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DIVERSITY OF MAMMALS IN SUNGAI YU ECOLOGICAL CORRIDOR, PAHANG

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ABSTRACT

Information and knowledge on species diversity are vital for planning and evaluating conservation strategies. Therefore, the Malaysian Government had developed a Central Forest Spine (CFS) Master Plan to maintain and restore connectivity of isolated forests in order to secure mutual coexistence of development and conservation. Sungai Yu Corridor is listed as one of the primary linkages under CFS Master Plan which serves as globally important area for biodiversity conservation. This corridor is divided into two isolated forests which include the Tanum Forest Reserve (on the Taman Negara side), separated from the Ulu Jelai and Sungai Yu Forest Reserves (on the Main Range side) by the Kuala Lipis-Gua Musang road. Three viaducts have been constructed along the road in order to allow the safe movement of wildlife across the road. Track surveys and camera trapping were used in this study area in Sungai Yu Forest Reserve for three months to determine the mammal species diversity. A total of 94,547 images were recorded from 7,706 trap-nights in Sungai Yu Forest Reserve, with 28 mammals species documented. Barking deer (*Muntiacus muntjak*) was the most frequently photographed species with 30.08% detection, followed by wild boar (*Sus scrofa*) with 21.23% detection and mousedeer with 8.31% detection. These findings provide knowledge and baseline information for long-term wildlife monitoring in Sungai Yu Forest Reserve.

Keywords: Species diversity, camera trapping, mammals, Sungai Yu Corridor

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INTRODUCTION

Deforestation and changes in land use are the main proximate factors causing habitat deterioration and forest fragmentation in tropical regions (Jaeger, 2000; Azevedo-Ramos *et al*., 2006; Joyce, 2006). These activities transform continuous forests into a collection of poorly interconnected small fragments, distantly separated from larger continuous forests (Harris, 1988; Daily *et al*., 2001). Under the National Physical Plan (NPP), the Central Forest Spine (CFS) is defined as the backbone of Peninsular Malaysia's Environmentally Sensitive Area (ESA) network, which compromises of four major forest complexes including; (i) Banjaran Titiwangsa - Banjaran Bintang - Banjaran Nakawan, (ii) Taman Negara - Banjaran Timur, (iii) South-East Pahang, Chini and Bera Wetlands, and (iv) Endau Rompin Park - Kluang Wildlife Reserves. Therefore, the Malaysian Government had embarked on the CFS Master Plan to maintain and restore the connectivity of isolated forests in order to secure mutual coexistence of development and conservation through creation of linkages and corridors within the CFS of Peninsular Malaysia (DFTCP & FDPM, 2010).

According to Beier and Loe (1992), wildlife corridors, also called dispersal corridors or landscape linkages, as opposed to linear habitats, are linear features whose primary wildlife function is to connect at least two significant habitat areas. The project entitled "Improving Connectivity in the Central Forest Spine (IC-CFS)" is currently being carried out in Peninsular Malaysia. The aims of this project are to: 1) improve the federal and state level capability to execute the CFS Master Plan (through the implementation of sustainable forest landscape management plans in three pilot's sites); 2) diversify financing sustainably through diversification; and 3) increase the allocation of funds for conservation. The IC-CFS project has three components which includes; wildlife survey, law enforcement, and human-wildlife conflict (HWC).

Information and knowledge on species diversity are vital for the planning and evaluation of these CFS Master Plan strategies, but most of these data are still lacking. The baseline information on species richness (O'Brien & Kinnaird, 2011), diversity (Ahumada *et al*., 2011), and density (Maffei & Noss, 2008), as well as the information on the activity patterns of wildlife based on species presence (Tobler *et al*., 2008) are vital for planning and formulating strategies for conservations (Tobler *et al*., 2008), to evaluate the effectiveness of conservation programmes and to improve conservation management (Nowell & Jackson, 1996; Stander, 1998; Karanth, 2003). Therefore, a large-scale area systematic survey using camera trapping is crucial to document terrestrial animal species diversity in the Sungai Yu Ecological Corridor (SYEC). SYEC is listed as one of the primary linkages under CFS Master Plan and serves as a globally important area for biodiversity conservation. Here, we assess presence of mammals, species richness, and their occupancy at the SYEC using camera-trap-based information.

