

LARGE AND MEDIUM-SIZED MAMMALS FROM THREE CENTRAL FOREST SPINE CORRIDOR LOCATIONS IN PAHANG, WEST MALAYSIA

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ABSTRACT

A total of 37 corridors were proposed in the Central Forest Spine Master Plan for Ecological Linkages (CFS) developed by the Malaysian Federal Government in 2010. In Pahang, there are nine CFS corridors consisting of six primary linkages and three secondary linkages established. In this study, we recorded mammal's occurrence in three CFS corridors, namely the Krau Wildlife Reserve-Benchah Forest Reserve-Som Forest Reserve-Yong Forest Reserve (CFS1 SL2), Tanum Forest Reserve (Greater Taman Negara) - Sungai Yu (CFS1 PL1) and Lepar Forest Reserve - Berkelah Forest Reserve (CFS2 SL1). Camera traps were used to obtain data on mammal presence in each study area. We obtained 379 photographic images from 2,982 trap nights comprised of 18 species of mammals. The highest detection was the wild pig (45.1%) followed by barking deer (12.1%), Malayan porcupine (11.3%), and the lesser mouse deer (10.3%). The result shows that all three CFS corridors play a vital role as wildlife habitats for medium to large mammals while simultaneously maintaining connectivity of divided habitats. Future studies are recommended to expand the data collection effort by increasing the number of trap nights, the number of locations for the camera trap, and the size of the area covered for CFS 1 SL2 and CFS2 SL1. We also recommend frequent monitoring of each site to ensure the area is free from any illegal activities.

Keywords: CFS, Corridor, Pahang, mammals, camera traps

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INTRODUCTION

Forest fragmentation has been identified as a threat to biodiversity and conservation in the National Physical Plan (DTCP, 2005). The plan also ascertained that the best land management was crucial for forest conservation in Malaysia. The policy included Central Forest Spine (CFS) as a backbone to the environmentally sensitive area (ESA). Thus, linking fragmented forest areas was important for creating a balance between development and conservation activities (DTCP, 2005). Central Forest Spine (CFS) Master Plan for Ecological Linkages was developed to restore ecological connectivity between 4 fragmented forest complexes, namely the Banjaran Titiwangsa - Banjaran Bintang - Banjaran Nakawan, Taman Negara Banjaran Timur, South East Pahang, Chini and Bera Wetlands, and Endau Rompin Park-Kluang Wildlife Reserves (DTCP, 2005). Within the forest complexes, 37 ecological linkages were identified to link the major forest blocks, consisting of 17 primary and 20 secondary linkages. The aim of the CFS is a long-term plan to rebuild, maintain and reconnect the main fragmented forest in Peninsular Malaysia. The plan's benefit is to reduce the negative impact of forest fragmentation on the biodiversity aspect and to ensure species will be preserved and the continuation of its ecological function will remain. It also focuses on other components such as maintaining forested areas, sustainable forest management practices and forest rehabilitation programmes (Shukri *et al.*, 2014).

CFS areas encompass primary forest (including legally protected areas), secondary forest, forest islands, private land, settlements, and many other mixed land use and activities that lie on the proposed backbone of Peninsular Malaysia (DTCP, 2009a). Wildlife studies are still lacking, especially in the forest outside of protected areas and permanent forest reserves in Peninsular Malaysia and CFS areas. In the past 15 years, wildlife surveys focused on legally preserved habitats such as wildlife reserves and national parks (DWNP, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2009a, 2009b, 2017). Several diversity studies on mammals have been carried out in the Tembat Forest Reserve (TFR) and Petuang Forest Reserve (PFR) in Hulu Terengganu (Magintan *et al.* 2017 & DWNP, 2009c), Jerangau Forest Reserve, Terengganu (Mohd-Azlan & Sharma 2006; Mohd-Azlan, 2006), Bukit Kerinchi, Kuala Lumpur (Karuppannan *et al.*, 2014), Temenggor Forest Reserve (Rufino *et al.*, 2008) and some studies in CFS corridors (Ghazali *et al.*, 2019; Clements *et al.*, 2012). All of the study areas revealed the high diversity of wildlife and the importance of the study sites as wildlife habitats.

