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CAMERA TRAPPING OF WILDLIFE IN THE NEWLY ESTABLISHED BALEH NATIONAL PARK, SARAWAK

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Abstract: The persistence of biodiversity in the Bornean rainforest depends on its ability to adapt to anthropogenic exploitation. The remaining forests in Sarawak are fragmented and isolated and their ability to support large sized mammals is of great concern. In view of this, camera trapping survey was conducted in the recently gazetted Baleh National Park to record the richness, activity pattern and distribution of medium-to-large sized mammals. A total of 15 infrared camera traps were set within the park. We identified at least 27 species of mammals, 12 birds and two reptiles. From the total mammalian species detected, four were listed as "totally protected" and 15 as "protected" under the Sarawak Wild Life Protection Ordinance 1998. Additionally, under the IUCN 2018 Red List criteria, one species was identified as "critically endangered" (*Manis javanica*), one as "endangered" (*Catopuma badia*), seven as "vulnerable" and four as "near threatened". This study had identified the occurrence and distribution of some rare, endangered and threatened species. The presence of these species can be used to identify core conservation sites within Baleh National Park.

Keywords: Birds, reptiles, mammals, *Manis javanica*, *Catopuma badia*.

Introduction

Species distribution and habitat needs are critical in planning wildlife conservation. The lack of information on the distribution of many Borneo species has impeded conservation efforts, especially for critical species. The terrestrial mammals of Borneo comprise some 288 species, which are dominated by 102 chiropteran and 61 rodent species (Payne *et al*., 1985; Phillipps & Phillipps, 2016). Medium- to large-sized terrestrial mammals are generally charismatic and they are often used to promote tourism. But many of them are also of conservation concern (Leu *et al*., 2011). Mammalian species respond differently to changes in their habitats and some may be very sensitive to environmental distress (Pires *et al*., 2012). Since they are an important component of terrestrial ecosystems, a decrease in their population through hunting, and/or loss of habitats may affect other species, including humans.

Many existing protected areas in Sarawak, including Baleh National Park, has had some history of logging and agriculture use, which leads to the growth of secondary forests and human settlements (Mohd-Azlan & Lawes, 2012). Gaveau *et al*. (2014) estimated that oil palm planting and logging were carried out on approximately 10 % (78,480 km^2) of the Borneo landmass in 2010. The density of logging roads in Borneo is high (the highest was reported in Sarawak at 0.89 km per km^2) compared to international standards. The primary logging road density in Central Africa is 16 times lesser than in Borneo (Laporte *et al*., 2007; Gaveau *et al*., 2014). Those roads have caused many protected areas in Sarawak to become fragmented and isolated. Yamada *et al*. (2014) had studied the impact of logging roads on dung beetles and small mammals in Temengor forest reserve in Perak, Malaysia. They observed that the construction of logging roads to a selective logging site in the forest would not only negatively affect the species' biodiversity, but also their ecological functions. (Laurance *et al*., 2009).

Degradation of dipterocarp forests will bring negative consequences to terrestrial ecosystems in Borneo as all mast-fruiting communities support nomadic vertebrates in their reproduction (Curran *et al*., 1999; Curran & Leighton, 2000). A study by Cusack *et al*. (2015) showed that Borneo terrestrial rodents responded negatively to the level of microhabitat disturbances in logged forests and black rats (*Rattus rattus*), which is an invasive species, would colonise the degraded sites. A similar scenario can be expected for large mammals. Therefore, although many studies suggested that logged forests are still valuable for biodiversity conservation to some extent (Wells *et al*., 2008; Berry *et al*. 2010; Edward *et al*., 2010), the secondary forests that arise in those areas can facilitate the spread of generalist species, including invasive ones such as black rats (Cusack *et al*., 2015; Yamada *et al*., 2014). In view of these complexities, it is important to understand the species diversity in protected areas.

