Small Mammals from Samunsam Wildlife Sanctuary, Sarawak, Malaysian Borneo

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ABSTRACT

Small mammal survey was conducted at Samunsam Wildlife Sanctuary (WS) from 20th until 25th October 2014. This survey aimed to assess the diversity of small mammals particularly from the order Chiroptera, Insectivora, Rodentia and Scadentia. These orders were targeted primarily to gain better understanding on the ecology and distribution of these understudied taxa in Borneo. Our survey recorded a total of 30 species of small mammals from six trapping nights. Order Chiroptera was recorded with the highest number of species (seven families; 22 species), followed by order Rodentia (two families; six species) and order Scandentia (two species). None was recorded from the order Insectivora. The most abundant species were *Rhinolophus trifoliatus* (n=6) for Chiroptera, *Maxomys whiteheadi* (n=7) for Rodentia and *Tupaia tana* (n=5) for Scandentia. Data presented here is the first comprehensive information on Samunsam's small mammals. This data can be used to gain better insights on the population trends at regional and local scale, as well as in improving the management plans of Samunsam WS. Although species diversity in Samunsam WS is comparable to other sites in western Sarawak, result presented here need to be treated with caution as this is the first comprehensive study that only cover area close to park headquarters.

Keywords: Chiroptera, diversity, Insectivora, inventory, Rodentia, Scandentia

INTRODUCTION

Sarawak is known as the state in Malaysia that has the most number of totally protected areas (TPAs), followed by Sabah. Categorically, there are three types of TPAs in Sarawak namely, National Park (NP), Wildlife Sanctuary (WS) and Nature Reserve (NR) (Thorsell, 1985). These TPAs varies in size and accessibility. NP is open to the public and this is the most visited area among the three TPAs. Similarly, NR is also open to public and serve as a recreational site but is smaller in size, usually less than 1,000 ha. Unlike the other TPAs, WSs are limited only for research and conservation where general public have limited access to these sites. Nevertheless, they play important role in promoting conservation of wildlife and habitat especially among general public.

WS was specifically established with the aim to preserve and conserve the vulnerable ecosystems or endangered wildlife in a particular area. The establishment of WS portrays the effort from the state government in recognising the important role and the necessities to safeguard the natural environment and biodiversity. There are several WSs established in Sarawak such as Samunsam WS, Pulau Tukong Ara Tukong WS and Lanjak Entimau WS are situated in Western Sarawak, whereas Sibuti WS in Miri, Eastern Sarawak. Samunsam WS was gazetted in 1979, making it the oldest WS established in Sarawak. After the expansion of the gazetteer, this WS covers an area of about 16,706 ha (Figure 1). Samunsam WS stretches from the border of Indonesia towards 2 km of the coast, and the undulating terrain is not more than 25 m above sea level, with the Samunsam River flowing through it. The soil structure comprises of alluvium soil that can be found along the river to terrace alluvium and loamy sandstone. These soil structure and landscape provide optimum

condition for the different vegetation types found in Samunsam WS including mangrove, nipa, riverine forest, heath forest and mixed dipterocarp forest (Rubis, 2001).

Samunsam WS is primarily known for its proboscis monkey populations. In the beginning, this sanctuary was intended to protect the habitat of proboscis monkey as this species was endemic to Borneo. These proboscis monkeys depend on areas both inside and outside the boundary of Samunsam WS including the mangrove, riverine and peat swamp forests of the coastal lowlands (Bennett, 1986). Indirectly, the preservation of these areas has contributed towards protection of other floras and faunas that can be found in Samunsam WS including small mammals. However, most of the study in Samunsam is concentrated on primates (four species: Aken & Kavanagh, 1982; Bennett, 1988; Bennett & Sebastian, 1988; Rajaratnam, 1992) and birds (36 species: Long & Collar, 2002; Wilson, 2006), leaving a huge gap on the knowledge between primates, birds and the rest of the understudied fauna found in Samunsam WS. Therefore, in this study we present the first baseline data on both volant (Chiroptera) and non-volant small mammals (Rodentia and Scandentia) in Samunsam WS.

