Journal of Sustainability Science and Management
Volume 17 Number 3, March 2022: 313-333
eISSN: 2672-7226

UPDATED ASSESSMENT OF GROUND-DWELLING MAMMALS IN AYER HITAM FOREST RESERVE, SELANGOR

NUR SYAKIRAH BAHARUDIN[1], MARINA MOHD. TOP @ MOHD. TAH[1,2]*, MOHD FARIS RABBANI SUBARI @ SUBIYRI[1], NUR SA'ADAH MAZLAN[1] AND TENGKU RINALFI PUTRA TENGKU AZIZAN[3]

[1]Department of Biology, Faculty of Science, [2]Center of Foundation Studies for Agricultural Science, [3]Department of Veterinary Preclinical Science, Veterinary Faculty, Universiti Putra Malaysia, 43400 Serdang, Malaysia.

**Corresponding author: marinamohd@upm.edu.my*
Submitted final draft: 9 August 2021 *Accepted: 8 October 2021* http://doi.org/10.46754/jssm.2022.03.023

Abstract: This study focus on Compartment 14 of the Ayer Hitam Forest Reserve (AHFR) aims to fill-in the 16-year research gap in the compartment under review and provide up-to date survey data on the various species and composition of said species especially non-volant small mammals for future reference, conservation, and management. The survey of species diversity and composition of mammals in AHFR was carried out over a five-month period from November 2017 to March 2018. The methods used to collect the data used in this study include live trapping and camera trapping used simultaneously. These methods were used to specifically quantify and identify mammal species in the study area. This survey identified and recorded nine different species of non-volant small mammals and five species of ground-dwelling big mammals. Live traps that were specifically designed to capture non-volant small mammals managed to record five of the species. Camera traps used in the survey captured data on both small non-volant mammals and ground-dwelling big mammals recorded seven non-volant small mammal species and five species of big ground-dwelling mammal in the study area. The results showed the presence of eight families of mammals consisting of Cercopithecidae, Hystricidae, Muridae, Sciuridae, Suidae, Tragulidae, Tupaiidae and Viverridae. In general, both methods whether camera trapping or live trapping were significantly different from each other in terms of the data collected on species diversity of non-volant small mammals and the camera trap had the highest values on Shannon-Weiner Diversity Index, at $H = 1.769$ which was slightly more than the values seen using the live trap method, which scored $H = 1.365$. The data collected on the species composition of non-volant small mammals in the Compartment 14 study area was low which might be due to the excessive amount of human activity such as jogging, hiking and camping in the area. The anthropogenic activity had adversely affected, disturbed and upset the ecological behaviour of ground dwelling mammals in the area. This may have led to a migration of the species to quieter area within AHFR which in turn decreased the biodiversity within Compartment 14.

Keywords: Diversity, highly disturbed area, lowland Dipterocarp Forest, camera trap, live trap.

Introduction

In recent years, Malaysia has been recognized as one of the 17 mega-diverse countries providing habitats for around 6.2% of the world's known mammals with 344 species (Jayaraj *et al.,* 2013; Ruppert *et al.,* 2015; Munian *et al.,* 2020).

However, the Malaysian tropical rainforest is quickly disappearing due to industrial activities such as logging and agricultural development (Meijaard & Sheil, 2008), which raises concerns regarding the decline in the current composition of ground-dwelling mammals in the country.

The destruction, fragmentation and degradation of forest habitats due to human activity is one of the primary drivers of biodiversity loss and this negatively affects the ecological processes and the provision of ecosystem services (Lindenmayer & Fischer, 2006; Haddad *et al*., 2015; Crooks *et al*., 2017).

Ayer Hitam Forest Reserve originally belonged to and was managed by the Selangor

State Government. It was gazetted to Universiti Putra Malaysia in 1996 for education in forestry and scientific research (Ahmad Ainuddin *et al.,* 2007). Despite the loss and subsequent reduction of available forest area, this forest is still being used by the indigenous community as a source of food and other natural resources (Konijnendijk, 2018).

According to Haron and Fadli (2007), AHFR is said to be important to the indigenous community, specifically the ethnic subgroup of Temuan as a result they are the only tribe that is allowed to make use of the natural resources in the AHFR in their daily routines.

Ayer Hitam Forest Reserve is a secondary and regenerating rainforest that has been classified as permanent forest reserve since 1951 (Paiman & Amat, 2007). The last update of ground dwelling mammal inventory in AHFR was done in 2001 by Zakaria *et al.* The research and corresponding data was then left untouched and had not been updated ay all in the last 15 years.

A standalone survey was continued by Ahmad Juffiry *et al.* (2015) on Compartments 12, 13, 14 and 15. In 2017, Mohd. Aliff updated the inventory of non-small mammal species in areas of Compartment 12 and 15, and Tee *et al.* carried out camera trapping surveys in AHFR in 2018. The current study is focused on Compartment 14, which is classed as a "highly disturbed" area (Siti Khadijah, 2016) due to the high levels of anthropogenic activities such as jogging, jungle trekking, and hiking in the area.

In general, five species of primates have been successfully recorded they are *Presbytis melalophos* (Lotong Ceneka), *Trachypithecus obscurus* (Lotong Celak), *Hylobates lar* (Ungka Tangan Putih), *Macaca nemestrina* (Beruk) and *Macaca fascicularis* (Kera) but their population densities are low when compared with other secondary forest areas in Peninsular Malaysia (Zakaria & Topani, 1999).

Other small mammal species that have been recorded are from three orders, five families, and 14 species (Paiman & Amat, 2007). The orders and families were recorded by Zakaria *et al.* (2001) including mammals from the order Rodentia from two families namely Muridae and Sciuridae, Insectivora from one family namely Erinaceidae, Scandentia from the family namely Tupaiidae and Primates from one family namely Lorisidae.

The main objective of this study is to determine the presence of ground-dwelling mammal species within Compartment 14, AHFR using both live and camera traps. The use of both methods is meant to increase the success rate of the study and assist with the proper identification of ground-dwelling mammals of various sizes.

This study has also updated the list of ground-dwelling mammal inventory collected at the Ayer Hitam Forest Reserve, in Puchong, Selangor.

Materials and Methods

Study Site

This study was conducted at Compartment 14 located at 03˚01'21'' N, 101˚38'20.0'' E of Ayer Hitam Forest Reserve, in Puchong Selangor. Compartment 14 is the biggest compartment in the AHFR with a total area of approximately 279 hectares (Paiman & Amat, 2007). The only remaining area for this lowland Dipterocarp Forest is a small, forested area of about 1248 ha comprising of six compartments (Nurul Shida *et al.*, 2014). Government of Selangor has gazetted this forest since 1996 to Universiti Putra Malaysia (UPM) for educational purposes (Ahmad Ainuddin *et al.*, 2007).

In general, the topography of this lowland dipterocarp forest is rugged and hilly. Compartment 14 has the highest peak in the AHFR which stands 344m above sea level, in an area known as Permatang Kumbang. According to Nurul Shida *et al.* (2014), there are 205 trees per hectare in this compartment with 70.19 dipterocarp trees and 134.81 non-dipterocarp trees. Nyatoh is the dominant species of tree in the area with coverage of 11.32% this is followed by Meranti which has an average coverage area of 10.56%.

Paiman and Amat (2007) stated that Compartment 14 had undergone a commercial regeneration following felling operations in the compartment from 1936 to 1943, where the pre-felling inventory was conducted before 1936. This forest has also undergone yearly selective felling from 1946 to 1947. Other than that, Compartment 14 had gone through a process of poison girdling and climber cutting in 1961. A pre-felling (pre-F) inventory was also recorded for Compartment 14 along with Compartment 1.

The sample site was plotted and broken into five sections to conduct the survey. See Figure 1. There is no demarcation for each section and it is only mapped for easy access to a certain areas. Plotting and segregating the area was done to ensure all areas of the Compartment would be covered, thus no specific size for each section was recorded. This survey was conducted over five months of sampling period starting from November 2017 until March 2018. The sampling and monitoring of ground-dwelling mammals was done twice for all the five sections to minimize bias in the data.