Studies on mammalian diversity outside of protected areas in Pahang are limited. Most studies were in protected areas such as the Krau Wildlife Reserve (Krau WR) and Pahang National Park. Wildlife research and expedition in Krau WR had begun since the 1960's by local and foreign researchers (DWNP/ DANCED, 2001). While for Taman Negara, wildlife study and scientific expeditions started actively in the 1970s (Khan, 1971; William, 1978; Olivier, 1978). Other important biodiversity areas in Pahang are the Tasek Chini and Tasek Bera. Tasek Chini and Tasek Bera were declared as man and biosphere and Ramsar sites in 2009 and 1994, respectively. However, there are limited studies on the wildlife outside of the two main protected areas in Pahang. A study by Jambari *et al.* (2015) and Magintan *et al.* (2015) in Taman Negara Pahang, Taman Negara Terengganu and Taman Negara Kelantan revealed relatively high observations of wildlife through camera trapping assessment. The forested area statistic in 2018 shows that Pahang has a total of 2,056,695 ha of forested area, encompassing 1,559,385 ha of permanent forest reserves (JPSM, 2018). The plantation area covers 732,052 ha, or 20.4% of the total size of Pahang (Ahmad, 2017).

The study of mammals diversity in the proposed area for corridors in Pahang is essential to facilitate the authority in managing the corridors as pathways for wildlife to move within forest pockets and eventually to the larger forest areas. In Pahang state, a total of nine CFS corridors were proposed, with six as primary linkage and three as secondary linkage (DTCP, 2009a, 2009b). Information on occurrences of mammals in the corridors can assist the authority in the actions that should be prepared and achieved specifically. Thus, the objectives of this study were firstly to collect and update data on wildlife in the corridors and secondly, to monitor the occurrences of wildlife periodically in the area for management and conservation purposes.

METHODS

The method used for this study was direct observation and indirect observation, which included a camera trapping program. A total of 28 camera traps were deployed during the study periods, starting from February 2018 until January 2019, in three sites explained in the following paragraphs. Images from the camera traps were gathered and analysed. Species identifications followed Khan (1992) and Francis (2008). For diversity comparison between study sites, the data were analysed using PAST version 2.17c. The diversity indices used for comparison were the Simson and Shannon index. The relative abundance of photographed mammals are determined by calculating the number of detection and the detection rate per 100 trap nights based on the study by Laidlaw *et al.* (2000).

Study Sites

Krau Wildlife Reserve-Bencah Forest Reserve-Som Forest Reserve-Yong Forest Reserve (CFS1 SL2)

The Krau Wildlife Reserve-Bencah Forest Reserve-Som Forest Reserve-Yong Forest Reserve is SL2 ecological Corridor, 20 km long and 40 km wide, predominantly consists of forested land (Figure 1). It covers a relatively small area of approximately 161.87 ha. It is located within the District Jerantut and Lipis about 15 minutes drive from Jerantut and 30 minutes drive from Kuala Lipis town. Within the Corridor are the Som FR, Kerambit FR and Ulu Mas FR, which are an integral part of the Krau Wildlife Reserve; and on the FRs outside the Corridor are the Yong Forest Reserve and Krau Forest Reserve. The SL2 Corridor and its surrounding region are commonly characterised by hill land with gentle slopes. The elevations vary from 150 m to 300 m a.s.l. The SL2 Corridor comprises 89.29 % of lowland, while 10.71 % is hill land below 300m a.s.l.

Tanum Forest Reserve (Greater Taman Negara) – Sungai Yu (CFS1 PL1)

The PL1, Tanum – Sungai Yu Ecological Corridor, is 12 km long and 9 km wide of predominantly forested land (Figure 1). It covers a relatively small area of approximately 4,233 ha. The area is located within the Mukim Batu Yon at the western part of Taman Negara. On the left side is the Sg. Yu Forest Reserve and Ulu Jelai Forest Reserve are an integral part of the Main Range. On the right side is the Tanum FR adjacent to Taman Negara. Most of the PL1 Corridor and its surrounding region are characterised by hill land and highlands with steep slopes in many areas, ranging from 150m to 1,250 m a.s.l.