MATERIALS AND METHODS

Study Area

Samunsam WS (Figure 1) can be accessed by land and one and half hour boat ride from Sematan's Jetty. The sampling sites were divided into two sites identified as Site 1 and Site 2. The former is the trail leading to the dam (direction from the general office) from the general office, which is mainly covered by lowland dipterocarp forest, heath forest and nipa. Meanwhile, the later is located at the forest edges and open grass field behind the general office.

Trapping and Identification

There were 20 units of four-shelves mist nets, four units of four-bank harp traps, 100 units of cage traps and 60 units of small pitfall traps that were used in trapping session between 20th to 25th October 2014. Mist nets and harp traps were set across trails, small streams or any water-bodies identified to be bat's flyways. The mist nets and harp traps were checked every 5-15 minutes intervals from 1830 until 2130, and repositioned the next day to avoid habituation. Additionally, hand nets were used to capture bats found at roosts. Meanwhile, cage traps were deployed along the forest transect with 5 m distance between each trap and checked twice a day (0900 until 1030 and 1500 until 1700). The cage traps were re-baited every two days. Finally, pitfalls were placed randomly along the trails in Site 1 and Site 2.

Data Collection and Tissue Samples

Collected samples were identified using keys from Payne *et al.* (1985) and Lekagul and McNeely (1988). The age stages of bat samples were identified by observing the epiphyseal-diaphyseal fusion on metacarpals (Kunz & Parsons, 1988). The morphological characters

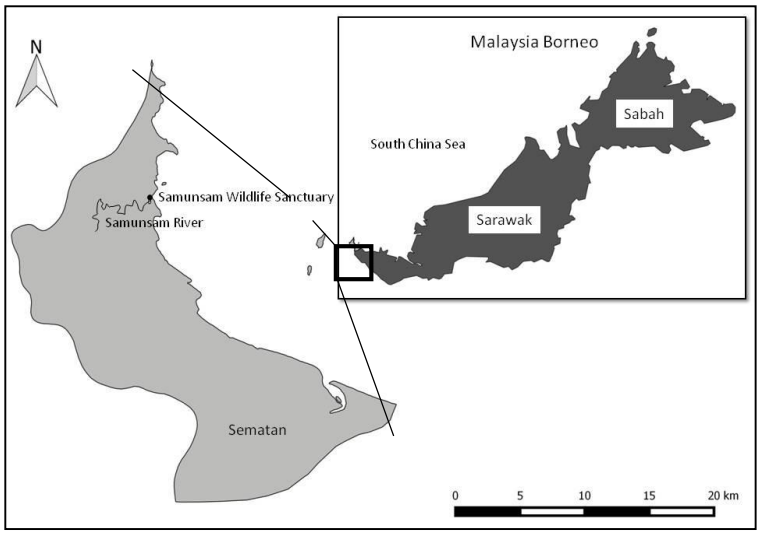

Figure 1. Malaysian Borneo map showing the Samunsam Wildlife Sanctuary located at Western Sarawak.

were measured using digital caliper and recorded following Nagorsen and Peterson (1980). Selected samples were prepared as museum vouchers whereas others were released. Tissue samples from museum vouchers (liver and pectoral muscle) were preserved in 95% ethanol while the whole body were preserved in 70% ethanol. All samples were deposited in Universiti Malaysia Sarawak Zoological Museum.

Data Analysis

The Shannon-Wiener Diversity index (*H'*) was used to estimate species diversity. This index was chosen as it is sensitive to changes in the abundance of rare species in a community. The Shannon-Wiener index and diversity *t*-test analysis were analysed using PAST software (Hammer *et al*., 2001). The *t*-test was conducted to compare the abundance and composition of bats assemblages between mist nets and harp traps. Relative species abundance can be calculated by dividing the number of species from a group with the total number of species from all groups. Rarefaction curve was constructed using *R* software (R Core Team, 2013) with the vegan package (Oksanen, 2011) to compare the species richness with different sampling efforts between other sites actively studied within Western Sarawak including Gunung Gading National Park (G Gading NP), Bako National Park (Bako NP), Kubah National Park (Kubah NP), and Mount Penrissen (Mt Penrissen). Rarefraction analysis was only performed on bat species diversity where most of the data is concentrated compared to other non-volant small mammals data.