METHODOLOGY

Study Area

SYEC is located at 15 km south of the Taman Negara National Park entrance at Sungai Relau (also known as Merapoh) in Pahang (Figure 1). A narrow stretch of the forest surrounding Sungai Yu is the only link connecting the two largest wildlife landscape in Peninsular Malaysia; the Main Range and Greater Taman Negara. Sungai Yu drains into Sungai Pahang, the longest river in Peninsular Malaysia. Total of the study area is 4,344.9 ha, 10 km along the highway, 3 km east and 3 km west from the highway. There are three viaducts located within this study area.

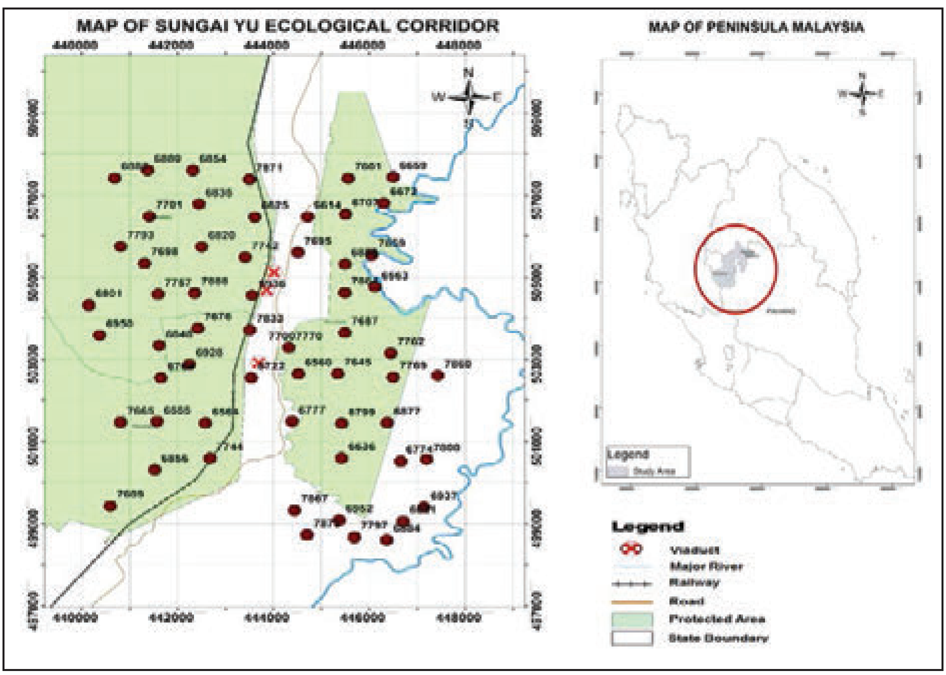

Figure 1 Camera trap locations (red dots) based on survey sites of Sungai Yu Ecological Corridor.

Track Survey

Track surveys were conducted from January till July 2017. Signs of all large mammals (with body weight of >20 kg) such as tracks, claw marks, faeces, vocalization or direct sighting were recorded. This could belong to a total of 13 large mammals (Lim, 1999; Morrison *et al*., 2007), excluding the bearded pig which has a limited distribution in southern Peninsular Malaysia (Kawanishi *et al*., 2006). Track surveys are important to determine the best site for camera trapping, which provides the best detection of wildlife. This survey covered active logging roads, old logging roads, ridge, forest trails, saltlicks and stream beds within the SYEC. Plaster casts of animal footprints found during the track survey were also prepared. Additionally, the location of snares and abandoned illegal campsites were also recorded to compare the detection of animals with human disturbances and poaching pressure.

Camera Trapping

The camera trap survey consisted of 60 sites with a total of 120 camera traps used (paired at each site). Each station was sampled for over a 3-4 month period from February to July 2017. The points for camera trap placement in each sampling occasion were variable, but the camera trap density was standardised to a pair of units for each 1.0 km^2. In exceptional cases (e.g., where access to the site is limited), camera traps were placed closer together. A minimum of 400m distance between camera trap locations was used for this study in order to minimise spatial autocorrelation of data. Camera traps were set along suitable locations within each cell, as they are likely to be used by large mammal species (based on data from track surveys). All camera traps were operational 24 hours per day, with time and date for each exposure recorded.