Sampling Method

Two methods namely live trapping and camera trapping were used to collect data samples during the survey. The use of more than one sampling method aimed to increase the chances of recording targeted samples of ground dwelling mammals in the study area. Live trapping was

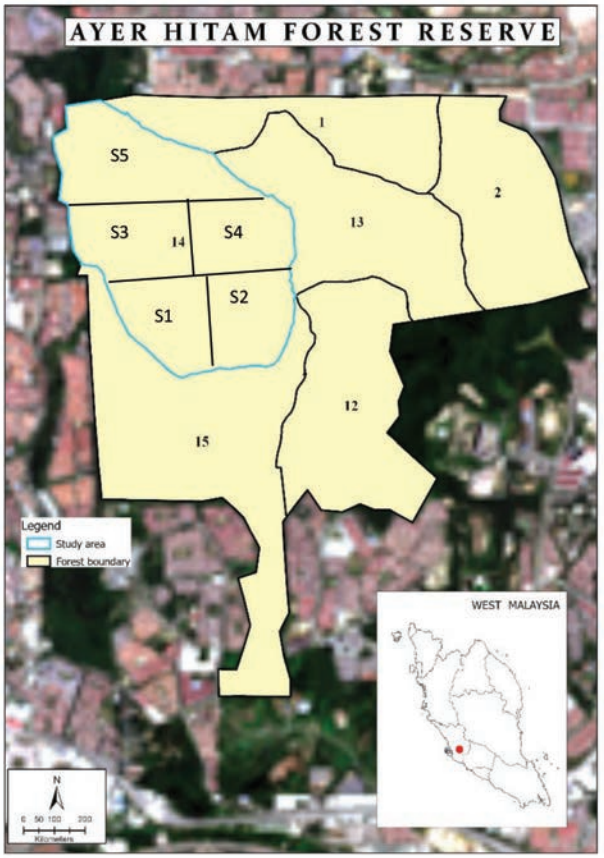


Figure 1: A division into smaller sections was carried out inside the Compartment 14 coverage area, marked as S1=Section 1, S2=Section 2, S3=Section 3, S4=Section 4, S5=Section 5
(Adapted from Google Earth Pro V 7.1, 2018)

specifically used to capture non-volant small mammal species, meanwhile camera trapping was used to record both small and big ground-dwelling mammal species in study area.

Figure 2 shows a distribution of 30 units of live traps (wire mesh rat traps) deployed in Compartment 14 based on ecological conditions and topography of the surrounding area. Live traps were also deployed between five and 10 metres from riverbanks and other water sources to increase capture rates of non-volant small mammal species. Other than that, live traps were also placed on dead logs, semi-open areas resembling animal trails, near thistle plants and branches of trees (Jambaari *et al.*, 1999; Zakaria *et al.*, 2001; Norfahiah *et al.*, 2012) to increase the odds of successfully trapping the target animals.

All 30 units of live traps were set up at distances ranging between 10 and 15 metres between each trap and were covered with forest litter both to provide thermal insulation for the captured samples and to camouflage the traps themselves (Torre *et al*., 2004). Live traps were baited by using coconut kernels, bananas, palm oil fruits, papayas and peanuts and were left open for three days and two nights consecutively.

Captured ground dwelling mammals were transferred into dark plastic bags (Payne *et al*., 2008) and cotton wool coated with ethyl acetate were prepared to anesthetize the samples (Barnett & Dutton, 1997). The anesthetized captured samples were then measured (weight, head and body length, tail length, ear length, hindfoot length), sexed and had their respective species identification done in line with the processes outlined by Payne *et al.* (2008) and Francis (2019).

All captured animals were also tagged with nail polish (Tingga *et al*., 2012) on their mails for identification and were released back in the area where they were caught (Shukor, Zainab & Zubaid, 2001). Captured samples were then identified using a reference book by Francis (2008).

A total of four camera traps from two different models, two Digital Trail Cameras and two Wildlife Cameras both with 16 MP 1080p resolutions, were used in this study.

All four units of the camera traps were deployed randomly in each section to avoid bias (Figure 3). All four units of camera traps were placed on vertical mountings such as tree trunks at the height of between 30 and 50 centimetres off ground level depending on ecological

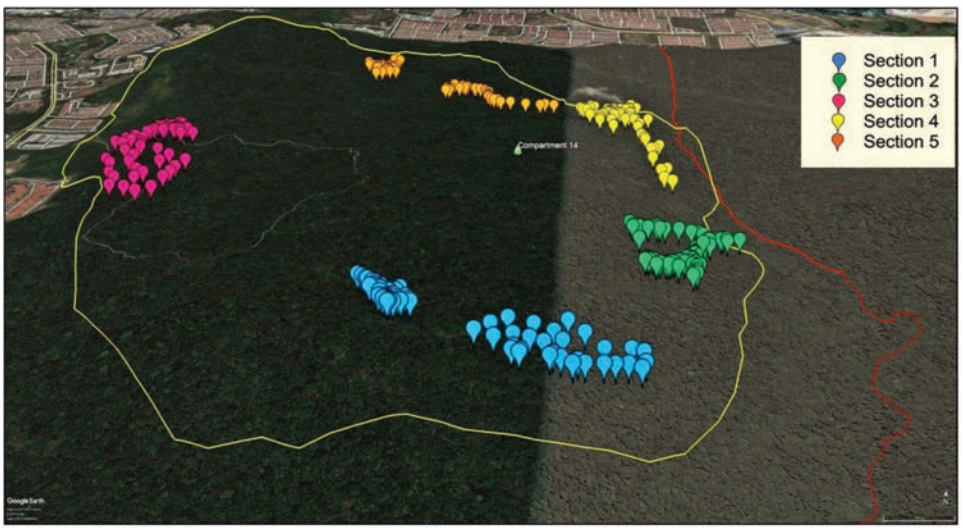


Figure 2: Distribution of duplicated 30 live traps in each section of Compartment 14 (03˚01’21” N, 101˚38’20.0” E), AHFR. (Adapted from Google Earth Pro V 7.1, 2018)

conditions in the area. All four units of camera traps were left open for 14 consecutive days for each section per sampling time. The total sampling days for camera trap method was 126 days over the five months survey time. A mix of baits were also placed in front of the camera traps to attract any ground-dwelling mammals foraging nearby (De Bondi *et al.*, 2010). The methods were supported by Mills *et al.* (2019) who reported placing attractants (edible baits or inedible lures) at camera trap stations increased capture rates for some species. Other than that, a series of camera trapping surveys was also done by Giman *et al*. (2007) in plantations in central Sarawak to monitor wildlife population within the forest. Camera sites were baited with a variety of commercially available scent lures. Camera trapping method has also been applied by Sundai *et al.* (2016) to large mammals study at Ulu Sebuyau National Park. Altogether, six camera traps were deployed with a distance of at least 1 km radius between each camera. Thus, multiple cameras will be needed to increase the detection probability and effective trap night for rapid surveys (Mohd Azlan, 2009).

Data Analysis

Samples were cross-checked against previous inventory records at the AHFR to check the availability of crucial and elusive mammal species in AHFR. Data was recorded in a table and compared with data from 1999 when the AHFR inventory was first taken until current study.

Species diversity and evenness was then directly calculated through the use of analytical indices. In this study, the species diversity index which included the Shannon-Weiner index was used to determine the quality of the diversity of ground dwelling mammals in Compartment 14 of the AHFR.

For other parameters, a t-test was used to compare the effectiveness of the two different methods that were used to collect data for this study to wit the camera trapping and live trapping methods. These indices were calculated using Paleontological Statistics (PAST) version 3.18.

Results and Discussion

A total of 13 species (18 individuals captured by live traps and 80 via camera trap photos) from eight different families of ground-dwelling mammals were recorded in Compartment 14, of the AHFR. From Table 1, it can be seen that mammals from the family Sciuridae (squirrels) were the most abundant order of small mammals captured. Almost 30.77% of the mammals captured were from this order.