RESULTS

From the six trapping-nights, we managed to record 30 species of small mammals representing 76 individuals from ten families (Table 1). For

Table 1. List of bats caught at Samunsam WS using three different techniques including mist nets, harp traps and hand nets. Species conservation status was assigned to each species according to the IUCN 2017 list.

Family Species	♂	♀	**Total Individuals**	**Harp Trap**	**Mist Net**	**Hand Net**	**IUCN Status**	**Relative abundance (%)**
Pteropodidae								
Balionycteris maculata	1	2	3	-	3	-	LC	3.95
Chironax melanocephalus	0	1	1	-	1	-	LC	1.32
Cynopterus brachyotis	4	1	5	-	5	-	LC	6.58
Cynopterus horsfieldii	0	1	1	-	1	-	LC	1.32
Macroglossus minimus	0	1	1	-	1	-	LC	1.32
Penthetor lucasi	1	0	1	-	1	-	LC	1.32
Emballonuridae								
Saccolaimus saccolaimus	2	0	2	-	-	2	LC	2.63
Megadermatidae								
Megaderma spasma	5	0	5	-	-	5	LC	6.58
Nycteridae								
Nycteris tragata	1	0	1	-	1	-	NT	1.32
Rhinolophidae								
Rhinolophus affinis	1	0	1	-	1	-	LC	1.32
Rhinolophus sedulus	2	0	2	2	-	-	NT	2.63
Rhinolophus trifoliatus	4	2	6	2	4	-	LC	7.86
Hipposideridae								
Hipposideros bicolor	3	0	3	3	-	-	LC	3.95
Hipposideros ridleyi	2	1	3	3	-	-	VU	3.95
Vespertilionidae								
Arielulus cuprosus	1	0	1	-	1	-	DD	1.32
Kerivoula hardwickii	3	1	4	4	-	-	LC	5.26
Kerivoula intermedia	2	2	4	2	2	-	NT	5.26
Kerivoula papillosa	3	0	3	3	-	-	LC	3.95
Kerivoula pellucida	1	0	1	1	-	-	NT	1.32
Murina cyclotis	1	0	1	-	1	-	LC	1.32
Murina suilla	1	1	2	1	1	-	LC	2.63
Myotis adversus	2	0	2	2	-	-	LC	2.63
Number of individuals	40	13	53	38	10	7		
Number of species	19	10	22	19	5	2		
Net and trap-night			130	20	100	10		
Capture rate			0.4	1.9	0.1	0.5		
H' diversity index			2.901	2.787	1.47	0		

*LC=Least Concern; NT=Near Threatened; DD=Data Deficient; VU=Vulnerable; (-) = not recorded in this study

the Order Chiroptera, there are seven families recorded namely, Emballonuridae, Hipposideridae, Megadermatidae, Nycteridae, Pteropodidae, Rhinolophidae and Vespertilionidae. The highest number of species was recorded from Family Vespertilionidae (eight species), followed by Pteropodidae (six species), Rhinolophidae (three species), and Hipposideridae (two species), whereas family Emballonuridae, Megadermatidae and Nycteridae each was recorded with single species. From this field sampling, 38 individuals representing 19 species (1.9/trap-night) were captured in harp traps, 10 individuals with five species (0.1/net-night) were mist-netted and seven individuals with two species (0.5/net-night) were captured using hand nets.