Data Analysis

All images captured by camera traps were recorded in the camera trap database. Images with more than one individual in the frame were considered as individual detection for the species. Photos for the same species detected within an hour, regardless of the number of pictures taken at the same location, were considered as detection of the same individual of the particular species. All mammal photographs in camera traps were identified based on Francis and Barret (2008). Data obtained from the analysis were illustrated in graph and maps using R Software version 3.4.2, GNU (Bell Laboratories, Lucent Technologies) to display the occupancy and species richness of all mammal species along SYEC. A combined species evaluation (multi-species) was chosen (Roberge & Angelstam, 2004). The occupancy of 95% credible interval as the species-specific state variable of abundance was used to assess differences across all camera traps under an unbiased framework and determine a covariate of both occupancy and detection probability (p) with and without a covariate. Distance to the road for each camera was used as a covariate and was calculated using GIS-Arc Map 10 for Windows software package (Mugerwa *et al*., 2012).

RESULTS AND DISCUSSION

Track Survey

A total of 152 km was tracked within the study area and fourteen detections of mammal signs were recorded during the survey via direct and indirect observation as listed in Table 1. All GPS coordinates of the observations were recorded.

Table 1 Mammals detected from footprints, visuals, markings, and vocalisations.

Species	Common Name	Type of Detection
Sus scrofa	Wild boar	Footprint, dung, visual
Elephas maximus	Asian elephant	Footprint, dung
Tapirus indicus	Malayan tapir	Footprint, dung
Muntiacus muntjak	Barking deer	Footprint, dung
Trachypithecus obscurus	Dusky leaf monkey	Visual, vocalisation
Symphalangus syndactylus	Siamang	Visual, vocalisation
Tragulus sp.	Mousedeer	Footprint
Rusa unicolor	Sambar deer	Footprint
Helarctos malayanus	Malayan sun bear	Footprint, claw mark
Panthera tigris malayensis	Malayan tiger	Footprint
Panthera pardus	Leopard	Footprint
Cuon alpinus	Dhole	Footprint
Hystrix brachyura	Malayan porcupine	Visual

Camera Trapping

We conducted camera trapping surveys at 60 camera trap points, resulting in 7,706 trap nights. Few camera traps did not yield data due to malfunction or were stolen or damaged by weather, elephants, or poachers.

Throughout the study, there were a total of eight mammalian orders represented by 16 families (Table 2). Fourteen species were detected from the order

Carnivora, five from Artiodactyla, four from Primates and two from Rodentia. The order Pholidota, Proboscidea and Perissodactyla were each represented by one species. Our results showed that Carnivora had the highest species recorded, followed by Artiodactyla.

A total of 28 species of mammals were detected using camera traps within the study site (Table 2*).* According to the IUCN Red List of Threatened Species (IUCN, 2019), there were two Critically Endangered species recorded (Malayan tiger and Malayan pangolin). Overall, 11 out of 14 large mammals found in Peninsular Malaysia were detected, except for gaur, Sumatran rhinoceros, and bearded pig. Six out of seven felids species, including the Malayan tiger, leopard, clouded leopard, golden cat, marbled cat, and leopard cat, were recorded. Flat-headed cat (*Prionailurus planiceps*) was the only felid species not detected. The four Malayan tiger images detected were identified belonged to two individuals.

