cheiromeles torquatus*, *Dyacopterus spadiceus*, *Hipposideros ridleyi*, *Kerivoula hardwickii*, *Kerivoula intermedia*, *Kerivoula minuta*, *Kerivoula pellucida*, *Macroglossus minimus*, *Megaerops ecaudatus*, *Myotis ridleyi*, *Rhinolophus borneensis*, *Rhinolophus creaghi*, and *Rhinolophus philippinensis*.

Table 2. Summary and status of bats caught in Sg, Kangkawat Research Station.

Family	Species	No. of individuals	Localities	IUCN Red List	Distribution (Phillipps & Phillipps, 2018)
Pteropodidae	<i>Balionycteris maculata</i>	8	Nepenthes, Kawang, South Rim, Pelajau,	LC	Common
	<i>Cynopterus brachyotis</i>	6	Pelajau	LC	Common
	<i>Cynopterus minutus</i>	1	South Rim	NT	Common
	<i>Dyacopterus spadiceus</i>	1	Pelajau	LC	Common
	<i>Macroglossus minimus</i>	2	Nepenthes	LC	Common
	<i>Megaerops ecaudatus</i>	1	Pelajau	LC	Common
Molossidae	<i>Chaerephon cf. johorensis</i>	1	Pelajau	VU	Scarce
	<i>Cheiromeles torquatus</i>	3	Basecamp, Pelajau	LC	Common
Nycteridae	<i>Nycteris tragata</i>	1	South Rim	NT	Common
Hipposideridae	<i>Hipposideros ater</i>	4	Nepenthes	LC	Common
	<i>Hipposideros cervinus</i>	14	Nepenthes, South Rim, Pelajau	LC	Common
	<i>Hipposideros diadema</i>	4	Nepenthes, South Rim, Pelajau	LC	Common
	<i>Hipposideros dyacorum</i>	2	Pelajau, Nepenthes	LC	Common
	<i>Hipposideros ridleyi</i>	2	Nepenthes	VU	Common
	Rhinolophidae	<i>Rhinolophus acuminatus</i>	11	Nepenthes, South Rim	LC
<i>Rhinolophus borneensis</i>		4	Nepenthes, South Rim, Pelajau	LC	Endemic
<i>Rhinolophus creaghi</i>		7	Nepenthes, Kawang, Pelajau	LC	Common
<i>Rhinolophus philippinensis</i>		1	Pelajau	LC	Common
<i>Rhinolophus sedulus</i>		9	Nepenthes, South Rim, Pelajau	LC	Common
<i>Rhinolophus trifoliatus</i>		1	Nepenthes	LC	Common
Vespertilionidae	<i>Kerivoula hardwickii</i>	1	Nepenthes	LC	Common
	<i>Kerivoula intermedia</i>	4	Nepenthes, Pelajau	NT	Common
	<i>Kerivoula minuta</i>	1	Pelajau	NT	Common
	<i>Kerivoula papillosa</i>	2	South Rim	LC	Common
	<i>Kerivoula pellucida</i>	2	Pelajau	NT	Common
	<i>Myotis ridleyi</i>	5	Pelajau, South Rim	NT	Common

Order Rodentia, Scandentia, Insectivora: Species composition

Ten individuals of small mammals from order Rodentia (2 spp.), Scandentia (2 spp.), Insectivora (1 sp.) and one small carnivore were recorded during the three days trapping. The trapping success recorded (i.e. number of individuals caught divided by the total number of trap-nights) was 3%. The order Rodentia was represented by *Maxomys rajah* (n = 4), and *Maxomys whiteheadi* (n=1). For the order Scandentia, two individuals represented by the endemic Northern Long-footed Treeshrew, *Tupaia longipes* and one individual of the large treeshrew, *Tupaia tana*. One species from order Insectivora, *Echinosorex gymnura* and one small carnivore, the common palm civet, *Paradoxurus hermaphroditus* were recorded during this survey. Meanwhile the trapping success for pitfall traps in three trapping days was 0%.

Table 3. Summary and conservation status of non-volant small mammals in Sg. Kangkawat Research Station.

Order	Species	Common Name	Frequency n	Trail	IUCN Red list status	Distribution
Rodentia	<i>Maxomys rajah</i>	Rajah Sundaic Maxomys	4	Nepenthes; Pelajau	VU	Common
	<i>Maxomys whiteheadi</i>	Whitehead's Sundaic Maxomys	1	Pelajau	VU	Common
Scandentia	<i>Tupaia longipes</i>	Northern Long-footed Treeshrew	2	Nepenthes	LC	Common Endemic
	<i>Tupaia tana</i>	Large Treeshrew	1	Nepenthes	LC	Common
Insectivora	<i>Echinosorex gymnura</i>	Moonrat	1	Pelajau	LC	Common
Carnivora	<i>Paradoxurus hermaphroditus</i>	Common Palm Civet	1	Nepenthes	LC	Common

Discussion

Chiroptera

Survey using 15 mist-nets (10 nets in Slope trail, three nets in Summit trail and two in Waterfall trail) and 5 harp-traps (three traps in Slope trail, one trap in Summit trail and one in Waterfall trail) on bats done in Mt. Kuli Research Station had documented 11 spp. of bats (9 insectivorous bats and 2 frugivorous bats) (Bunya et al, 2012). Meanwhile, the present study using 21 mist-nets (five nets in Nepenthes trail, Kawang trail, South Rim trail, Pelajau trail, and one canopy net at basecamp) and 16 four traps (four traps in Nepenthes trail, Kawang trail,

South Rim trail, and Pelajau trail) had documented 26 spp. of bats in Sg. Kangkawat Research Station with 15 spp. of new records for ICCA. Interestingly, one bat species that was only recorded in Peninsular Malaysia was found in this study. The Northern Free-tailed Bat, *Chaerephon cf. johorensis* is a new record to Sabah and Borneo. This species is listed as Vulnerable in IUCN Red List and reported to occupy the upper canopy level. This study suggests that more studies on bats targeting canopy level species are needed for more sampling coverage and species discoveries. The next direction from this study is to confirm the identity of this species using morphological analysis and molecular analysis.