Rhinolophus trifoliatus was the most abundant species (7.86%) with six captured individuals, followed by *Cynopterus brachyotis* and *Megaderma spasma* both with five captured individuals (6.58%), respectively. Furthermore, nine species were recorded as singletons namely, *Chironax melanocephalus, Cynopterus horsefieldi, Macroglossus minimus, Penthetor lucasi, Nycteris tragata, Rhinolophus affinis, Arielulus cuprosus, Kerivoula pellucida* and *Murina peninsularis.* Of the 22 species of bats, 16 species were listed as Least Concern, four species as Near Threatened, and a single species, *A. cuprosus*, was listed as Data Deficient and *Hipposideros ridleyi* listed as Vulnerable in the IUCN Red List (IUCN 2017; Figure 2).

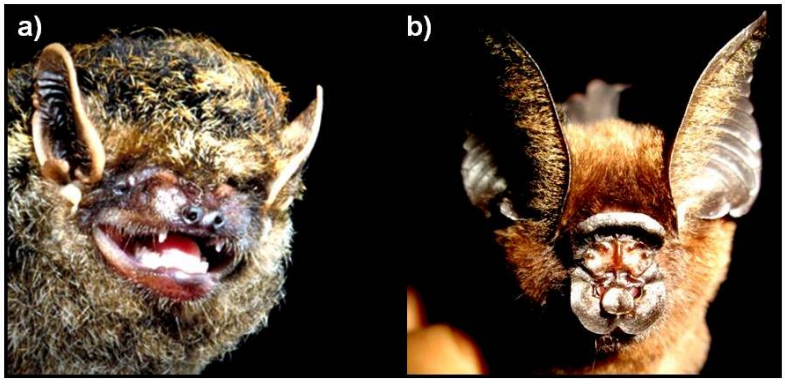

Figure 2. The photos of a) *Arielulus cuprosus* and b) *Hipposideros ridleyi* that listed as Data Deficient and Vulnerable, respectively in IUCN Red List 2017.

The non-volant small mammals sampling recorded six species from order Rodentia and two species from order Scandentia. However, no capture was made using the pitfall traps. The most abundant species for non-volant small mammals was *Maxomys whiteheadi* with seven individuals (9.20%) followed by *Tupaia tana* with five individuals (6.58%) (Table 2). In total, five species of the non-volant small mammals were listed as Least Concern and three species were listed as Vulnerable in the IUCN Red List (IUCN, 2017; Figure 3).

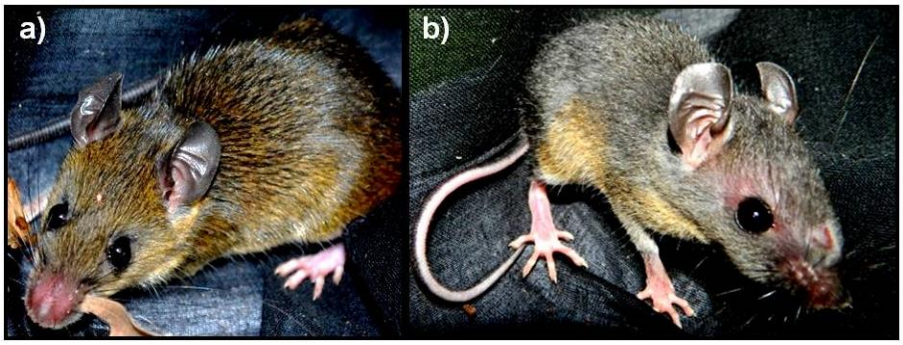

Figure 3. The photos of a) *Maxomys rajah* and b) *Maxomys whiteheadi* that listed as Vulnerable in IUCN Red List 2017.

Table 2. List of non-volant small mammals caught at Samunsam Wildlife Sanctuary using cage traps. Species conservation status was assigned to each species according to those in IUCN 2017 list.