Species Occupancy of Mammals

The overall species richness around the ecological corridor area was relatively high. A combined mammal's species occupancy in SYEC is illustrated in Figure 2. The graph corroborates that barking deer (*Muntiacus muntjak*) had the highest percentage of occupancy, followed by the pig-tailed macaque (*Macaca nemestrina*) and wild boar (*Sus scrofa*). The most likely reason to explain this occurrence is the decreased presence of primary predators such as tiger in the study area, which influences the number of prey species such as barking deer and wild boar. The Malayan sun bear (*Helarctos malayanus*) and Malayan tapir (*Tapirus indicus*) were found to be widepread within the study area. The presence of tiger did not seem to affect the presence of Malayan sun bear and Malayan tapir. Other large herbivores such as Sambar deer (*Rusa unicolor*) showed a lower occupancy and there was no detection of gaur. This could be due to the high human disturbance and poaching activities that were recorded in this SYEC. It is believed that deforestation and agricultural development activities surrounding this area facilitaed access for poachers into the forest. This is supported by evidence of 42.81 % of the camera traps showing a detection of illegal poachers and encroachers. Our study showed that the increasing number of access roads to the forest could cause an increase in poaching activity, especially if no prevention measures are taken to prevent hunting (Laurance *et al*., 2006; Mohd-Azlan & Lading, 2006). The amount of sampling effort also explained why there was low occupancy of some species. Although the number of camera traps used in the survey was large, camera trap stations within a particular plot were not as spaced apart as initially intended, particularly in areas of high elevation primary forest.

Table 2 Mammal species recorded at Sungai Yu Ecological Corridor (Note: LC= Least Concern; VU= Vulnerable; EN= Endangered; CR= Critically Endangered; NT= Near Threatened following IUCN Red List of Threatened Species, 2019).

No.	Order Family	Scientific Name	Common Name	Local Name	IUCN Status
	Carnivora				
1	Felidae	*Catopuma temminckii*	Golden cat	Kucing tulap	NT
2	Felidae	*Neofelis nebulosa*	Clouded leopard	Harimau dahan	VU
3	Felidae	*Panthera pardus*	Leopard	Harimau kumbang	VU
4	Felidae	*Panthera tigris malayensis*	Malayan tiger	Harimau belang	CR
5	Felidae	*Pardofelis marmorata*	Marbled cat	Kucing dahan	NT
6	Felidae	*Prionailurus bengalensis*	Leopard cat	Kucing batu	LC
7	Viverridae	*Arctictis binturong*	Binturong	Binturong	VU
8	Viverridae	*Hemigalus derbyanus*	Banded civet	Musang belang	NT
9	Viverridae	*Paguma larvata*	Masked palm civet	Musang lamri	LC
10	Viverridae	*Arctogalidia trivirgata*	Small-toothed palm civet	Musang akar	LC
11	Viverridae	*Viverra zibetha*	Large Indian civet	Musang jebat	LC
12	Mustelidae	*Martes flavigula*	Yellow-throated marten	Mengkira	LC
13	Ursidae	*Helarctos malayanus*	Malayan sun bear	Beruang matahari	VU
14	Canidae	*Cuon alpinus*	Dhole	Anjing hutan	EN
	Primates				
15	Cercopithecidae	*Macaca fascicularis*	Long-tailed macaque	Kera	VU
16	Cercopithecidae	*Macaca nemestrina*	Pig-tailed macaque	Beruk	VU
17	Cercopithecidae	*Trachypithecus obscurus*	Dusky langur	Lontong chengkong	NT
	Artiodactyla				
18	Hylobatidae	*Symphalangus syndactylus*	Siamang	Siamang	EN
19	Bovidae	*Capricornis sumatraensis*	Sumatran serow	Kambing gurun	VU
20	Cervidae	*Rusa unicolor*	Samba deer	Rusa	VU

Table 2 (Continued)

No.	**Order** **Family**	**Scientific Name**	**Common Name**	**Local Name**	**IUCN Status**
21	Cervidae	*Muntiacus muntjak*	Barking deer	Kijang	LC
22	Suidae	*Sus scrofa*	Wild boar	Babi hutan	LC
23	Tragulidae	*Tragulus kanchil*	Lesser mouse-deer	Pelanduk	LC
	Rodentia				
24	Hystricidae	*Atherurus macrourus*	Brush-tailed porcupine	Landak batu	LC
25	Hystricidae	*Hystrix brachyura*	Malayan porcupine	Landak raya	LC
26	Manidae	*Manis javanica*	Malayan pangolin	Tenggiling	CR
	Proboscidea				
27	Elephantidae	*Elephas maximus*	Asian elephant	Gajah	EN
	Perissodactyla				
28	Tapiridae	*Tapirus indicus*	Malayan tapir	Tapir	EN