Lepar Forest Reserve – Berkelah Forest Reserve (CFS2 SL1)

The objective of the linkage in this area is to maintain the connection between the Greater Taman Negara forest complex and the Cini-Bera forest complex (Figure 1). The area is located in the vicinity of Paya Bungor and consists of a mixed habitat of open water bodies, freshwater swamp forests, and riparian forests. The Lepar river flows south from the edge of Berkelah Forest Reserve. At Paya Bungor, there is a stretch of state-land forests east of the old Karak highway, stretching to the Lepar FR. This Corridor is characterised by forest land, followed by water bodies and agriculture such as rubber and oil palm plantations. Berkelah FR is separated from the Pahang River and subsequently, the Chini-Bera forest complex by the Karak highway, the new Expressway, as well as pockets of agriculture and settlements along the Karak. It is comprised of hill dipterocarp rainforest encompasses unlogged forest (primary forest) and logged forest (logged forest) The Lepar and Bungor forest reserves are fragmented from Berkelah FR by oil palm plantations, as well as paddy and rubber smallholdings.

There are two settlements located along Sungai Leper and within Leper FR namely the Kampung Km 56 Paya Bungor (an aborigine settlement) and Kampung Gedong Siam. Settlements along the Kuantan-Maran road are mostly Malay traditional settlements comprising of Kampung Rohai, Kampung Semugi, Kampung Berkelah, Kampung Belugur, Kampung Paya Merbau, Kampung Paya Bungor, Kampung Seri Jaya and Kampung New Zealand.