Logged forests are also prone to wildfires (Cochrane *et al*., 1999; Nepstad *et al*., 1999; Laurence, 2001; Siegert *et al*., 2001), especially in countries with hot and dry climate. Poor forest management will increase canopy exposure, which, in turn, alters the microhabitats of many species by raising ground temperature and sunlight penetration. (Putz *et al*., 2008). Mammals with narrow ecological niches live above the ground or in the upper canopy levels, while tolerant mammals are usually herbivorous or omnivorous and live in the lower vegetative strata (Meijaard *et al*., 2006). Logging, which reduces forest canopy coverage, has been observed to alter species composition in forests (Berry *et al*., 2008). Therefore, before conservation can be carried out, it is important to understand the distribution and composition of endangered species, especially in protected areas with history of logging.

The Baleh National Park in Kapit, Sarawak, is a protected area in the Upper Baleh region that serves as an important tool for the conservation of biological diversity and, consequently, provide a foundation for sustainable development in a region dominated by the logging industry. Although hunting is prohibited in Baleh National Park, little is known about the diversity of medium and large mammals in this area. Despite the remote location of this area, the vast network of logging roads provides access for intrusion and excision. However, the extend of these threats to the biodiversity in Upper Baleh remains poorly understood. As a result, remote protected areas, such as Baleh National Park, may not be receiving enough support and resources, making their effective management a challenging task.

Therefore, the objective of this study is to document the rare, endangered and threatened medium to large mammal species of conservation importance with the aid of camera trapping. This study is expected to identify several cryptic species, especially those of conservation importance (Mohd-Azlan & Engkamat, 2013). The presences of flagship species are expected to facilitate the protection of their core habitat and expedite the formulation of a management plan for Baleh National Park.

Materials and Methods

Study site

The study was carried out at the Baleh National Park in Baleh, Kapit Division, Sarawak, which was accessible by land and river. The Baleh National Park is a mix dipterocarp forest gazetted on 21st September 2017 (Gazette No.4079) with a land size of approximately 66,721 hectares that spanned from the district to the Malaysian-Indonesian border with Kalimantan. The topography consisted of plateaus and mountain chains up to 1000 m above sea level (Muol & Noweg, 2018). Most of the riverine forest is in pristine condition, although there were traces of logging. Logging was still conducted when this study was carried out. The areas under logging concessions were divided into coupes and re-entries were made after rotations between the coupes. This had resulted in the formation of many pockets of secondary forests intersected with logging roads.

Vegetation survey in Mujong River area (Tanaka *et al*., 2007) identified a flora population of hardwood trees (*Eusideroxylon zwageri* and *Eusideroxylon melangangai*), common ferns (*Dicranopteris* sp.), nutrushes (*Scleria purpurascens*), fig trees (*Ficus* sp.) and blumes (*Fragraea crassipes*). The land near human settlements (longhouses) were mostly secondary forests and agricultural land (temuda), which had been planted with rubber trees, rice, vegetables and fruits (e.g., *Ananas cosmosus, Durio* spp., *Canarium odontophyllum*, *Theobroma cacao, Manihot esculenta* and *Sauropus androgynus*) (pers. obs.). The Baleh river was clearer upstream but could become murky when it rained. The population was mostly Iban, but there was a significant Kenyah community living near the border with Kalimantan. The local communities hunted wildlife for food.

Data collection

The data was collected in approximately 24 % of the total park area (160.24 km^2). Sampling sites were divided into three (different logging concession areas) to cover a larger area as shown in Figure 1. Sampling was conducted at 15 camera stations set up in an average distance of 1 km from each other. Each camera was positioned adjacent to game trails, pathways, natural salt licks and at random locations with no habitat preferences to increase the detection of different terrestrial mammal species according to Bernard *et al*. (2013). The study areas were accessed by four-wheel-drive vehicles and on foot through logging roads and old skid trails and by boat along rivers.