Some species could be restricted to specific habitat types and would therefore have been missed by our surveys if that habitat type was not well represented during sampling. Indeed, in this study, all camera trap sites were located within a low elevation range; all our cameras were located below than 500 m elevation and hence, we did not sample forest habitats located above 750 m, (Hazebroek *et al*., 2004)

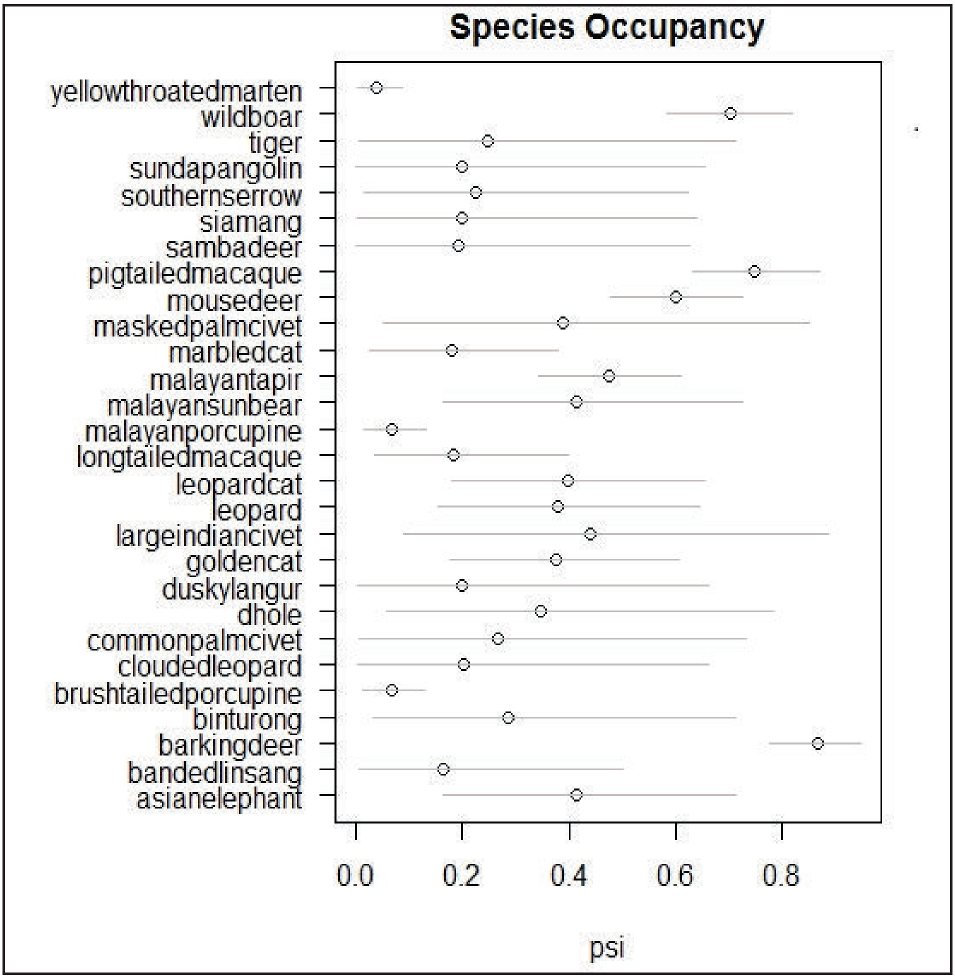

Figure 2 Analysis of multi-species occupancy across all camera traps at the study area.

Effect of Distance to Road on Occupancy

Distance to roads played a significant role in influencing species detection probability. Some species were attracted to the roads, while other species preferred to avoid roads. Figure 3 shows that the Malayan sun bear and dhole detectability increased with increasing distance from the roads. In contrast, the detectability of some species such as Malayan porcupine, brush-tailed porcupine, mousedeer (*Tragulus* sp.) and wild boar increased when the distance to road decreased. This condition may be a response to the availability of food sources and their excellent adaptation to exploited human areas (Whitmore, 1984; Forman & Alexander, 1984).

Interestingly, for some species such as Malayan tapir, the distance from roads did not show any significant effect on their occupancy. This explained why road kills occurred frequently for some species, especially for Malayan tapir. Thus, viaducts could play a significant role in minimizing such road kills. For viaducts to be effective, the area surrounding it should provide sufficient resources such as saltlicks, food and fences to guide wildlife to cross the road safely.