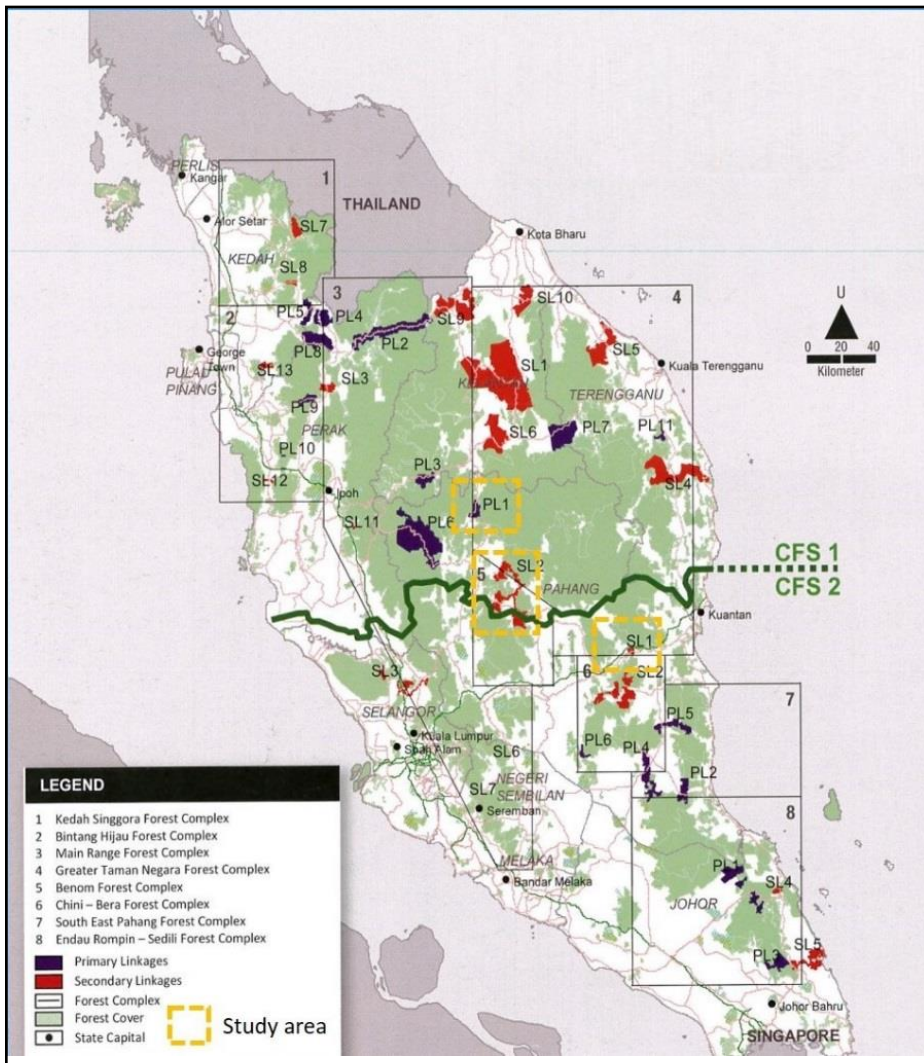


Figure 1 Map of Peninsular Malaysia showing three locations of study sites (JPBD, 2010).

RESULT AND DISCUSSION

A total of 379 photographic images were obtained from 2,982 trap nights throughout the study periods (Table 1). The images comprised mammals from 18 species of six mammalian Order namely, Primate, Carnivore, Proboscidae, Perissodactyla, Artiodactyla and Rodentia (Table 2). There were five families of carnivores, which include Ursidae, Felidae, Mustelidae, Viverridae and Canidae. Carnivores were detected 34 times, or 9% of the total detections, with the highest species richness (9 species). Three endangered and three vulnerable species were identified according to IUCN (2019) (Table 2). The second highest in species richness and the most detected was the Artiodactyl encompassing four species and 67.8% detection. Family Felidae represents the highest number of species, which include the black leopard, clouded leopard, leopard cat, and Asiatic golden cat. The most common species were wild pig and pig-tailed macaque. Two species known to occur in at least two locations were the Asian elephant, Malayan tapir, Malayan sun bear and lesser mouse deer. A total of 12 species were detected only in one place, either in CFS1 PL1 or CFS2 SL1 or CFS1 SL2.

Table 1 The number of camera traps, trap nights and images captured during the study period.

Location	Study period	No. of camera traps	No. of trap night	No. of photographed images of animal	No. of species captured
CFS 1 SL 2 (Krau WR – Som FR and Yong FR)	April - July 2018	8	694	107	5
CFS2 SL 1 (HS Lepar – HS Bekelah)	April - July 2018	6	624	47	5
CFS1 PL 1 (Sg. Yu FR & Sg. Tanum FR)	February 2018 - January 2019	14	1,664	225	16
Total:		28	2,982	379	

Table 2 Summary of animals recorded during camera trapping programs from 2018 to 2019 in three Central Forest Spine corridors, Pahang.

Order	Family	Common name	Scientific name	Status (IUCN)	Act 716	CITES	CFS1 SL2	CFS2 SL1	CFS1 PL1
Primate	Cercopitheciidae	Pig-tailed macaque	<i>Macaca nemestrina</i>	VU	First Schedule	App. II	✓	✓	✓
		Long-tailed macaque	<i>Macaca fascicularis</i>	LC	First Schedule	App. II		✓	
Carnivore	Ursidae	Malayan sun bear	<i>Helarctos malayanus</i>	VU	Second Schedule	App. I		✓	✓
		Black leopard	<i>Panthera pardus</i>	NT	Second Schedule	App. I			✓
	Felidae	Clouded leopard	<i>Neofelis nebulosa</i>	VU	Second Schedule	App. I			✓
		Leopard cat	<i>Prionailurus bengalensis</i>	LC	Second Schedule	App. I			✓
		Asiatic golden cat	<i>Catopuma temminckii</i>	NT	Second Schedule	App. I			✓
Mustelidae	Yellow-throated marten	<i>Martes flavigula</i>	LC	Second Schedule	App. III			✓	
Viverridae	Common palm civet	<i>Paradoxurus hermaphroditus</i>	LC	First Schedule	App. III			✓	
	Malayan civet	<i>Viverra zangalunga</i>	LC	First Schedule	n/a			✓	
	Dhole	<i>Cuon alpinus</i>	EN	Second Schedule	App. II			✓	
Proboscidae	Elephantidae	Asian elephant	<i>Elephas maximus</i>	EN	Second Schedule	App. I	✓		✓
		Tapir	<i>Tapirus indicus</i>	EN	Second Schedule	App. I	✓		✓
Artiodactyla	Suidae	Wild pig	<i>Sus scrofa</i>	LC	First Schedule	n/a	✓		✓
		Barking deer	<i>Muntiacus muntjak</i>	LC	First Schedule	n/a			✓
Bovidae	Bovidae	Serow	<i>Capricornis sumatraensis</i>	VU	Second Schedule	App. I	✓		✓
		Lesser mouse-deer	<i>Tragulus kanchil</i>	LC	First Schedule	n/a		✓	
Rodentia	Hystricidae	Malayan porcupine	<i>Hystrix brachyura</i>	LC	First Schedule	App. III			✓