Family Species	♂	♀	Total Individuals	Cage Trap	IUCN Status	Relative abundance (%)
Muridae						
Maxomys rajah	1	0	1	1	VU	1.32
Maxomys whiteheadi	7	0	7	7	VU	9.20
Niviventer cremoriventer	3	0	3	3	VU	3.95
Rattus tiomanicus sabae	0	1	1	1	LC	1.32
Sundamys muelleri	2	1	3	3	LC	3.95
Sciuridae						
Callosciurus notatus	0	2	2	2	LC	2.63
Tupaiidae						
Tupaia gracilis	1	0	1	1	LC	1.32
Tupaia tana	4	1	5	5	LC	6.58
Number of individuals	18	5	23	23		
Number of species	6	4	8	8		
Net and trap-night			500	500		
Capture rate			0.04	0.04		
H' diversity index			1.847	1.847		

*LC=Least Concern; VU=Vulnerable

After six sampling nights, the total number for both volant (Figure 4) and non-volant (Figure 5) small mammals captured has not reached asymptote, suggesting that there are still additional species to be added to the current list given ample time and effort. All species collected are listed as protected species in Sarawak based on the Sarawak Wildlife Protection Ordinance 1998.

Comparisons of Trapping Methods

All three trapping methods were successful in capturing bats (Table 3). Family Vespertilionidae (trapping effort/nights = 0.65) showed the highest overall captured rate using harp traps followed by family Hipposideridae (trapping effort/nights = 0.3) and family Rhinolophidae (trapping effort/nights = 0.2). Pteropodidae (trapping effort/nights = 0.12) showed the highest overall captured rate using mist nets. As for the hand-netting, two species of insectivorous bats were captured using this technique represented by two families Emballonuridae (*Saccolaimus saccolaimus*) and Megadermatidae (*M. spasma*) with the trapping effort/nights is 0.2 and 0.5 respectively. There is a significant difference in the species and relative abundance of bats captured using mist nets and harp traps ($t = 5.18$, df = 16.56, $p < 0.01$).

Species Diversity Indices

The number of volant small mammals captured in Samunsam WS increased exponentially until the 6th night (Figure 4). The increase indicated by the species accumulation curve suggested that

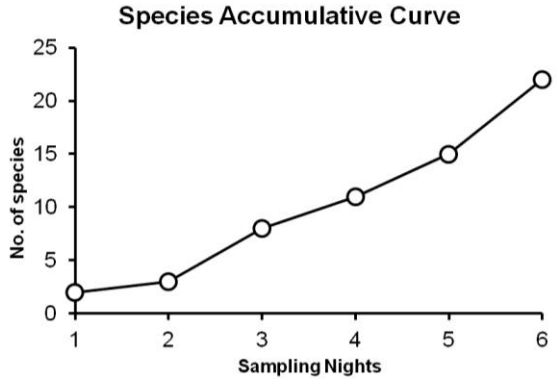

Figure 4. Species accumulative curve for volant small mammals.

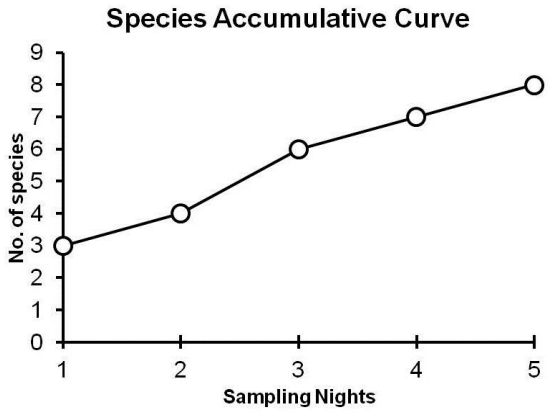

Figure 5. Species accumulative curve for non-volant small mammals.

Table 3. Comparison of the number of captures and species counts of small mammals in mist nets, harp traps, hand nets and cage trap by family.