Reconyx™ and Bushnell® camera traps, which were modified with sealant and silica gel to make them humid-resistant under local conditions, were set up to operate 24 hours for five months. Cameras were placed on tree trunks approximately 30 cm above the ground. The interval between each trigger was set to minimum of one minute, which reduced multiple captures of the same individual per trigger. Time and date were automatically recorded on each photograph with animals. All camera settings were adjusted according to Mohd-Azlan *et al*., (2018) and Navennec *et al*. (2016). The location of all cameras was recorded using the Global Positioning System (Garmin GPSMAP® 64s)

The information about the survey, site and deployment were recorded and maintained where it was important to ensure that all data were downloaded into correct folders on the computer. The files were renamed with an appropriate format of coding, including location,

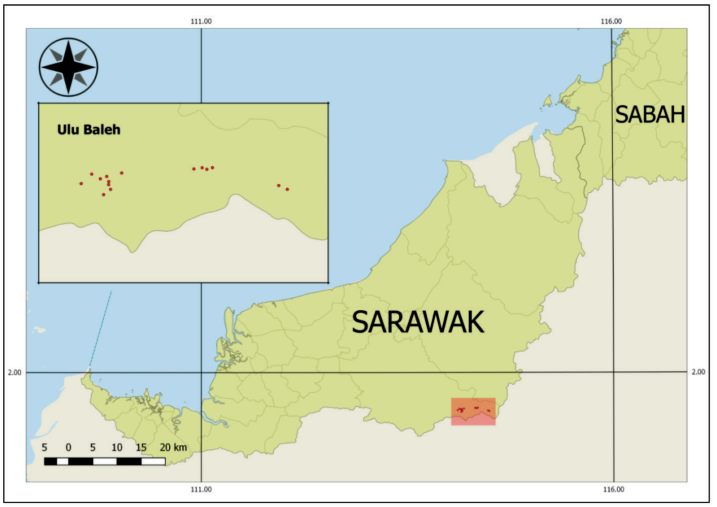


Figure 1: The camera trapping sites (indicated by red dotes) in Baleh National Park was set up at different logging sites

site and photograph number. The photos were then logged into a spread sheet for further analysis.

Camera trap data were separated according to their study areas. The identified animals were sorted according to species, where data organization, storage, analysis of camera trap pictures was based on Sanderson and Harris (2013) using the ReNamer software. After all the photos were relabelled and stored according to their location, species and number of individuals, Data organize was then run to obtain the raw data for further data analysis (Sanderson & Harris, 2013).

Unidentified animals due to poor angle or overexposure were placed under a general category, such as family or genera. Some species present at a study site might not be detected by the camera traps, which would result in false absences in the collected data. Hence the naïve estimate of occupancy was defined as the number of camera trap sites occupied by an animal species divided by the number of sites surveyed (Rovero *et al*., 2014). However, the naïve estimate of occupancy could underestimate the true occupancy (Mackenzie *et al*., 2002; Mackenzie & Bailey, 2004).

Identified animal images were sorted based on independent photographic events, which was a photograph of an animal species captured between one-hour intervals per camera location. The percentage of images taken at different time categories were correlated to activity levels of the species, where nocturnal was classified between 1800 and 0600 hours, while diurnal was between 0601 and 1759 hours (Mohd-Azlan & Engkamat, 2006; 2013). Activity pattern was tabulated only for species with independent images of more than 10. The visualization of species activity data was done using the functions in package *camtrap R* (Niedballa *et al*., 2017) in R (R Development Core Team, 2016). The estimator for the coefficient of overlap was used because it is recommended for small sample sizes, with higher value indicates more overlapping in activities between species (Ridout & Linkie, 2009).

Results and Discussion

This study was carried out for more than 1,678 camera trap nights (total of all active camera days) for five months (November 2015 to March 2016). A total of 9,448 photographs were taken, including 28 exposed while setting up and retrieving the cameras. Approximately 44 % of the photos were blanks (n = 4,162) due to false trigger, while there were only 3,932 photos of identifiable animals. The independent animal records accumulated to 1063 images (Table 1). Camera trap stations were active for an average of 111.9 days (87 days minimum to 116 days maximum).