Notes: CFS1 SL2= Krau Wildlife Reserve-Benchah Forest Reserve-Som Forest Reserve-Yong Forest Reserve, CFS2 SL1= Lepar Forest Reserve - Berkelah Forest Reserve, and CFS1 PL1= Tanum Forest Reserve (Greater Taman Negara) - Sungai Yu.

The highest detection was the wild pig, followed by barking deer, Malayan porcupine, and the lesser mouse deer with the detection percentage of 45.1%, 12.1%, 11.3%, and 10.3%, respectively (Figure 2). The wild pig images also appeared to be high in all sites. There were 12 species with less than 10% of the total camera traps detection. Three species were only detected once: the dhole, serow and yellow-throated marten. The other species detected twice were the clouded leopard, common palm civet and Malayan civet.

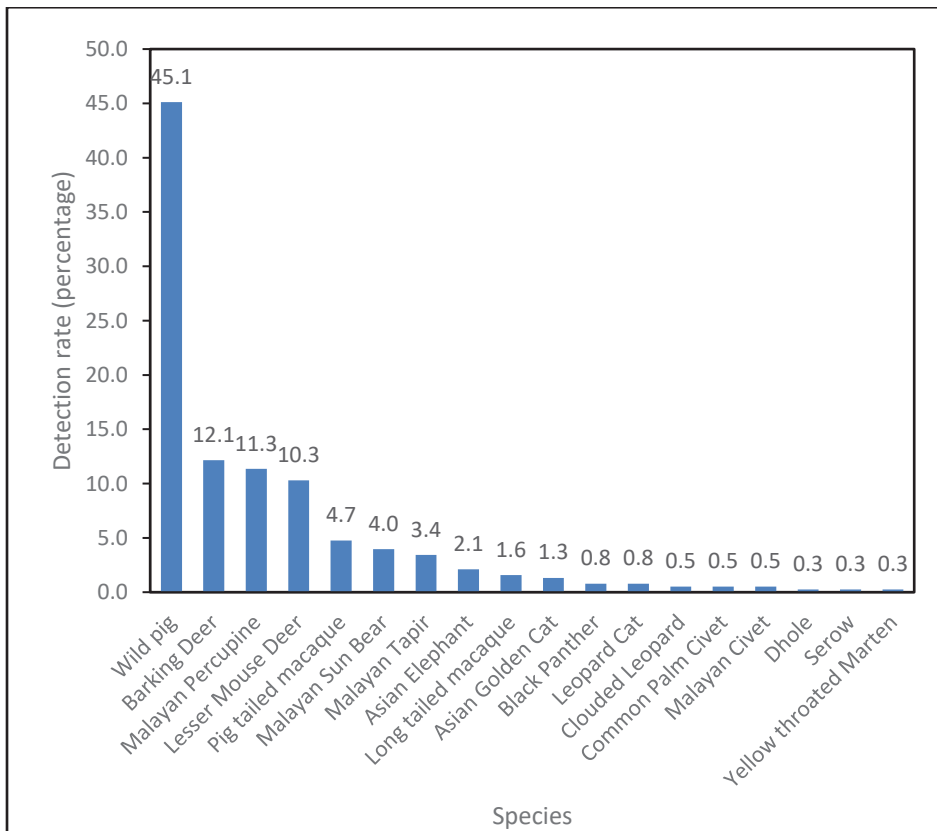


Figure 2 The relative abundance of photographed mammals were determined by calculating the number of detection and the detection rate per 100 trap nights based on the study done by Laidlaw *et al.* (2000).