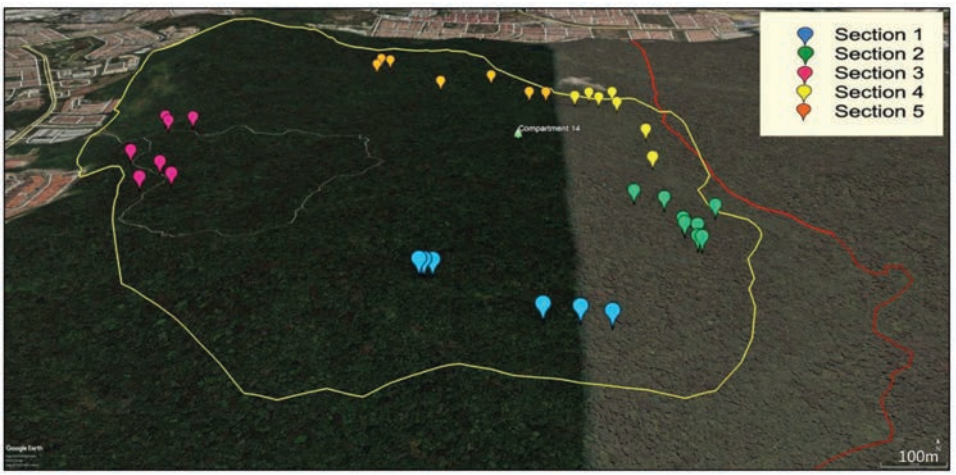


Figure 3: Distribution of duplicated four camera traps in each section of Compartment 14 (03˚01’21” N, 101˚38’20.0” E), AHFR. (Adapted from Google Earth Pro V 7.1, 2018)

The other five families recorded were, Hystricidae, Suidae, Tragulidae, Tupaiidae and Viverridae with each family accounting for 7.69% of the mammals recorded in this study.

Mammals from the families Cercopithecidae (15.38%) and Muridae (15.38%) were both recorded with two species each representing their family. The number of ground-dwelling mammal species recorded in this study was quite low and the results ran in parallel with the shrinking size of forest's borders and the increase in anthropogenic activity within the study area.

According to a study by Reilly *et al*. (2017), hiking trails and jungle trekking activities may displace animals from otherwise suitable habitats. Aside from that, animals may change their patterns of activity according to interactions with recreationists. Human intervention and disruption have had a great effect on animal foraging activity in the daytime, which increased as the day progressed and moved ever greater distances from the closest hiking trails (Pęksa & Ciach, 2018).

A report by Sze Ling (2018) supported the earlier statement that said the AHFR is host to the lowest mammal diversity in comparison with other forest reserves in Selangor, which is supported by the small number of species and low number of individual animals recorded in this study. This could be the effect of the fragmentation of the forests that have been

Table 1: Species of ground-dwelling mammals recorded in this study by using both camera traps and live traps

Order	Family	Species	Common Name	Percentage (%)	Capture Method
Primates	Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque	15.38%	CT
		Macaca nemestrina	Pig-tailed Macaque		CT
Rodentia	Hystricidae	*Hystrix brachyura*	Malayan Porcupine	7.69%	CT
	Muridae	*Maxomys surifer*	Red Spiny Maxomys	15.38%	LT
		Rattus tiomanicus	Malaysian Wood Rat		LT
	Sciuridae	*Callosciurus nigrovittatus*	Black-striped Squirrel	30.77%	CT
		Callosciurus notatus	Plantain Squirrel		CT, LT
		Rhinosciurus laticaudatus	Shrew-faced Ground Squirrel		CT
		Sundasciurus tenuis	Slender Squirrel		CT, LT
Artiodactyla	Suidae	*Sus scrofa*	Wild Boar	7.69%	CT
	Tragulidae	*Tragulus* sp.	-	7.69%	CT
Scandentia	Tupaiidae	*Tupaia glis*	Common Tree-shrew	7.69%	CT, LT
Carnivora	Viverridae	*Paradoxurus musangus*	Common Palm Civet	7.69%	CT

Note: LT = Live Trap; CT = Camera Trap

pushed to the brink due to anthropogenic development.

In the current study, live trapping specifically targeted at capturing non-volant small mammals managed to account for five species. In comparison, the camera trapping method which was focused on capturing data on both non-volant small mammals and ground-dwelling big mammals recorded seven non-volant small mammal species and five species of big ground-dwelling mammals in the study area.

Camera trapping eliminates the need to physically handle the captured animals and offers a method for detecting rare, elusive, or trap-shy mammals that may be missed by traditional, intensive, shorter-duration live trapping methods (Gray *et al.*, 2017; Rendall *et al.*, 2014). According to Pollock *et al.* (2002), major limitations associated with the use of camera traps for terrestrial mammals is that some species may not be detected.

Mammals from the order Rodentia were more abundant compared with other orders with six species recorded using camera traps and five species recorded by using live traps. This species consists of animals that are fossorial, have limbs specially adapted for use in burrowing, where they dig holes and burrows or nests to live in. Musser (2017) says that the population growth rates of rodents has risen as they can co-exist with human beings, who indirectly provide them with shelter and food resources as a consequence of daily human activity.

Only two members of the family Sciuridae were recorded using live traps along with two species from the family Muridae and one species from the family of Tupaiidae. Mohd. Aliff (2017) managed to locate more rodent species near Compartment 12 and 15.

These two compartments are frequently visited as Sultan Idris Shah Forestry Education Centre (SISFEC) has its headquarters in these compartments, thus probability that Murids will migrate to these localities is high since they will invariably be full of food sources.

Figure 4 shows the species that were mentioned above include *Callosciurus notatus*, *Sundasciurus tenuis*, *Maxomys surifer*, *Rattus tiomanicus* and *Tupaia glis*. Members of the Muridae family as mentioned by Wells *et al.* (2007) is comprised of commensal species in the AHFR and according to the results, is the most common small mammal in the area.

The other two species of Sciurid were *Callosciurus nigrovittatus* and *Rhinosciurus laticaudatus*. These two species are considered elusive and possess trap shy behaviour as they have never been caught in live traps but were recorded by camera traps. Syakirah *et al.* (2000) previously mentioned that population of *C. nigrovittatus* appeared to be low in their study area, Tasek Bera, and this finding was further supported by the findings in a study by Zakaria *et al.* (2001) where only one mammal from the respective species was recorded in the AHFR area under review.

These two species became more elusive and had their population sizes reduced following the high forest conversion rates that occurred at felling times (Lim & Yeo, 2012). *Rhinosciurus laticaudatus* was the only species to be recorded in the Near Threatened under IUCN Red-list of Threatened Species (2020).

Figure 5 shows stills from the camera traps of two elusive species engaged in foraging behaviours as the mixed bait placed infront of the traps worked as attractants which allowed for the stills to be captured.

Figure 6 (A) is a still photo of *C. nigrovittatus* which has a similar body structure and features to the *C. notatus*. The existence of two different colours of both species may lead to dimorphism. According to the reference material provided by Francis (2008), *C. nigrovittatus* has a pale cream-coloured band over its lateral body and grey colour over belly. Meanwhile, Figure 6 (B) shows another elusive species, *R. laticaudatus*. This species resembles *T. glis* wherein it possesses a similarly elongated and pointed snout the length of which is shorter than that of the *T. glis*.