A total of 27 mammal and 12 bird species were recorded. Mammal species richness filtered similarly (excluding small mammals, birds and reptiles) in this study was higher, if not comparable, to other protected areas in Sarawak (13 species at Lambir Hills National Park, Mohd-Azlan & Lading, 2006; 27 species at Lanjak Entimau Wildlife Sanctuary, Mohd-Azlan & lading, 2013; and, 20 species at Tanjung Datu National Park, Mohd-Azlan *et al*., 2018). The most common mammal family were muridae (rats and mice), followed by porcupines (*Hystrix brachyura*) and Bornean bearded pigs (*Sus barbatus*). *S. barbatus* was recorded at 13 sites and *H. brachyura* at eight sites out of 15 camera stations. Additionally, the cameras also recorded hunters armed with guns and hunting dogs.

From the mammalian species detected (Table 2), four were listed as "totally protected" and 15 as "protected" under the Sarawak Wild Life Protection Ordinance 1998. Whereas, according to the International Union for Conservation of Nature 2018 (IUCN 2018) Red List, one species each was listed as "critically endangered" and "endangered". Seven species were classified as "vulnerable" while four others as "near threatened". There were also two species listed in Appendix I and seven in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which regulated their trade internationally.

Table 1: Species recorded in camera traps from November 2015 until March 2016 at Baleh National Park

Taxa	Common name	No. of locations occupied (n=15)	Naïve occupancy	No. independent records
Order: Scandentia				
Tupaiidae	Treeshrew	6	0.4	105
Order: Primates				
Macaca nemestrina	Pig-tailed macaque	10	0.667	39
Macaca fascicularis	Long-tailed macaque	3	0.2	4
Homo sapiens	Human	2	0.133	4
Prebytis rubicunda	Red langur	1	0.067	1
Order: Rodentia				
Hystrix brachyura	Common porcupine	8	0.533	101
Muridae	Rats and mice	6	0.4	280
Sciuridae	Squirrel	5	0.333	27
Hystrix crassispinis	Thick-spined porcupine	5	0.333	79
Trichys fasciculata	Long-tailed porcupine	5	0.333	56
Rheithrosciurus macrotis	Tufted ground squirrel	4	0.267	10
Order: Carnivora				
Helarctos malayanus	Sun bear	10	0.667	17
Viverra tangalunga	Malay civet	4	0.267	12
Hemigalus derbyanus	Banded palm civet	3	0.2	29
Canis familaris	Domestic dog	2	0.133	2
Martes flavigula	Yellow-throated marten	2	0.133	3
Herpestes brachyurus	Short-tailed mongoose	2	0.133	4
Prionailurus bengalensis	Leopard cat	1	0.067	1
Diplogale hosei	Hose's civet	1	0.067	9
Catopuma badia	Bay cat	1	0.067	1
Arctictis binturong	Binturong	1	0.067	1
Manis javanica	Pangolin	1	0.067	6
Mustela nudipes	Malay weasel	1	0.067	1
Pardofelis marmorata	Marbled cat	1	0.067	2
Arctogalidia trivirgata	Small-toothed palm civet	1	0.067	1
Paguma larvata	Masked palm civet	1	0.067	1
Order: Artiodactyla				
Sus barbatus	Bearded pig	13	0.867	111
Rusa unicolor	Sambar deer	7	0.467	25
Muntiacus muntjak	Common barking deer	5	0.333	18
Tragulus napu	Greater mousedeer	4	0.267	13
Muntiacus atherodes	Bornean yellow muntjac	4	0.267	22