CFS1 PL1 is one of the important linkages for two main wildlife habitats and large forest landscapes: the Pahang National Park (TNP) and the main range forest complexes. TNP is one of the richest in biodiversity in this region (MNRE, 2006) and the habitat for almost all the largest and medium species of mammals

in Peninsular Malaysia. This is proven by having the highest diversity index and the highest composition of mammals species in this study (Table 3). The park is surrounded by various types of land use, including Taman Negara Kelantan in the northern part and Taman Negara Terengganu in the eastern part. The southern of this park is consists of various land use including oil palm plantation, human settlements, orchards, forest reserves, production forest reserves and rubber plantations. Roads and railways separate this area from other large forest areas. Apart from medium size mammals found in this area, the occurrence of large mammals such as the Asian elephant and the Malayan tapir require a large roaming area. Thus, the CFS1 PL1 linkage is crucial to connect TNP to other areas for large animals to move freely between the large habitats and minimise roadkill.

Table 3 Diversity indices in three study sites.

Diversity indices	CFS1 SL2	CFS2 SL1	CFS1 PL1
Taxa_S	5	5	16
Detection	107	47	225
Dominance_D	0.7762	0.5201	0.1518
Simpson_1-D	0.2238	0.4799	0.8482
Shannon_H	0.5237	0.9894	2.137
Evenness_e ^H /S	0.3376	0.5379	0.5299
Chao-1	5	5	16.25

Notes: CFS1 SL2= Krau Wildlife Reserve-Bencah Forest Reserve-Som Forest Reserve-Yong Forest Reserve; CFS2 SL1= Lepar Forest Reserve - Berkelah Forest Reserve and CFS1 PL1= Tanum Forest Reserve (Greater Taman Negara) - Sungai Yu

The incidences of wildlife roadkill on highways and roads in Peninsular Malaysia are quite alarming. Between 2009 and 2018, a total of 92 incidents of roadkill were reported (DWNP, 2019). Data on wildlife need to be collected and updated from forest areas where wildlife roadkills occur. Hence, this study should be carried out regularly to provide information to the relevant authorities. Wildlife from fragmented forest areas should be assessed and analysed in order for the relevant government agencies such as DWNP to monitor the area. Wildlife displacement, Human-wildlife conflict and roadkill usually occur in fragmented habitats (Magintan *et al.*, 2012, Ahmad-Zafir & Magintan, 2016; Jamhuri *et al.*, 2018). With the information available, roadkill or wildlife conflict can be prevented and mitigated immediately.

In this study, there were differences in the composition of species of mammals found in the three sites. The difference was obviously due to the status of their habitat and also the surrounding areas. The CFS2 SL1 and CFS1 SL2 showed lower detection compared to the CFS1 PL1. The size and land use of the surrounding habitat plays a vital role in determining the occurrence of mammal species in these study sites. The medium and large-size mammals require a larger roaming area, thus, CFS1 PL1 portrayed more species occurrence and larger animals such as the Asian elephant and Malayan tapir. For small mammals, vegetation structure has no direct link to their occurrence, but the surrounding areas, the forest edge, and the proximity to palm plantations might lead to their existence (Ruppert *et al.*, 2015). Another reason was the species composition difference, perhaps due to the inconsistent effort in terms of the number of trap nights for all sites. The number of trap nights for CFS1 PL 1 was higher than the CFS2 SL1 and CFS1 SL2 trap nights. As a result, the number of wildlife species detected at all sites differed.