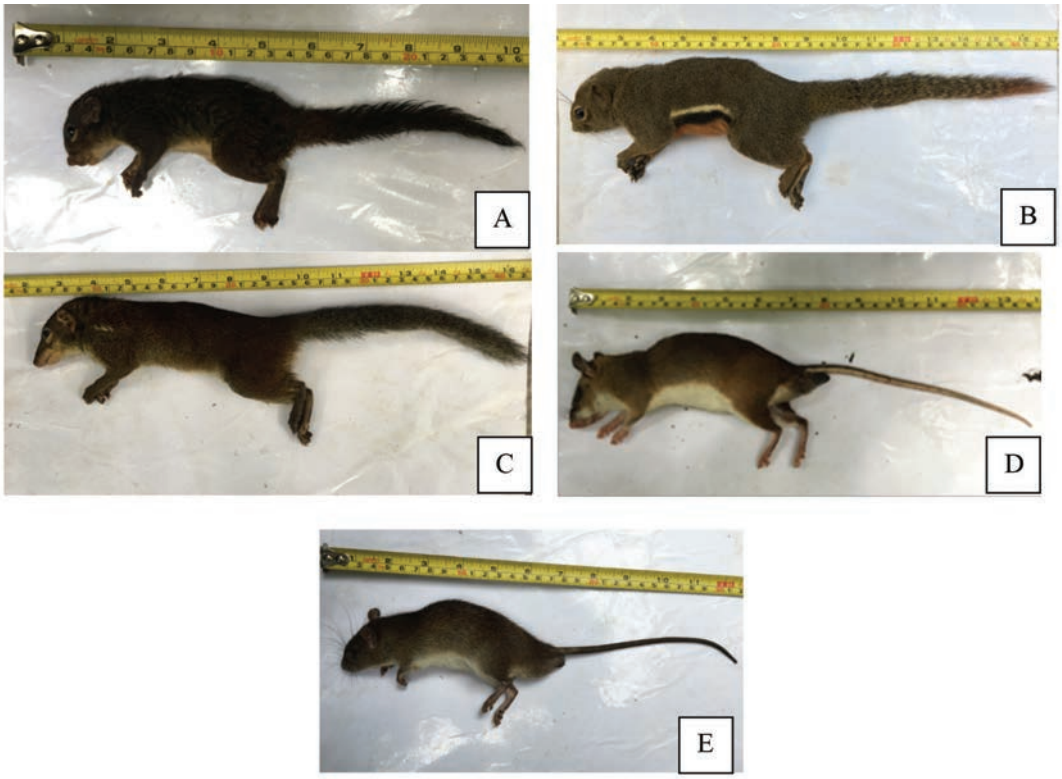


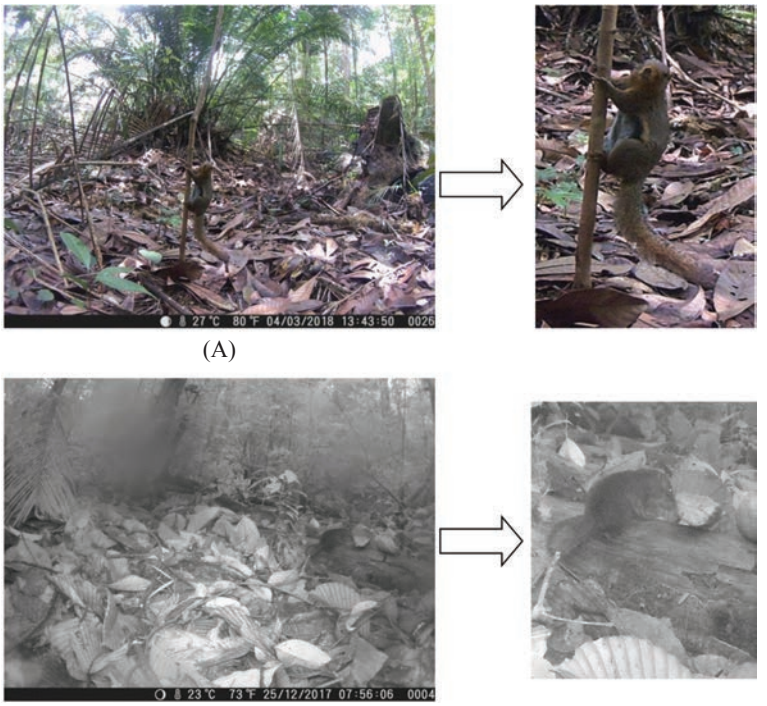
Figure 4: Non-volant small mammals recorded using live traps (A: *Sundasciurus tenuis*, B: *Callosciurus notatus*, C: *Tupaia glis*, D: *Maxomys surifer*, E: *Rattus tiomanicus*)

Aside from that, the tail of *R. laticaudatus* is characteristically short and bushy, unlike that of the *T. glis* which is nearly twice as long. Other distinct features that differentiate these two species include the distinctive band on the shoulder which a special characteristic of the *T. glis* and not the *R. laticaudatus*.

Due to the fact that Compartment 14 of the Ayer Hitam Forest Reserve is a "highly disturbed" area (Siti Khadijah, 2016), there are higher numbers of "generalist" species roaming in the area than those of the natural inhabitant species. Such species include those from the family of Cercopithecidae, which consist of *Macaca fascicularis* and *M. nemestrina*. They are commonly known as generalist feeders which can thrive in human-modified environments (Tee *et al.*, 2018).

A previous study by Zakaria and Topani (1999) mentioned that there were five species of primates inhabiting the AHFR. However, in 2001 Zakaria *et al.* managed to discover one more elusive primate species. The species was that of the *Nycticebus coucang* (Slow Loris) which brought the total number of primate species in the inventory to six. It was recorded by means of a visual encounter survey (VES) and only one of the species was recorded in the inventory.

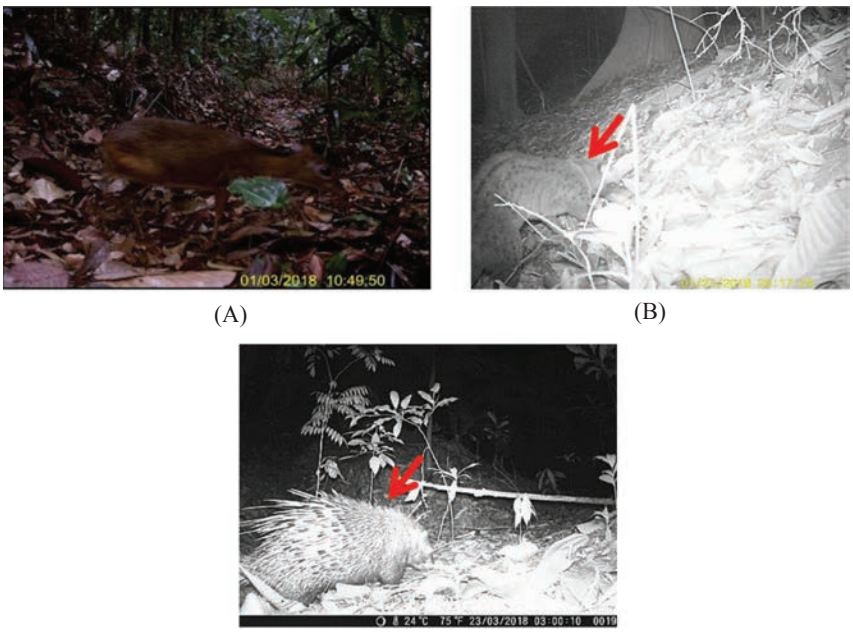
Adaptability trends suggest that only the well-adapted species such as *M. fascicularis* and *M. nemestrina* can acclimate to the conditions in the "disturbed" area (Karimullah & Shahrul, 2012) in which high anthropogenic activity takes place as compared with other primate species.



(A)

(B)

Figure 5: Record of two elusive species within Compartment 14.
(A: *Callosciurus nigrovittatus*, B: *Rhinosciurus laticuadatus*)



(A)

(B)

(C)

Figure 6: Three newly recorded species from the study of ground-dwelling mammal inventory of SISFEC
(A: *Tragulus* sp., B: *P. musangus*, C: *H. brachyura*)

This study was unconclusive as to whether there was a reduction in the number of primate species in the AHFR. The possible reasons for this include:

(i) induced stress from illegal encroachments from high levels of anthropogenic activities such as jogging and hiking that were actively conducted day and night.

(ii) the de-gazettement of the AHFR which led to deforestation and a shrinkage of available habitats.

Both possible reasons are correlated with forest disturbance and forest loss which lead to a reduction in available food sources and a change in ecological foraging behaviours (Bracebridge *et al*., 2012).

Poaching is another possible reason although no clear evidence of poaching has ever been documented in the AHFR. Despite the lack of evidence, it does not change the fact that illegal poaching is and has occurred in the AHFR. Several on ground and spontaneous interviews were carried out during the duration of the study where illegal trackers and hikers were encountered. From the interviews, it was discovered that there were people who came into AHFR to poach birds and it was possible for them to poach other species as well.

The Erinaceidae and Lorisidae families inthe AHFR were not successfully recorded by the current study, as the survey did not include nocturnal surveys, which requires other more specific techniques and equipment to monitor nocturnal ground-dwelling mammals using visual encounter survey (VES). Both Erinaceidae and Lorisidae however, may be unable to tolerate the high-stress area that is Compartment 14 and indeed all of the AHFR is surrounded by residential areas and is frequently trespassed upon.

Erinaceidae as mentioned in Brozovic *et al*. (2018) can only survive in high quality lowland forests and they show the highest occupancy rates in sustainably managed forest reserves of that nature. Meanwhile, as suggested by Sodik *et al*. (2019), forest fragmentation and habitat loss have had a direct negative impact on mammals of the Lorisidae family.

Figure 6 shows three new insights in several new families that were recorded in the highly disturbed area. These families include Hystricidae, Tragullidae and Viverridae. *Hystrix brachyura* and *Paradoxurus musangus* were newly added to the inventory of ground-dwelling mammals in SISFEC.