Birds				
Argusianus argus	Great argus	4	0.267	6
Trichastoma malaccense	Short-tailed babbler	3	0.2	5
Pellorneum capistratum	Black-capped babbler	3	0.2	5
Chalcophaps indica	Emerald dove	3	0.2	4
Rollulus rouloul	Rollulus rouloul	2	0.133	3
Copsychus malabaricus	White-rumped shama	2	0.133	2
Lophura ignita	Bornean crested fireback	2	0.133	3
Pomatorhinus mantanus	Chestnut-backed Scimitar-babbler	1	0.067	1
Lophura bulweri	Bulwer's pheasant	1	0.067	1
Trichixos pyrropygus	Rufous-tailed shama	1	0.067	1
Pitta baudii	Blue-headed pitta	1	0.067	1
Pitta granatina	Garnet pitta	1	0.067	3
Herpetofauna				
Scincidae	Skink	5	0.333	32
Varanus sp	Monitor lizard	2	0.133	2
Anura	Frog	1	0.067	9
TOTAL				**1063**
Minimum number of species				**46**
CTNs				**1678**
Number of photo records / CTNs				**0.634**

Table 2: Status of identified mammalian species photographed according to IUCN (2016), SWLPO (1998) and CITES

Common name	Scientific name	IUCN	SWLPO	CITES
Pangolin				
Pangolin	*Manis javanica*	CR	P	II
Langurs				
Red leaf langur/ red langur	*Presbytis rubicunda*	LC	TP	II
Macaques				
Long-tailed/ Crab-eating macaque	*Macaca fascicularis*	LC	P	II
Pig-tailed macaque	*Macaca nemestrina*	VU	P	II
Tufted Ground Squirrel				
Tufted ground squirrel	*Rheithrosciurus macrotis*	VU	TP	NL
Porcupines				
Common porcupine	*Hystrix brachyura*	LC	P	NL

Long-tailed porcupine	*Trichys fasciculata*	LC	P	NL
Thick-spined porcupine	*Hystrix crassispinis*	LC	P	NL
Sun bear				
Sun bear	*Helarctos malayanus*	VU	P	I
Mustelids				
Yellow-throated marten	*Martes flavigula*	LC	NL	III (India)
Malay weasel	*Mustela nudipes*	LC	NL	NL
Civets				
Malay civet/ Tangalung	*Viverra tangalunga*	LC	P	NL
Binturong/ Bearcat	*Arctictis binturong*	VU	P	III (India)
Small-toothed palm civet	*Arctogalidia trivirgata*	LC	P	NL
Masked palm civet	*Paguma larvata*	LC	P	III (India)
Hose's civet	*Diplogale hosei*	VU	P	NL
Banded palm civet	*Hemigalus derbyanus*	NT	P	II
Mongooses				
Short-tailed mongoose	*Herpestes brachyurus*	NT	P	NL
Wild cats				
Marbled cat	*Pardofelis marmorata*	NT	TP	I
Leopard cat	*Prionailurus bengalensis*	LC	P	II
Bay cat	*Catopuma badia*	EN	TP	II
Bearded pig				
Bornean bearded pig	*Sus barbatus*	VU	NL	NL
Mouse deer				
Greater mousedeer	*Tragulus napu*	LC	NL	NL
Muntjac (Barking deer)				
Bornean red muntjac/ Common barking deer	*Muntiacus muntjak*	LC	NL	NL
Bornean yellow muntjac	*Muntiacus atherodes*	NT	NL	NL
Sambar deer and Tembadau (Banteng)				
Sambar deer	*Rusa unicolor*	VU	NL	NL

The species accumulation curve (Figure 2) did not reach an asymptote as it showed additional species were recorded with additional survey days. This suggested that 118 days of camera trapping in Baleh National Park might not be adequate to achieve sampling saturation based on a sampling completeness ratio of 0.78 (observed/expected no. species).

Sun bear and Bornean bearded pig showed no clear activity patterns, suggesting that they were of arrhythmic pattern (Figure 3). As for both muntjacs species and pig-tailed macaque, they were predominantly diurnal with their activity patterns peaking during the day. Whereas for the civets, porcupines and Sambar deer, they were nocturnal as their activities slowed down at dawn and peaked at dusk. The bearded pig and Sambar deer showed the least overlapping of activities, with of only 0.6.