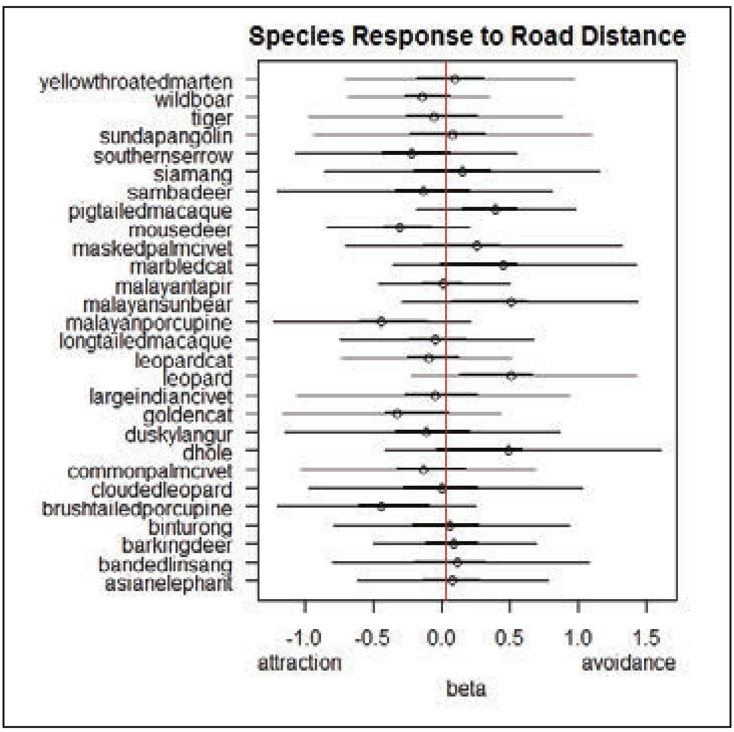

Figure 3 Multi-species occupancy using distance to road as covariate.

Species Richness

The result from Figure 4 showed the species richness analysis corroborated the data from camera traps that detected the most mammals species being camera trap 7797 and 7770. Camera trap 7770 was located close to the viaduct. The mammals recorded within camera trap 7770 and 7797 included the Malayan tiger, leopard, leopard cat, Asian elephant, Malayan sun bear, dhole, Malayan tapir, Malayan porcupine, marbled cat, barking deer, mousedeer, wild boar and pig-tailed macaque. To increase species richness, more habitat enrichment should be done. This includes creating artificial saltlicks and planting more trees across several trophic levels.

Artificial salt licks have been an important management tool to attract wildlife (Atwood & Week, 2003). Although there were a lot of species detected during this study, there were a few camera trap sites that detected fewer wildlife species. This might be due to the effects of anthropogenic disturbances such as illegal poaching, farming, and fishing. Other than that, there were also breeding signs detect via camera traps for the Asian elephant, Malayan sun bear, barking deer and wild boar. This showed that the area surrounding viaduct can provide sufficient resources for breeding animals, and therefore underscores the importance of protecting and minimizing development within wildlife corridors.