Based on feeding guild, insectivorous bats made up of 80.61% of bats assemblages in Sg. Kangkawat Research Station. The assemblages of bats in Sg. Kangkawat Research Station was dominated by Rhinolophidae (6 spp, 26 individuals) and Hipposideridae (5 spp., 33 individuals). In general, most *Rhinolophus* and *Hipposideros* are narrow space active gleaning foragers that actively forage in the forest understorey (Phillipps & Phillipps, 2018). *Hipposideros cervinus* and *Rhinolophus acuminatus* recorded the highest species abundance. Both species were mostly caught using harp traps at forest understorey. Both species are widely distributed and locally common in lowland forests of Sabah. *Hipposideros cervinus* is the most common insectivorous bats in Borneo's caves while *Rhinolophus acuminatus* were reported to roost under palm leaves (Phillipps & Phillipps, 2018).

In Borneo, there are at least 18 species of frugivorous bats (Phillipps & Phillipps, 2018) and six species of small fruit bats were recorded in this study. Fruit bats made up 19.39% of bat assemblages in this study. Most of fruit bats caught in this study are common fruit bat species with *Cynopterus minutus* listed as Nearly Threatened in the IUCN Red List. Small fruit bats are abundant throughout Borneo. They play significant roles in seed dispersal and pollination in Borneo (Phillipps & Phillipps, 2018).

Structure of forest habitat influenced the assemblages of bats in the tropical forest ecosystem. The bat assemblage tends to be more diverse in preserved habitats and in environments with higher structural complexity (Falcão, Espírito-Santo, Fernandes & Paglia, 2018). The assemblages of bats in Sg. Kangkawat Research Station may be structured based on the forest habitat. The combination of pristine forest habitat inside the ICCA and heavily disturbed forest habitats surrounding the fringes of the ICCA may provide diverse assemblage's structure and species exploration for bats. Studies reported that

habitat structures such as fragmented and continuous forest showed inconsistent responses at the assemblage level of bats such as species richness, diversity, and composition (Cosson, Pons, & Masson, 1999; Estrada & Coates-Estrada 2002; Faria, Laps, Baumgarten, & Cetra, 2006; Meyer, Struebig, & Willig, 2016; Wordley et al., 2018). For example, cave-dwelling hipposiderid and rhinolophid bats were less abundant in repeatedly logged sites than in primary forest (Furey et al., 2010; Meyer, Struebig, & Willig, 2016). In the current study, hipposiderid and rhinolophid bats dominate the assemblages of bats in Sg. Kangkawat Research Station. In addition, 35% of recorded bat species in Sg. Kangkawat Research Station are at risk of extinction. With this, ICCA provides important habitats for bats and further studies are needed to understand the responses at the assemblage level of bats in various habitat types in ICCA.

In this study, sampling efforts of bats were limited by rainy nights. For better species coverage, sampling at sub-canopy and canopy level is important to avoid bias in the sampling of bats Sg. Kangkawat Research Station. The sampling period should be lengthened and could include the use of various sampling methods such as bat detectors in various localities in ICCA. This is important to enhance understanding of the diversity of bats in ICCA, specifically in Sg. Kangkawat Research Station.

Non-volant Small mammals

For non-volant mammals, the most abundant species was *Maxomys rajah*. *Maxomys rajah* and *Maxomys whiteheadi* are listed as Vulnerable in IUCN Red List. Endemic species, *Tupaia longipes* was recorded in this study. All the species of non-volant small mammals recorded here also appear to be commonly found in most sites in ICCA as all species had been documented in previous studies (Ong et al., 2013). In previous studies, four species of order Scandentia, one species of order Insectivora and 10 species of order Rodentia (including 3 spp. of porcupines) had been documented in ICCA (Matsubayashi et al., 2011; Bernard et al, 2013; Ong Kay York et al., 2013). During this study, one small carnivore, *Paradoxurus hermaphroditus* was caught in the cage trap. Previous camera trap studies done in ICCA had documented seven species of Viveridae civets and *Paradoxurus hermaphroditus* was not recorded in those studies.

There are a few suggestions to improve the coverage of non-volant small mammals species for future studies. Firstly, the sampling period of non-volant small mammals trapping should be lengthened in the future. Throughout this field sampling, all the cage traps were placed on the ground and this may reduce

the possibility to capture other small mammals that are arboreal (Khan et al., 2017). Placing the traps according to their microhabitat, niche and foraging areas will prompt capture of different species (Khan et al., 2017). Although pitfall traps were prepared during this sampling, no samples were recorded. The use of fences may facilitate the pitfall traps and selection of sites more forest cover may increase the capture rate. The use of camera trap methods may contribute to more species coverage such as tufted ground squirrel and mousedears.

Conclusion

This study documented 26 species of volant small mammals (Chiroptera) and 6 species of non-volant small mammals (Rodentia, Scadentia, Insectivora, Carnivora). A noteworthy finding in this study was the documentation a new distribution record of the Northern Free-tailed Bat, *Chaerephon cf. johorensis* for Sabah and Borneo. This suggests that Sg. Kangkawat Research Station and the ICCA in general are useful for mammal conservation and hold high potential for small mammal studies and species discovery. There are possibilities that more species of small mammals from Sg. Kangkawat Research Station will be recorded in future surveys of longer sampling periods and efforts at different areas of the research station.

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