Family	Harp trap (4 traps)			Mist net (20 nets)			Hand net (2 nets)			Cage Trap (100 traps)		
	n	Species counts	Capture rate (bats/ trap-night)	*n*	Species counts	Capture rate (bats/ trap-night)	*n*	Species counts	Capture rate (bats/ trap-night)	*n*	Species counts	Capture rate (small mammals/ trap-night)
Pteropodidae	0	0	0	12	6	0.12	0	0	0	-	-	-
Emballonuridae	0	0	0	0	0	0	2	1	0.2	-	-	-
Megadermatidae	0	0	0	0	0	0	5	1	0.5	-	-	-
Nycteridae	0	0	0	1	1	0.01	0	0	0	-	-	-
Rhinolophidae	4	2	0.2	5	2	0.05	0	0	0	-	-	-
Hipposideridae	6	2	0.3	0	0	0	0	0	0	-	-	-
Vespertilionidae	13	6	0.65	5	4	0.05	0	0	0	-	-	-
Muridae	-	-	-	-	-	-	-	-	-	15	5	0.03
Sciuridae	-	-	-	-	-	-	-	-	-	2	1	0.004
Tupaiidae	-	-	-	-	-	-	-	-	-	6	2	0.06
H' diversity index			1.139			0.977			0.598			0.841

(-) = not recorded in this study

there are more species to be discovered if sampling continues. Species diversity index (*H'*= 2.901) showed relatively high diversity of bat species but low non-volant small mammals diversity (*H'*= 1.847) in Samunsam WS (Table 2) compared to other sites in western Sarawak (e.g. Gunung Gading NP; unpublished data, Jenang, 2015; Bako NP, Kubah NP, Mount Penrissen; Jayaraj *et al*., 2011). Bats species richness between national parks was compared using rarefaction curves, showing the differences in contrast to the species number and individuals of each species (Figure 6). The graph indicated that Samunsam WS has a rarefaction curve value that is larger than all the sites in western Sarawak compared here (Gunung Gading NP, Bako NP, Mount Penrissen, and Kubah NP). If 49 individuals of Chiroptera were collected at Samunsam WS, it is expected to record 21 species of bats. Gunung Gading NP, Bako NP, Kubah NP and Mount Penrissen, are expected to record 17, 13, 11, and 10 species respectively when 49 individuals were caught.

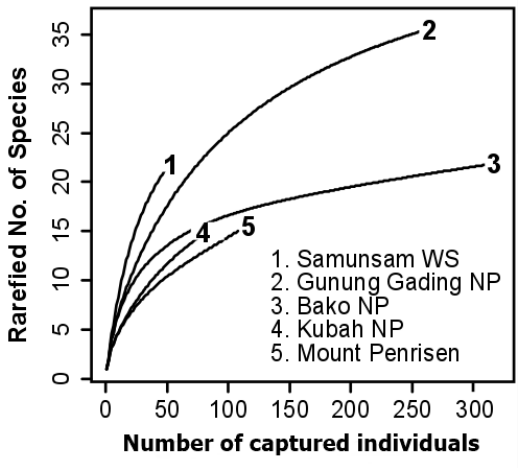

Figure 6. Rarefaction curve of bats in compare to four other sites in Western Sarawak.

DISCUSSION

This survey has resulted in 30 species of small mammals comprised of 22 species of Chiroptera, six species of Rodentia and two species of Scandentia. Samunsam WS also recorded the highest species richness in terms of volant small mammals compared to other sites including Bako National Park, Kubah National Park and Mount Penrissen analysed here. As for small mammals, the occurrence of a species in an area does not fully confined by their microhabitat. The resources availability in the area also contributed to high number of captured species. By having different microhabitat and vegetation type, more resources are available and more species tend to co-exist in the most beneficial microhabitat or vegetation layers. The flat terrain and easy land accessibility of Samunsam WS allows more microhabitats and area to be sampled thus resulting in high number of species in such short trapping period (Wells *et al.*, 2004).