Hystrix brachyura is listed as "protected" under the Wildlife Conservation Act (2010), thus the hunting of this species is strictly prohibited. This law might relate to this species' ability to stay in the forest without any natural predators. The indigenous community may have also reduced or stopped hunting the *H. brachyura* as this species is hard to find given that it is nocturnal and mostly active at night.

The *Hystrix brachyura* has most likely adapted to the conditions and environment of the urban forest as it appears to be thriving and sports relatively large numbers at the Sungai Lalang Forest Reserve and Bangi Forest Reserve (Tee *et al.*, 2018). The results of previous findings support the existence of *H. brachyura* in the AHFR that is considered an urban forest which has a larger area compared with the Bangi Forest Reserve.

This study also proves, the occurrence of other species such as *P. musangus* is common for the urban forests like the AHFR as this species can adapt to both primary and secondary forests including urban forest reserves like the AHFR. *Paradoxurus musangus* is a commonly found species but the density of the species is lower in secondary forests than the primary forests (Nakashima *et al.,* 2010). There were only three times this species was recorded by camera traps randomly placed in Compartment 14 over the duration of the study.

Paradoxurus musangus was widely distributed throughout the AHFR, as it is able to tolerate a broad range of environments, thus global population is not at risk and is of no concern at this time (Duckworth *et al.*, 2016). At the Bukit Timah Nature Reserve (BTNR)

Singapore, the increase in the numbers of *P. musangus* has been possibly augmented by escaped pets or deliberate releases (Chan & Davison, 2019). This lends weight to the threat of *P. musangus* being locally poached for illegal smuggling.

Paradoxurus musangus functions as a seed dispersal vector and has special characteristics that do not randomly disperse the seeds but prefer to disperse them in open areas where there is less canopy cover (Nakashima *et al*., 2010). The appearance of this species in this study shows that there are higher numbers of *P. musangus* and the species occupies more of Compartment 14 than any other canine species that inhabits other compartments in the AHFR.

Paradoxurus musangus has also exhibited territorial behaviours with a home range of about 1.7 km^2 (Rabinowitz, 1991). Previous research papers do not cover their home range limits.

Sus scrofa only started being formally recorded by Tee *et al.* in 2018 previous studies did not record the species as a ground-dwelling mammal in the inventory. According to the rangers and staff at SISFEC, *S. scrofa* is commonly encountered near human settlements but not in deep forests such as that of Compartment 14.

A recent addition to the SISFEC species inventory, *Tragulus* sp. was only recorded in the AHFR inventory since 1999. Previously, Tee *et al.* (2018) managed to record *T. kanchil* via camera trapping. The indigenous community in the area uses *S. scrofa* as a means of subsistence when encountered, although such encounters with *Tragulus* sp. are rare. Based on camera trapping results, the *Tragulus* sp. in the AHFR have developed nocturnal patterns of behaviour and have become more elusive due to forest fragmentation and frequent encroachments. According to Farida *et al.* (2006), *Tragulus* sp. is a shy species and is rarely seen in the forest and have only been caught in camera traps foraging the forest floor looking for fruits.

Table 2 shows the species inventory for ground dwelling mammals in the AHFR from 1999 until the current study. A total of 33 species of ground dwelling mammals were recorded over the 1999 – 2018 period. Also listed together in Table 2 is the conservation status (IUCN, 2020; Perhilitan, 2017; WCA, 2010) of the ground-dwelling mammals currently listed in the AHFR species inventory. The current IUCN Red List of Threatened Species (2020) placed all 33 known ground-dwelling mammals in the AHFR into the following IUCN (2020) conservation status categories: one species as "Data Deficient"; 21 species as "Least Concern"; one species as "Near Threatened"; three species as "Vulnerable"; six species as "Endangered"; one species as "Critically Endangered".

The difference in diversity of ground-dwelling mammals in each study carried out in the AHFR varies due to several factors including the variation in sampling methods, total effort and the duration of study (Table 2).

Jambari *et al.* (1999), Zakaria *et al.* (2001) and Mohd. Aliff (2017) used only live traps in their study. Whereas only camera traps were used in study by Tee *et al.* (2018). Zakaria and Topani (1999) used the Distance Sampling Method in their survey on primates. Three methods (live traps, the Distance Sampling Method and opportunistic surveys) were used by Ahmad Juffiry *et al.* (2015) in their study. While, in this current study only live traps and camera traps were used.

In addition to detecting small mammal species captured in live traps, the camera-trapping method was able to detect several rare and elusive small- and medium-sized terrestrial mammals. This could enable simultaneous collection of data for species that would usually require tailored trapping techniques or very long sampling periods to be detected. Unlike the live-trapping technique, camera trapping was simultaneously able to record information on larger, non-target species of mammals. Even when collected as 'by-catch' during species-specific studies, the detection of nontarget species may still provide useful information (Kelly & Holub, 2008).

Compared with the AHFR, different results were obtained at two other forest reserves, located in the north of the Selangor State Park, namely the Gading Forest Reserve and the Bukit Kutu Forest Reserve where a total of 16 species of non-volant small mammals were documented in which mammals from the Muridae family were the most abundant species (Munian *et al*., 2020).

A study by Dee *et al.* (2019) managed to record seven species of non-volant small mammals in their survey at the Ulu Gombak Forest Reserve with *Leopoldamys sabanus* being the most abundant species caught. In another study, Ruppert *et al.* (2015) found that at the Segari Melintang Forest Reserve (Compartments 62 and 63 1A) in the Manjung District, of Perak, a total of 14 species (nine genera) of small mammals was caught with *Tupaia glis* being the species most frequently caught. Meanwhile, at the Kenaboi Forest Reserve, an area that has been extensively logged before it was gazetted as a forest reserve some 20 years ago, non-volant small mammals that belong to a total of 15 species were recorded in the study area.

Rodentia was the order that had the largest representation in the Malaysian forest reserves (Ramli & Hashim, 2009). In a study conducted by Shahfiz and Shahrul (2011) at two forest reserves in Cameron Highlands, Pahang namely, the Mentigi Forest Reserve and the Ulu Bertam Forest Reserve, a total of 18 individuals from five species of non-flying small mammals were captured. Five individuals from each of these families namely the common treeshrew (*Tupaia glis*), the grey-bellied squirrel (*Callosciurus caniceps*) and white-bellied rat (*Niviventer fulvescens*) were caught.

A study by Nor Bazilah *et al.* (2018) at the Kemasul Forest Reserve recorded a total of 75 mammals from 13 species of small to medium-sized mammals with members of the Muridae family being the most dominant.

Although the diversity of small mammal recorded in each study site in Forest Reserve was different, this is possibly not an accurate representation of species diversity in that study area. This is because the sampling can be significantly improved by applying diverse techniques and extending the sampling period for each method.

Some species may be left undetected due to seasonal variations. Ramli and Hashim (2009) reported in a previous study that small mammal populations in tropical forests not only have seasonal variations but also variation in population structure, density, biomass, and species richness even if they are living within the same region but in different habitat types.

There were also some activities such as camping by outsiders or intruders observed during sampling session. The accumulation of foreign foods that were bought by the campers might have attracted the rodent species to Compartment 14 which may skew research results. According to Zakaria *et al*. (2001) members of the rodent family that usually comprises rats have been recorded in high numbers in areas near the settlements of indigenous people. The existence of the settlements may be responsible for attracting the rodent species to the area (Zakaria & Topani, 1999; Zakaria *et al*., 2001) as they generally can eat various foods without it causing them harm.

As mentioned in a study by Paramesvaran *et al*. (2013), *Rattus tiomanicus* (Malaysian Wood Rat) have apparently adapted to the new conditions and seem to be thriving becoming a predominant species while other rat species and populations have seen a rapid decline over the last 15 years.

According to Zakria and Topani (1999) in his study at the AHFR, rodents in this area were able to consume many types of food such as plants, fruits and seeds without it having any negative effects on them. An existing Orang Asli settlement in the area may also be responsible for the large number of rodents (Zakaria & Topani, 1999). Louis *et al.* (1988) reported at least thirteen species of rodents were captured around the Orang Asli village over the course of his study in the AHFR.