The nine carnivores representing 29% of Peninsular Malaysia 31 carnivores (DWNP, 2009d) recorded during this study were from Sg. Yu area (CFS1 PL1), a species recorded from CFS2 SL1 and none from CFS1 SL2. At Sg. Yu, smart green infrastructure was built as part of the effort under the CFS project to connect Taman Negara to the neighbouring forest reserve. Smart green infrastructure refers to infrastructures that are designed to avoid, minimise and mitigate negative impacts on wildlife in an area (Wan-Nordin *et al.*, 2020). Ratnayeke *et al.* (2018) revealed two regions in Peninsular Malaysia: the forest complex associated with Royal Belum State Park in the north-eastern Peninsular Malaysia and the area associated with Taman Negara National Park in the south-eastern of Peninsular Malaysia as to have a higher concentration of carnivores. The CFS1 PL1 is located within the Corridor connecting Taman Negara and the Titiwangsa Range. The highest small carnivore species totals documented from a single study in Peninsular Malaysia was in CFS linkage area 7 (Greater Taman Negara) in Terengganu, which has encountered 12 species of small carnivores (Hedges *et al.*, 2013). However, in terms of the number of species detected during the study, the CFS1 PL1 has lower detection than the CFS1 PL7. Perhaps higher detection carnivores in CFS1 PL7 were due to more camera trap nights. The sambar deer, an important ungulate species, has not been detected in any sites. A study by Kawanishi *et al.* (2014) revealed that Sg. Yu-Ulu Jelai had not recorded sambar deer on camera traps. Also, no sambar deer tracks were detected during the intensive sign survey at this site. Due to the rarity of detection of this species in any camera trapping studies, it leads to the assumption that the current status of the species is now in an alarming stage. In addition, Kawanishi *et al.* (2014) stated that the CFS1 PL1 was a priority area for protection by the authority due to the high hunting pressure.

CFS1 SL2 is a secondary linkage proposed to link the Krau Wildlife Reserve (WR) to the Taman Negara landscape. Although the SL2 comprises about 77.24% of the forest, multiple land uses such as human settlement, agriculture, and roads occur (DTCP, 2009a). Wildlife movement between forest remnants is obstructed by the existing land use. Som Forest Reserve can be a stepping stone for wildlife to move in and out of the Krau WR, Yong FR or Taman Negara. Low wildlife detection in this study area is perhaps due to the poor ecological connectivity between habitats.

CFS2 SL1 is a secondary linkage connecting the Greater Taman Negara complex and the forest complexes south of the Pahang river (DTCP, 2009b), namely the Lepar FR - Berkelah FR Linkage. The ecological connectivity in this area is obstructed by developments such as roads, settlements, and agriculture. Wildlife recorded here during the study mainly the medium-size mammals, namely the wild pig and the macaque. However, the Malayan sun bear detection indicates that this area is also home to this important species. Lepar Forest Reserve (FR) was one of the Sumatran rhino habitats in the past. However, no signs of rhinos have been recorded since 2000 (Flynn & Mohd Tajuddin, 1984; Zainal-Zahari, 1995). The tiger in Lepar FR was reported to have density estimates from 0.51 – 0.53 per 100 km² in 1999 using camera traps (Lynam *et al.*, 2007). At least one image of a tiger was captured during the study. The other large mammal observed in this area previously was the Malayan gaur (Ebil, 1982).

Another study on avian species was carried out in Berkelah FR in 2013. The findings showed that 60 species representing 23 families were captured (Bing *et al.*, 2013). This study revealed that primary forests might harbour a higher understorey bird species diversity and richness than logged forests. In the same study area, Rajpar & Zakaria (2014) revealed that the logging and recovery process might affect avian distribution and diversity. Generally, Asian elephants and most animals prefer less disturbed areas for giving birth (Sumanta *et al.*, 2014). Therefore, regeneration and forest restoration are important to attract wildlife to populate the disturbed area after logging. Rajpar & Zakaria (2014) studied on the effects of logging activities on avian richness and diversity in the different aged post-harvested forests in Berkelah FR. They showed that the most diverse forest was from the 20 years post-harvested forest compared to two, 10 and 35 years post-harvested forest. Many plants matured, and some started to bear fruits and flowers in 20 years post-harvested forest (Zakaria & Rajpar, 2015).

CONCLUSION

The three CFS linkages selected for this study in Pahang differ in terms of species occurrence and diversity. Species occurrence is mostly determined and influenced by their surrounding habitat and land use. Creating linkages at best provides safe

ways for the medium and larger mammals to cross the expressways. Areas with less disturbance and larger spaces are more likely to be inhabited by wildlife. In the future study, it is recommended to expand the data collection effort by increasing the number of trap nights and locations for camera traps and increasing the size of the area covered for CFS 1 SL2 and CFS2 SL1. It is also suggested that the authority closely monitor each site to ensure the area is free from any illegal activities.

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