Family Vespertilionidae is known as the most diverse and widespread family of bats in the world (Corbet & Hill, 1992). Consistently, most of the bat species recorded from this survey was from family Vespertilionidae, followed by family Pteropodidae. The family Vespertillionidae

usually found in the understorey of tall forest and lowland dipterocarp forest, hollow trees and curled banana leaves (Payne *et al*., 1985). High capture rate of fruit bats is possibly influenced by the presence of fruiting trees. The accessibility of fruit throughout the year and long fruiting season are key factors in maintaining the population of pteropodids in tropics (Fleming, 1988). For instance, figs of *Ficus* species are main food plants for bats and birds in Southeast Asia (Lambert, 1991). It is particularly abundant in Asia and can be easily found in Samunsam WS.

The scarce record of *Arielulus cuprosus* is an interesting capture for Samunsam WS. This species is not well documented in Sarawak. Their occurrence in Samunsam WS suggests the importance of this sanctuary as an important habitat for this understudied species. The first record of the species in Sarawak was captured at Mt Penrissen (Khan *et al.*, 2008). It has been subsequently recorded in various localities throughout Sarawak: Kubah NP (Mohd-Azlan *et al*., 2008), Lanjak Entimau WS (Tingga *et al.*, 2010), Similajau NP (Khan *et al*., 2008), and Kalimantan (Suyanto & Struebig, 2007). This species was collected from mist-net in both Samunsam SW and Penrissen as singleton. Scarce in specimens and low in capture rate has resulted in Vulnerable in the recent IUCN assessment (MacArthur, 2016).

Although mist-netting method was able to capture both frugivorous and insectivorous bats, nets were most efficient in trapping frugivorous bats in Samunsam WS. Family Pteropodidae represented the highest number of individuals captured using mist nets followed by family Rhinolophidae and family Vespertilionidae. These mist-nets were set across trails, over small rivers and in areas with food resources (fruiting and flowering trees), possibly suggesting that these frugivorous bats may be foraging on the vegetation below the canopy. Harp traps appeared to be exclusively trapping insectivorous bats in Samunsam WS. None of the frugivorous (non echolocating bats) collected inside any of the harp traps. It is possible that the larger frugivorous bat was able to escape from the harp traps after hitting on the banks. Most of the echolocating bats especially *Kerivoula hardwickii* and *Kerivoula papillosa* were the most abundant species caught in harp traps. However, it is also noticeable that most of the echolocating bats caught in harp traps were those species that forage actively in forest understorey.

As for the non-volant small mammals, the most abundant species was *Maxomys whiteheadi*, followed by *Tupaia tana*, and *Callosciurus notatus*. Although banana was recorded as the most preferred bait by rodent, squirrel and treeshrew (e.g. Lim, 1973) and used in this study, it is possible that some of the species may not be attracted to the smell. Besides baits, choosing the right location for cage traps also influenced the capture rate of small mammals and the movement of traps can increase the recorded species in a survey (e.g. Jayaraj *et al.*, 2013) Throughout this field sampling, all the cage traps were placed on the ground and this may affect the possibilities to capture other small mammals that are arboreal. Placing the traps accordingly to their microhabitat, niche and foraging areas will prompt capture of different species. Similar to other studies in the western Sarawak, low number of species (23 individuals and eight species) was recorded in Samunsam WS. All the species recorded here also appear to be commonly found in most sites in western Sarawak. To increase the yield of capture rate, we suggest that the sampling period of non-volant small mammals trapping should be lengthened in the future and possibly in a grid transect. This could also be facilitated by pit-fall trap to cover shrews and other small rodents. Although pit fall traps were prepared during this sampling, no samples were recorded. Perhaps this may be due to rain and sites that were chosen that is with less forest cover.

CONCLUSION

A total of 30 small mammal species were recorded in Samunsam WS. With a total of 22 species from 55 individuals, Chiroptera appeared to be the most common order at Samunsam WS. This was followed by the order Rodentia (six species) and order Scandentia (two species). Interestingly, species cumulative curves for both volant and non-volant small mammals have not yet reach asymptote. This suggests that there are possibilities that more species of small mammals from Samunsam WS will be recorded in future surveys of longer sampling period and effort at different areas of the wildlife sanctuary.

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