Table 2: Species inventory of ground-dwelling mammals in Ayer Hitam Forest Reserve from 1999 until 2018

Family Species	Jambari *et al.*, 1999	Zakaria & Topani, 1999	Zakaria *et al.*, 2001	Ahmad Juffiry *et al.*, 2015	Mohd. Aliff, 2017	Tee *et al.*, 2018	Current Study	IUCN 2020	PERHILITAN 2017	WCA 2010
Cercopithecidae										
Hylobates lar (Linnaeus, 1771)	NR	PR	NR	NR	NR	NR	NR	EN	EN	TP
Macaca fascicularis (Raffles, 1821)	NR	PR	NR	NR	NR	PR	PR	VU	LC	P
Macaca nemestrina (Linnaeus, 1766)	NR	PR	NR	NR	NR	PR	PR	EN	LC	P
Presbytis melalophos (Raffles, 1821)	NR	PR	NR	NR	NR	NR	NR	EN	-	NP
Trachypithecus obscurus (Reid, 1837)	NR	PR	NR	NR	NR	NR	NR	EN	NT	P
Hystricidae										
Hystrix brachyura Linnaeus, 1758	NR	NR	NR	NR	NR	NR	*PR	LC	NT	P
Erinaceidae										
Echinosorex gymnure (Raffles, 1822)	NR	NR	PR	NR	NR	NR	NR	LC	VU	P
Lorisidae										
Nycticebus coucang (Boddaert, 1785)	NR	NR	PR	NR	NR	NR	NR	EN	NT	TP
Manidae										
Manis javanica Desmarest, 1822	NR	NR	NR	NR	NR	PR	NR	CR	CR	TP
Muridae										
Leopoldamys sabanus (Thomas, 1887)	PR	NR	PR	PR	NR	NR	NR	LC	LC	NP
Maxomys rajah (Thomas, 1894)	PR	NR	NR	PR	NR	NR	NR	VU	LC	NP
Maxomys surifer (Miller, 1900)	PR	NR	PR	NR	NR	NR	PR	LC	LC	NP

Maxomys whiteheadi (Thomas, 1894)	NR	NR	NR	PR	PR	NR	NR	VU	LC	NP
Mus musculus castaneus Waterhouse, 1843	NR	NR	PR	NR	NR	NR	NR	LC	LC	NP
Niviventer fulvescens (Gray, 1847)	NR	NR	NR	NR	PR	NR	NR	LC	VU	TP
Pithecheir parvus Kloss, 1916	NR	NR	PR	NR	NR	NR	NR	DD	LC	TP
Rattus rattus (Linnaeus, 1758)	NR	NR	PR	PR	NR	NR	NR	LC	LC	NP
Rattus tiomanicus (Miller, 1900)	PR	NR	PR	PR	PR	NR	PR	LC	LC	NP
Sundamys muelleri (Jentink, 1879)	PR	NR	NR	PR	PR	NR	NR	LC	LC	NP
Scuiridae										
Callosciurus nigrovittatus (Horsfield, 1823)	PR	NR	PR	NR	NR	NR	PR	LC	LC	NP
Callosciurus notatus (Boddaert, 1785)	PR	NR	PR	PR	PR	NR	PR	LC	LC	NP
Lariscus insignis (F. Cuvier, 1821)	NR	NR	PR	NR	NR	NR	NR	LC	LC	NP
Rhinosciurus laticaudatus (Müller, 1840)	PR	NR	NR	NR	NR	NR	PR	NT	LC	NP
Sundasciurus tenuis (Horsfield, 1824)	NR	NR	PR	PR	PR	NR	PR	LC	LC	NP
Suidae										
Sus scrofa Linnaeus, 1758	NR	NR	NR	NR	NR	PR	PR	LC	LC	P
Tragullidae										
Tragulus sp.	NR	NR	NR	NR	NR	NR	*PR	LC	-	P

Tragulus kanchil (Raffles, 1821)	NR	NR	NR	NR	NR	PR	NR	LC	LC	P
Tupaiidae										
Tupaia glis (Diard, 1820)	NR	NR	PR	PR	PR	NR	PR	LC	LC	TP
Tupaia minor Günther, 1876	NR	NR	PR	NR	NR	NR	NR	LC	DD	TP
Viverridae										
Arctogalidia trivirgata (Gray, 1832)	NR	NR	NR	NR	NR	PR	NR	LC	LC	TP
Paradoxurus musangus (Raffles, 1821)	NR	NR	NR	NR	NR	NR	*PR	LC	LC	P
Viverra megaspila Blyth, 1862	NR	NR	NR	NR	NR	PR	NR	EN	NT	TP
Viverricula indica (É. Geoffroy Saint-Hilaire, 1803)	NR	NR	NR	NR	NR	PR	NR	LC	NT	P
Total species recorded	**8**	**5**	**14**	**9**	**6**	**8**	**13**			
Total families recorded	**2**	**1**	**5**	**3**	**3**	**5**	**8**			

Note:
IUCN = International Union for Conservation of Nature
WCA = Wildlife Conservation Act
PR = Present
NR = Not recorded
*PR = Present & Newly Recorded
LC = Least Concern
NT = Near Threatened
VU = Vulnerable
EN = Endangered
CR = Critically Endangered
DD = Data Deficient
P = Protected
TP = Totally Protected
NP = Not Protected
- = not assessed in Perhilitan, 2017

Table 3 shows the results of diversity indices of ground dwelling mammal species that had been recorded by using two methods which were live trapping and camera trapping. From the calculation of parameter Shannon's Diversity Index (*H'*), the *H* value for camera trap method exceeds *H* value of live trap method (camera trap, *H'* = 1.769 > live trap, *H'* = 1.365). It also shows the comparison between these two methods using diversity t-test, revealing that there was a significant difference between these two methods, t =2.554, p = 0.023.

Overall, camera trapping was more efficient in determining the species composition of terrestrial mammals (Kolowski & Forrester, 2017) compared with the live trapping method. On the other hand, these two methods are significantly different (t = 2.554, p = 0.023) in determining species composition and diversity of non-volant small mammals.

Table 4 shows the species diversity in current study (S = 13, *H'* = 2.056) is low compared to previous study (S = 14, *H'* = 2.341) by Zakaria *et al*. (2001). However, the value of Simpson's Dominance Index, *D*, indicates low species dominance in AHFR in 2001 at 0.123 while the value of species dominance is slightly higher in current study area at 0.166.

The current study contributed least number of Simpson's Dominance Index, *D*, compared to previous studies by Zakaria and Topani (1999), Ahmad Juffiry *et al*. (2015), Mohd. Aliff (2017) and Tee *et al*. (2018) as Compartment 14 was classified as a "highly disturbed" area due to active human activities such as jogging, hiking and camping.

The results of this study revealed that secondary forest had an impact on diversity and distribution of ground dwelling mammals. According to Yaap *et al.* (2010), presence of ground dwelling mammals in this type of habitat was influenced by the availability of food, water and shelter provided by the nearby settlement areas that surrounds the forest.

Table 3: Diversity indices on non-volant small mammals recorded in Compartment 14

Parameter	Method	
	Live Trap (Individual)	Camera Trap (Photos Captured)
Taxa (S)	5	8
Total Ground Dwelling Mammals	18	80
Shannon (*H'*)	1.365	1.769
Evenness (*E*)	0.783	0.733
***T*-test**		t = 2.554 p = 0.023

Table 4: Diversity indices of ground-dwelling mammals in Ayer Hitam Forest Reserve from 1999 until 2018

Parameter	Zakaria & Topani, 1999	Zakaria *et al.*, 2001	Ahmad Juffiry *et al.*, 2015	Mohd. Aliff, 2017	Tee *et al.*, 2018	Current Study
Taxa (*S*)	5	14	9	7	8	13
Individuals	110	32	62	23	608	98
Dominance (*D*)	0.266	0.123	0.329	0.236	0.361	0.166
Shannon (*H'*)	1.445	2.341	1.488	1.662	1.237	2.056
Evenness (*E*)	0.849	0.7424	0.492	0.753	0.431	0.601

Conclusion

The current study of the AHFR shows low species assemblages of ground-dwelling mammals compared with the assemblages before 2001. This may be related to shrinking size of the forest itself. AHFR has been fragmented and isolated from other lowlands dipterocarp forests. Originally, the AHFR covered an area of 4,270 hectares and after facing a series of de-gazettements only 1,200 ha of land is left in the current forest cover. SISFEC is aware of the findings and further efforts will be discussed internally to prevent any more loss of species assemblages within the AHFR.

Joint programmes between the management and community are one of the suitable methods to monitor illegal encroachment. Community-based patrol programmes are currently used to monitor the biodiversity in certain areas, and it has proven to be an effective multi-stakeholder approach to handling the issue of biodiversity loss.