Results of this study showed that Baleh National Park appeared to support a variety of medium to large mammals, including species

of conservation importance, such as Hose's civet and the Bornean bay cat. This study added a new locality record for these rare species. The presence of medium and large mammals, such as the critically endangered pangolin and endangered Bay cat in logged areas of the forest suggested that these species could tolerate some level of disruption in their habitats. However, carnivores were the most affected taxonomic group by the impact of selective logging in Borneo, followed by the both species of muntjacs (Brodie *et al*., 2014).

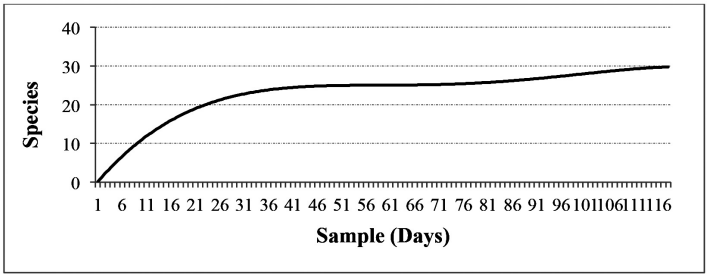
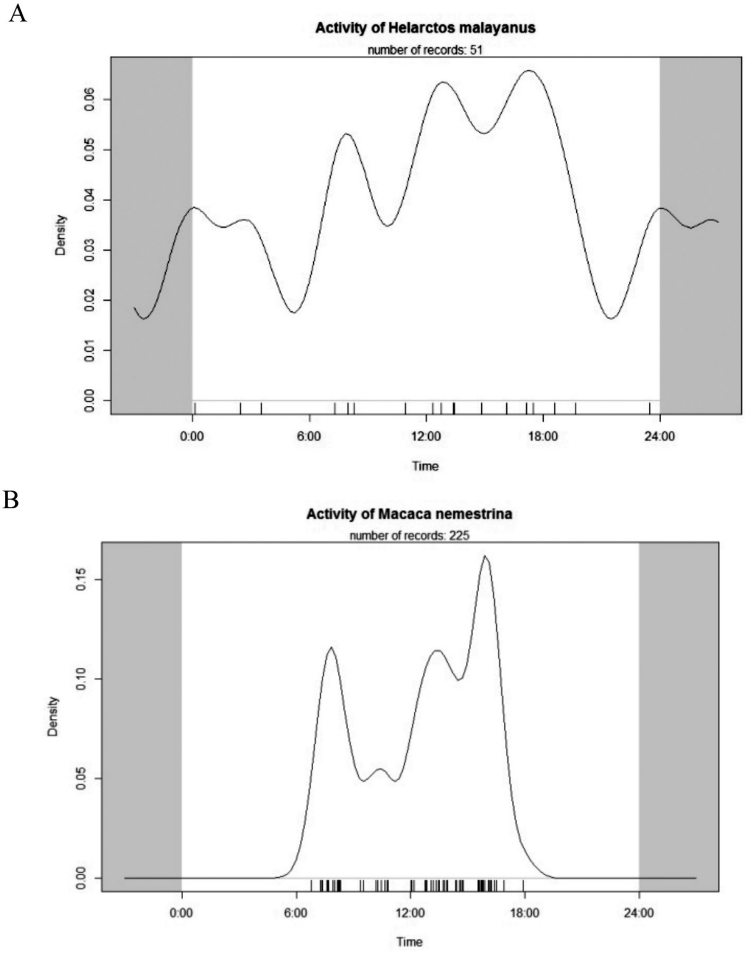


Figure 2: Species accumulation curve of mammals showing gradual increase towards the end, suggesting only few species could be detected if sampling was continued