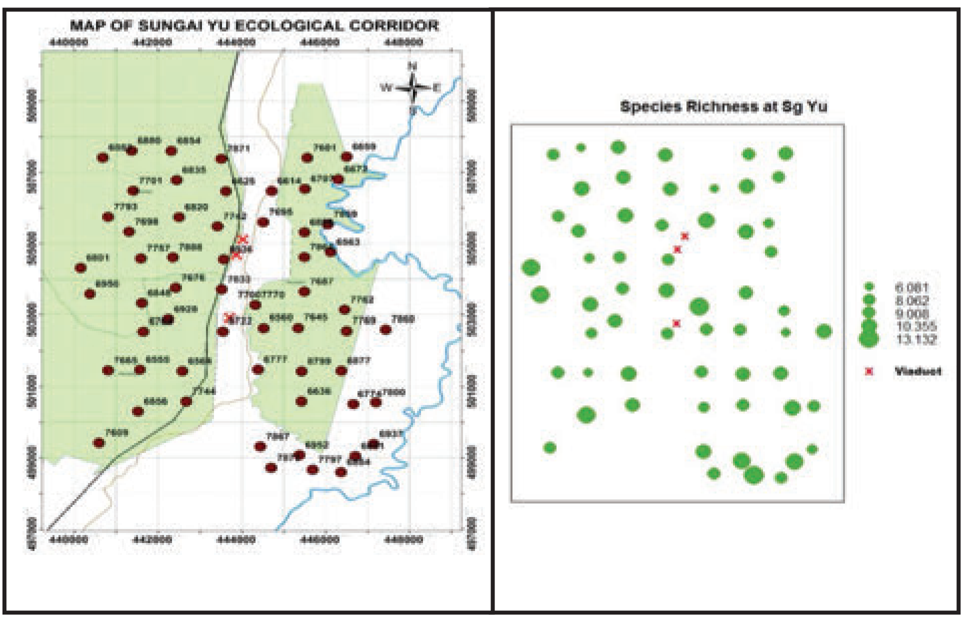

Figure 4 Species richness of Sungai Yu Ecological Corridor across all camera traps (red dots represent camera trap locations, while the largest green dot represents highest richness).

Encroachment

We recorded 1,131 images (42.81%) of human presence, including Orang Asli, villagers and illegal poachers – this indicates a high level of human disturbance in the study area and potential threats to the wildlife species. We predicted that poaching may effect the distribution and abundance of wildlife, specially mammals in the study area. The presence of human activities could alter local ecological parameters and should be considered as serious threats to the survival of the wildlife populations in the SYEC. There were also 13 units of operational camera trap stolen during the study, further illustrating the gravity of human disturbance and poaching at these sites. Police reports were made on these incidences. Thus, continuous monitoring programmes using camera trapping methods can provide valuable information to assess the impact of human activities on the diversity and abundance of wildlife species in their natural habitats. This information has been reported to the Law and Enforcement Division, Department of Wildlife and National Parks (DWNP) for further action.

Poaching

In Peninsular Malaysia, illegal poaching is one of the major causes of biodiversity extinctions. Year after year, threatened wildlife species such as Malayan tiger, Malayan pangolin, Asian elephant and Sambar deer have been poached due to their high value and high demand in the international black market. The value from this illegal poaching activity can reach up to millions of US dollars. It is belived that some of these hunted wildlife parts are used for traditional Chinese medicine. The patrolling undertaken by DWNP found signs of poaching by foreigners. Signs of poaching appeared to rampant as an increasing number of illegal traps were recorded during each visit. Illegal poaching is a very wicked problem to be tackled as it involves many poachers that traverse large areas in the forest. Sometimes, poaching activties can last for months. It is a standard operation procedure of DWNP to destroy any poaching traps encountered.

CONCLUSION

Our study showed that the stretch of state land along SYEC is very rich in biodiversity. This was presented to the National CFS Steering Committee. In early 2013, the state land along SYEC was gazetted as Tanum Forest Reserve as a protected forest under National Forestry Act 1984. The long-term protection of SYEC is important to protect and conserve mammals and other biodiversity. However, the low detection rates of certain species did not yield robust readings on the credible interval in the occupancy analysis - this suggests that more data is needed. Long-term wildlife monitoring must be conducted to assess the changes of habitat used by mammals. It is predicted that the habitat used by mammals will decline due to anthropogenic disturbances. For most of these animals, a large expanse of habitat is crucial for the long-term viability of populations. However, their habitats are being destroyed for development. In addition, there are more barrier for animals to reach resources such as food, shelter and to reproduce, isolated and fragmented habitats clearly pose a threat to the health of populations. A genetically diverse pool of individuals is needed to avoid the negative effects of inbreeding that reduces genetic diversity. Connected wildlife corridors play an important role in mixing the genetic pool, hence maintaining the genetically healthy populations. Furthermore, the level of poaching and road kills at the study site surrounding the viaduct site were also recorded to provide baseline data for better management of the SYEC area. Continuous enforcement efforts are essential to conserve and protect the biodiversity along SYEC. Regular coordination and communication between agencies such as local governments, conservation-based organizations and other close stakeholders will ultimately lead to better prospects for wildlife conservation.

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