This study also managed to record three species present in the "highly disturbed" area of Compartment 14. These species are *Tragulus* sp., *H. brachyura* and *P. musangus*. These species are nocturnal animals that are normally shy and will avoid encounter with humans, thus explaining the absence of recorded data of them in previous studies. In order to locate more elusive ground dwelling mammals, further studies are needed to cover all compartments.

Acknowledgements

We would like to thank the Faculty of Forestry, Universiti Putra Malaysia and the Sultan Idris Shah Forestry Education Centre (SISFEC) for providing the research facilities and we would like to thank the staff and the rangers that gave us warm hospitality and technical support thought the research period.

References

Ahmad Ainuddin, N., Hjortso, C. N., Norini, H., Khamarudin, M. N., Awang Noor, A. G., & Ismariah, A. (2007). Introducing Stakeholder Analysis in Malaysian Forestry - The case of Ayer Hitam Forest Reserve. *Pertanika Journal of Tropical Agricultural Science*, *30*(2), 131-139.

Ahmad Juffiry, S., Yusof, E., & Zakaria, M. (2015). Diversity of fauna species in Ayer Hitam Forest Reserve, Selangor, Malaysia. *The Malaysian Forester, 78*(1 & 2), 97-114.

Barnett, A., & Dutton, J. (1997). *Expedition Field Techniques Small Mammals*. Royal Geographical Society with IBG. http://uagra.uninsubria.it/didattica/SmallMammalsupdated.pdf

Bracebridge, C. E., Davenport, T. R., & Marsden, S. J. (2012). The impact of forest disturbance on the seasonal foraging ecology of a critically endangered African primates. *Biotropica, 44*(4), 560-568.

Brozovic, R., Abrams, J. F., Mohamed, A., Wong, S. T., Niedballa, J., Bhagwat, T., Sollmann, R., Mannan, S., Kissing, J., & Wilting, A. (2018). Effects of forest degradation on the Moonrat *Echinosorex gymnura* in Sabah, Malaysian Borneo. *Mammalian Biology*, *93*, 135-143.

Chan, L., & Davison, G. W. H. (2019). Synthesis of results from the comprehensive biodiversity survey of Bukit Timah Nature Reserve, Singapore, with recommendations for management. *Gardens' Bulletin Singapore*, *71*(1), 583-610.

Crooks, K. R., Burdett, C. L., Theobald, D. M., King, S. R., Di Marco, M., Rondinini, C., & Boitani, L. (2017). Quantification of habitat fragmentation reveals extinction risk in terrestrial mammals. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(29), 7635-7640.

De Bondi, N., White, J. G., Stevens, M., & Cooke, R. (2010). A comparison of the effectiveness of camera trapping and live trapping for sampling terrestrial small-mammal communities. *Wildlife Research*, *37*, 456-465.

Dee, J. W., Anwarali, K. F. A., Rosli, Q. S., Morni, M. A., Azhar, I., Lim, L. S., Tingga, R. C. T., & ABD Rahman, M. R. (2019). Comparative distribution of small mammals diversity in protected and non-protected area of Peninsular Malaysia. *Tropical Life Sciences Research, 30*(2), 131-147. https://doi.org/10.21315/tlsr2019.30.2.10

Delany, M. J. (1974). *The ecology of small mammals*. Hill Street, London: Edward Arnold Limited.

Duckworth, J. W., Timmins, R. J., Choudhury, A., Chutipong, W., Willcox, D. H. A., Mudappa, D., Rahman, H., Widmann, P., Wilting, A., & Xu, W. (2016). "*Paradoxurus musangus*". The IUCN Red List of Threatened Species. IUCN. https://www.threatenedtaxa.org/index.php/JoTT/article/download/4165/6445/

Farida, W. R., Semiadi, G., Handayani, T. H., & Harun (2006). Habitat distribution and diversity of plants as seed resource for mouse deer (*Tragulus javanicus*) and barking deer (*Muntiacus muntjak*) in Gunung Halimun National Park. *Tropics, 15*(4), 371-376.

Francis, M. C. (2008). *A field guide to the mammals of South-East Asi*a. New Holland Publishers.

Gray, E. L., Baker, A. M., & Firn, J. (2017). Autecology of a new species of carnivorous marsupial, the endangered black-tailed dusky antechinus (*Antechinus arktos*), compared to a sympatric congener, the brown antechinus (*Antechinus stuartii*). *Mammal Research, 62*(1), 47-63. https://doi.org/10.1007/s13364-016-0281-1

Google Earth Pro V 7.21. (2018). *Hutan Simpan Ayer Hitam, Puchong, 3°00'28.3" N, 101°38'32.5" E, 57 m*. Eye alt 8.0 km. Retrieved March 25, 2018 from http://www.earth.google.com

Haddad, N. M., Brudvig, L. A., Clobert, J., Davies, K. F., Gonzalez, A., Holt, R. D., & Cook, W. M. (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances*, *1*(2), e1500052 10.1126/sciadv.1500052

Haron, N., & Fadli, S. A. (2007). The importance of Ayer Hitam Forest Reserve (AHFR), Puchong, Selangor, to the Temuan ethnic subgroup. *Pertanika Journal Tropical Agricultural Science*, *30*, 97-107.

Haverland, M. B., & Veech, J. A. (2017). Examining the occurrence of mammal species in natural areas within a rapidly urbanizing region of Texas, USA. *Landscape and Urban Planning*, *157*, 221-230.

IUCN (2020). *The IUCN Red List of Threatened Species*. https://www.iucnredlist.org/

Jambaari, A., Rajagopal, S., & Azmi, Y. (1999). Short notes the vertebrates fauna of Ayer Hitam Forest Reserve, Puchong, Selangor. *Pertanika Journal Tropical Agricultural Science, 22*(2), 179-184.

Jayaraj, V. K., Siti Hajar, M. D., Mohd-Isham, A., Shahrul Anuar, M. S., Seri Intan, M., & Mohd Tajuddin, A. (2013). Diversity ad conservation status of mammals in Wang Kelian State Park, Perlis, Malaysia. *Journal of Species Lists and Distribution*, *9*(6), 1439-1448.

Jayaraj, V. K, Anwarali, K. F., Azhar, I., WeeChen, E., Ali, M., Ahmad, A. Yusoff, A. M. (2016). Diversity and conservation status of small mammals in Kelantan, Malaysia. *Songklanakarin Journal of Science and Technology*, *38*, 213-220.

Karimullah & Shahrul, A. (2012). The dominant species of Monkeys (*Macaca fascicularis*) in Northern Region of Peninsular Malaysia. *Pakistan Journal of Zoology*, *44*(6), 1567-1574.

Kelly, M. J., & Holub, E. L. (2008). Camera trapping of carnivores: Trap success among camera types and across species, and habitat selection by species, on salt pond mountain, Giles County, Virginia. *Northeastern Naturalist*, *15*, 249-262.

Kolowski, J. M., & Forrester, T. D. (2017). Camera trap placement and the potential for bias due to trails and other features. *Public Library of Science One*, *12*(10), e0186679.

Konijnendijk, C. C. (2018). *The forest and the city the cultural landscape of urban Woodland* (2nd ed.). Gewerhestrasse, Switzerland: Springer International Publishing AG.

Lim, N. T-L., & Yeo, A. W. M. (2012). Records of the Shrew-faced Squirrel, *Rhinosciurus laticaudatus* (Mammalia: Rodentia: Sciuridae), in Singapore. *Nature in Singapore*, *5*, 165-170.

Lindenmayer, D. B., & Fischer, J. (2006). *Habitat fragmentation and landscape change: An ecological and conservation synthesis.* Canberra, ACT: CSIRO.

Louis, R., Saharudin, A., & Shabrina, M. S. (1988). Ecological studies of the small mammals of the Ayer Hitam Forest Reserve, Puchong, Selangor. *Wildlife and Parks*, *6*, 88-98.

Meijaard, E., & Sheil, D. (2008). The persistence and conservation of Borneo's mammals in lowland rain forest managed for timber: Observation, overviews and opportunities. *Ecology Research*, *23*, 21-34.