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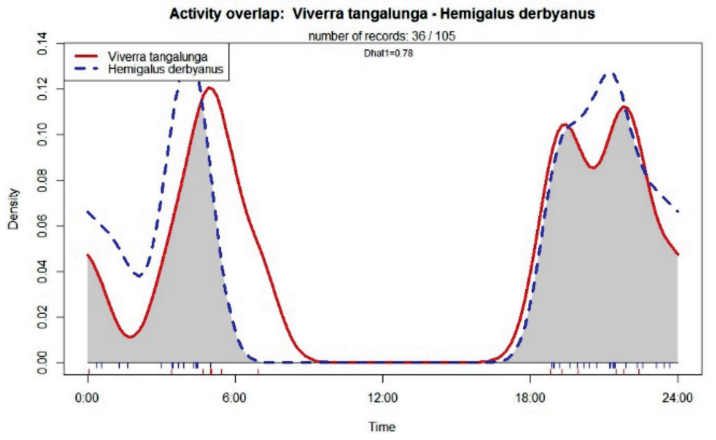
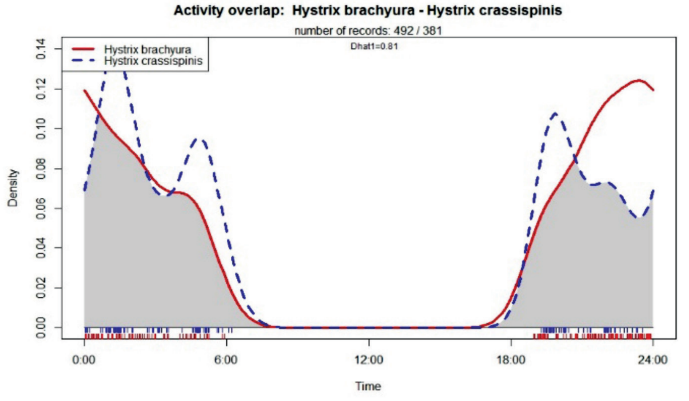
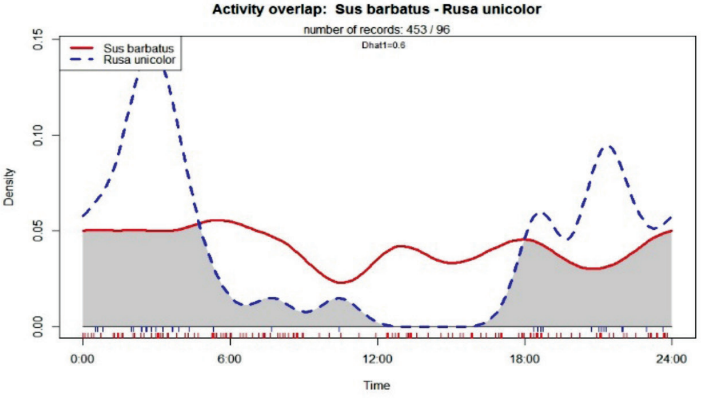

Activity overlap: Viverra tangalunga - Hemigalus derbyanus
number of records: 36 / 105
Dhat1=0.78
Viverra tangalunga
Hemigalus derbyanus
Density
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0:00
6:00
12:00
18:00
24:00
Time

D


Activity overlap: Hystrix brachyura - Hystrix crassispinis
number of records: 492 / 381
Dhat1=0.81
Hystrix brachyura
Hystrix crassispinis
Density
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0:00
6:00
12:00
18:00
24:00
Time

E


Activity overlap: Sus barbatus - Rusa unicolor
number of records: 453 / 96
Dhat1=0.6
Sus barbatus
Rusa unicolor
Density
0.00
0.05
0.10
0.15
0:00
6:00
12:00
18:00
24:00
Time