Mills, D. Fattebert, J. Hunter, L., & Slotow, R. (2019) Maximising camera traps data using attractants to improve detection of elusive species in multi-species surveys. *PLos ONE*, *14*(5). https://doi.org-10.1371-journal. pone.0216447

Mohd. Aliff, Z. (2017). *Species diversity of non-volant small mammals in acessible compartment 12 and 15 of Ayer Hitam Forest Reserve (AHFR), in Puchong, Selangor*. (Bachelor of Science (Education) Major Biology), Faculty of Science, University Putra Malaysia.

Mohd. Azlan, J. (2009). The use of camera traps in Malaysian rainforest. *Journal of Tropical Biology and Conservation*, *5*, 81 - 86.

Munian, K., Azman, S., Ruzman, A., Fauzi, M., & Alwani, Z. (2020). Diversity and composition of volant and non-volant small mammals in northern Selangor State Park and adjacent forest of Peninsular Malaysia. *Biodiversity Data Journal, 8*, e50304. https://doi.org/10.3897/BDJ.8.e50304.

Musser, G. (2017). Insectivore. In Encyclopedia Britannica (Ed.), *Encyclopedia Britannica, Inc*. https://www.britannica.com-animal-insectivore

Nakashima, Y., Inoue, E., Inoue-Murayama, M., & Abd. Sukor, J. R. (2010). Functional uniqueness of small carnivore as seed dispersal agents: A case study of the common palm civets in the Tabin Wildlife Reserve, Sabah, Malaysia. *Oecologia, 164*, 721-730.

Nor Bazilah, R., Abdul-Rahim, A. R., Shukor, M. N., & Farah Shafawati, M. T. (2018). Impacts of forest farm practice on small to medium-sized mammals at Kemasul Forest Reserve, Pahang, Malaysia. *AIP Conference Proceedings 1940*, 020045 (2018). https:// doi.org/10.1063/1.5027960.

Norfahiah. M., Azema. L., Marina. M. T., & Zakaria. M. (2012). Status and distribution of non-volant small mammals in Universiti Putra Malaysia, Bintulu Sarawak Campus (UPMKB). *Pertanika Journal of Tropical Agricultural Science, 35*(2), 363 - 369.

Nurul Shida, S., Faridah Hanum, I., Wan Razali, W. M., & Kamziah, K. (2014). Community structure of trees in Ayer Hitam Forest Reserve, Puchong, Selangor, Malaysia. *The Malaysian Forester*, *77*(1), 73-86.

Paiman, B., & Amat, R. Y. (2007). *Ayer Hitam Forest Reserve: Multimedia Super Corridor Community Heritage*. Serdang: Faculty of Forestry UPM.

Paramesvaran, S., Sani, R. A., Krishnasamy, Amal, N. M., Hassan, L., Mohd Zain, S. N., Latifah, I., Rahmat, M. S., Jeffery, J., Santhana, R. L., & Selvanesan, S. (2013). Distribution and morphological

measurements of wild and urban rodents from four habitats in the state of Selangor and Negeri Sembilan, Malaysia. *Malaysian Journal of Veterinary Research, 4*(2), 1-12.

Pęksa, Ł., & Ciach, M. (2018). Daytime activity budget of an alpine ungulate (Tatra chamois Rupicapra rupicapra tatrica): Influence of herd size, sex, weather and human disturbance. *Mammal Research, 63*, 443-453.

PERHILITAN. (2017). *Red list of mammals for Peninsular Malaysia Version 2.0*. Kuala Lumpur: Department of Wildlife and National Parks (PERHILITAN), Peninsular Malaysia. pp. 150.

Pollock, K. H., Nichols, J. D., Simons, T. R., Farnsworth, G. L., Bailey, L. L., & Sauer, J. R. (2002). Large scale wildlife monitoring studies: Statistical methods for design and analysis. *Environmetrics 13*, 105-119. doi:10.1002/env.514.

Rabinowitz, A. R. (1991). Behaviour and movements of sympatric civet species in Huai Kha Khaeng Wildlife Sanctuary, Thailand. *The Zoological Society of London*, *223*, 281-298.

Ramli, R., & Hashim, R. (2009). Diversity of small mammals inhabiting disturbed forest: A Case study on Kenaboi Forest Reserve, Jelebu, Negeri Sembilan, Malaysia. *Malaysian Journal of Science, 28,* 481-490.

Reilly, M. L., Tobler, M. W., Sonderegger, D. L., & Beier, P. (2017). Spatial and temporal response of wildlife to recreational activities in the San Francisco Bay ecoregion. *Biological Conservation, 207*, 117-126.

Rendall, A. R., Sutherland, D. R., Cooke, R., & White, J. (2014). Camera trapping: A contemporary approach to monitoring invasive rodents in high conservation priority ecosystems. *PLoS ONE, 9*(3), e86592. https://doi.org/10.1371/journal.pone.0086592.

Ruppert, N., Asyraf, M., & Shahrul, A. (2015). Diversity and biomass of terrestrial small mammals at a Malaysian Primary Rainforest (Segari Melintang Forest Reserve, Peninsular Malaysia). *The Journal of Tropical Life Science, 5*, 33-42.

Shahfiz, A., & Shahrul, A. (2011). *Survey of small mammals at two forest reserves in Cameron Highlands*. Conference: Seminar of Scientific Expedition at Cameron Highlands, Pahang

Shukor, M. N., Zainab, B., & Zubaid, A. (2001). Elevational diversity pattern of nonvolant small mammals on Mount Nuang, Hulu Langat, Selangor. *Online Journal of Biological Science, 1*(11), 1081-1084.

Siti Khadijah, A. (2016). *The effect of illegal recreation to the rate of infiltration in Ayer Hitam Forest Reserve (AHFR), Puchong, Selangor, Malaysia*. (Bachelor of Forestry Science), Faculty of Forestry, University Putra Malaysia.

Sodik, M., Pudyatmoko, S., Yuwono, P. S. H., & Imron, M. A. (2019). Resource selection by Javan Slow Loris *Nycticebus javanicus* E. Geoffroy, 1812 (Mammalia: Primates: Lorisidae) in a lowland fragmented forest in Central Java, Indonesia. *Journal of Threatened Taxa*, *11*(6), 13667-13679.

Sundai, S., Tisen, O. B., Chung, W. T., & Sundram, K. (2016). *The Terrestrial Fauna Composition of The Peat Swamp Forest of Ulu Sebuyau National Park, Sarawak*. Malaysia Sarawak Forestry Corporation, Malaysia.

Syakirah, S., Zubaid, A., Prentice, C., Lopez, A., Azmin, M. R., & Mohd-Yusof, A. (2000). A Small-mammal Survey at Tasek Bera, Pahang, Malaysia's First Ramsar Site. *Malayan Nature Journal*, *54*(1), 31-41.

Tee, S. L., Samantha, L. D., Kamarudin, N., Akbar, Z., Lechner, A. M., Ashton-Butt, A., & Azhar, B. (2018). Urban forest fragmentation impoverishes native mammalian biodiversity in the tropics. *Ecology and Evolution*, *8*(24), 12506-12521.

Tingga, R. C., Anwarali K. F, Mohd. Ridhwan, A. R., Juliana, S., Mohd Tajuddin. A. M. (2012). Small Mammals from Kuala Atok, Taman Negara Pahang, Malaysia. *Sains Malaysiana*, *41*, 659-669.

Torre, I., Arrizabalaga, A., & Flaquer, C. (2004). Three methods for assessing richness and composition of small mammal communities. *Journal of Mammalogy*, *85*(3), 524-530.

Wells, K., Kalko E. K. V., Lakim M. B., & Pfeiffer, M. (2007). Effect of Rain Forest logging on species richness and assemblage composition of small mammals in Southeast Asia. *Journal of Biogeography*, *34*, 1087-1099.

Wildlife Conservation Act. (2010). *Law of Malaysia, Act 716: Wildlife Conservation Act*. Malaysia: Percetakan Nasional Malaysia Berhad.

Yaap, B., Struebig, M. J., Paoli, G., & Koh, L. P. (2010). Mitigating the biodiversity impacts of oil palm development. *CAB Reviews, 5*(9), 1-11.

Zakaria, M., & Topani, R. (1999). Abundance of primates in Ayer Hitam Forest, Puchong, Selangor. *Pertanika Journal of Tropical Agricultural Science*, *22*(2), 105-109.

Zakaria. M., Sundai. S., & Rahim, M. (2001). Species composition of small mammals at the Ayer Hitam Forest Reserve, Puchong, Selangor. *Pertanika Journal of Tropical Agricultural Science*, *24*(1), 19-22.