F

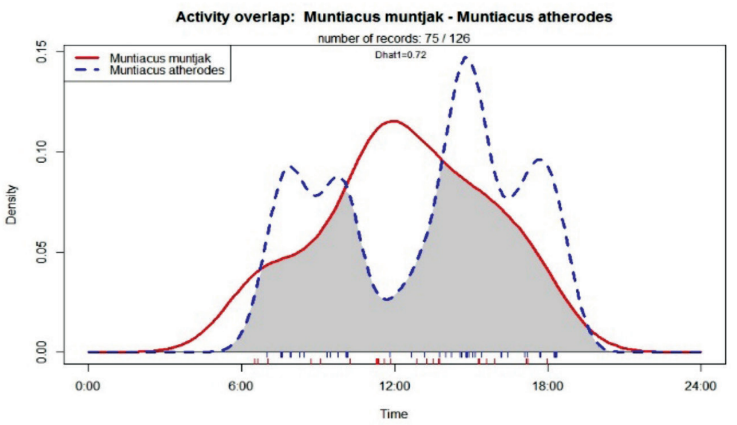


Figure 3: The activity patterns of medium and large mammalian species based on camera trapping data at Baleh National Park in five sampling months. Activity patterns were tabulated for (**A**) Sun bear, (**B**) Pig-tailed macaque, (**C**) Malay and banded palm civets, (**D**) Common and thick-spined porcupines, (**E**) Large ungulates: Bearded pig and Sambar deer and (**F**) Muntjacs: Common barking deer and Yellow Bornean muntjac

Meijaard *et al*. (1999) estimated that the sun bear had lost 30 % to 60 % of its habitat in Borneo because of logging and agricultural land conversion between 1960 and 1990. Therefore, the presence of that bear in this study showed that the national park could serve as a suitable habitat despite the commencement of logging since October 2000. The occurrences of sun bears in this forest suggested that the current habitat contained resources to help them survive. But their long-term survival due to poaching and other environmental disruptions needed to be studied further.

More studies were required to identify wildlife corridors between Baleh National Park and Betung Kerihun National Park in Kalimantan, Indonesia. These links connected all the rainsforests in the Bornean landmass to one large ecological system. They allowed animals to roam and promoted a large connected meta-population dynamic for good dispersers, hence reducing the risk of metapopulation extinction and, thereby, enhancing meta-community stability (Brodie *et al*., 2016). The corridors and its alignment should also be identified to reduce the impact of the Baleh dam construction. The loss of animal habitats due to lowland flooding could be mitigated with a proper wildlife management plan.

Baleh National Park could benefit from more surveys that took seasonality into consideration. The number of cameras and trapping effort need to be expanded wider to cover more areas in the national park. This could provide comprehensive information as more medium to large mammals could be detected. Even though this rainforest had been gazetted as a national park under the Heart of Borneo initiative, logging was still selectively carried out in many other areas that have yet to be protected. These logging operations needed to be managed sustainably to reduce the impact on animal habitats under the Forest Management Unit (FMU). Those operations needed to be managed sustainably to reduce the impact on animal habitats under the Forest Management Unit (FMU).

Areas where activities of endangered and vulnerable species like Hose's civets and Bornean bay cats were detected should be left alone and treated as core conservation sites for the protection of those species. Hunting was observed during the study and, therefore, the authorities should be made aware so it could be controlled. Figure 4 shows some of the animals captured by camera traps in the course of this study.

Figure 4: Some of the interesting photographs of endangered species captured by the camera traps. Top left: *Catopuma badia* (EN, TP), top right: *Diplogale hosei* (VU, P), bottom left: *Helarctos malayanus* (VU, P), bottom right: *Presbytis rubicunda* (LC, TP)

Conclusion

This study had documented rare and conservational-important species in unsurvey areas of Baleh National Park, providing baseline data to gauge community assemblage and population dynamics. The presence of evasive species also warranted further examination of the rainforest to understand their ecological needs and facilitate conservation efforts. Therefore, periodic monitoring of these species in Baleh National Park was needed to assess survival threats and prevent localized extinction. This could be achieved through collaborations with conservation organisations, government agencies and law enforcement authorities. This will not only benefit the survival of medium to large mammals but would also be critical in supporting biodiversity in Borneo Island.

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