

Diversity and Habitat Use of Terrestrial Mammals in the Area Proposed for Water Resource Development in Khao Soi Dao Wildlife Sanctuary, Thailand

Intanon Kolasartsanee*

Ecoliteracy and Conservation in Action Group, Department of Biology, Faculty of Science, Mahidol University, Bangkok, Thailand

ARTICLE INFO

Received: 19 Oct 2020
Received in revised: 11 Jan 2021
Accepted: 21 Jan 2021
Published online: 22 Feb 2021
DOI: 10.32526/ennrj/19/2020222

Keywords:

Camera trap/ Habitat destruction/
Cardamom Mountains rain forests/
Mae Nam Chanthaburi sub-basin/
Ta-riu/ Khlong Ta Liu Dam

* Corresponding author:

E-mail: intanon.kol@mahidol.ac.th

ABSTRACT

The Khlong Ta Liu dam construction plan was re-proposed to be constructed in the forest area of Khao Soi Dao Wildlife Sanctuary in the Ta-riu tributary without a biodiversity impact assessment. Five camera traps were mounted at the hotspot points for terrestrial mammals next to the main trail for 376 trap nights from the forest edge to the forest interior. Fifteen species of terrestrial mammals were found. Two species found were categorized as having endangered status, while seven have vulnerable status. Grazers and browsers, i.e., Sambar, Gaur, Northern Red Muntjac, and Asian Elephant were mostly detected at the forest edge, while omnivores and frugivores, i.e., Wild Boar, Greater Hog Badger, and Northern Pig-tailed Macaque were largely detected in the forest interior. Dhole should be a carnivore species specific to the forest edge while Clouded Leopard should be in the forest interior. The Normalized Difference Vegetation Index (NDVI) may relate to species of terrestrial mammals detected at each habitat. Among the five habitats, three would be destroyed upon construction of the dam, including the habitat with the highest diversity of terrestrial mammals. The habitat that would likely be least impacted had the lowest species richness of terrestrial mammals.

1. INTRODUCTION

Khao Soi Dao Wildlife Sanctuary (745 km²) is a part of the Cardamom Mountains rain forests ecoregion. It is the headwater of four sub-basins in eastern Thailand, with some water also flowing to Tonlé Sap Lake in Cambodia. Based on 2019 Thai population data from the Department of Provincial Administration, these four sub-basins provide water for at least 349,925 Thai people. Although an ecosystem service of Khao Soi Dao Wildlife Sanctuary is water provision, the wildlife sanctuary has been continuously encroached. By analyzing LANDSAT 8 satellite image from the U.S. Geological Survey using QGIS 3.10 program, the forest area covered was 581 km² in 2019 or 78% of the wildlife sanctuary area. The largest part of the forest area (246 km²) is the headwater of Mae Nam Chanthaburi sub-basin which provides water for at least 129,392 people in Chanthaburi city and another two districts. Within this largest part of the forest area, the Ta-riu tributary (74 km²) is the largest headwater

and is comprised of the North and South Ta-riu sub-tributaries (30 km² and 44 km², respectively). In 1989, construction of the Khlong Ta Liu Dam was recommended in the Ta-riu tributary for irrigation (JICA, 1989). It should be noted that the Royal Irrigation Department uses the name “Ta Liu” while the Department of National Parks, Wildlife and Plant Conservation and the Royal Survey Department use the name “Ta-riu”, but both names refer to the same area. The proposed Khlong Ta Liu Reservoir has a capacity of 30 million m³. By using QGIS 3.10 program to simulate the reservoir area from this capacity, at least 1.6 km² of the Ta-riu tributary would be inundated, including 1.2 km² in the North and 0.4 km² in South Ta-riu sub-tributaries (Figure 1). Although the dam proposal was rejected when it was originally proposed, it was later re-proposed by the Royal Irrigation Department in 2017 for flood regulation purpose (Kateworachai, 2017). This re-proposal was again rejected by the Department of National Parks, Wildlife

Citation: Kolasartsanee I. Diversity and habitat use of terrestrial mammals in the area proposed for water resource development in Khao Soi Dao Wildlife Sanctuary, Thailand. Environ. Nat. Resour. J. 2021;19(3):186-194. (<https://doi.org/10.32526/ennrj/19/2020222>)

and Plant Conservation. Although the Khlong Ta Liu reservoir can enhance control of water in the Mae Nam Chanthaburi sub-basin, the potential negative impact on biodiversity has never been assessed.

Biodiversity is the core of ecosystem services, i.e., provisioning, regulating, supporting and cultural. While the reservoir can enhance control of water provision and flood regulation services, other ecosystem services of this area would be lost if the biodiversity were to be destroyed by the dam construction. Terrestrial mammals are an important part of the biodiversity and help to support the ecosystem. Moreover, certain species are the keystone species in food webs. Negative impacts on the diversity of terrestrial mammals can in turn affect its supporting service which can consequently affect other ecosystem services. Camera traps are an effective tool for surveying mammals. Data on species identification, habitat use, time of usage, behavior, and the number of individuals can be collected. Using camera traps, surveys on diversity and the habitat use of terrestrial mammal can effectively illustrate the potential negative impacts on biodiversity if the dam is constructed.

2. METHODOLOGY

2.1 Camera trap survey

The North Ta-riu sub-tributary was selected as the study site for two reasons. First, most of the inundated area will be in this sub-tributary. Second, there were high levels of cooperation between the local Non-Timber Forest Products (NTFPs) collectors and the author during a community-based conservation project to conserve an endangered Pileated Gibbon (*Hylobates pileatus*) that was conducted between 2009 and 2012 (Kolasartsanee and Srikosamatara, 2014). With their participation, the survey was designed according to their local

experiences and the camera traps were unlikely to be destroyed or damaged by them. Five passive infrared-triggered camera traps, Bushnell 119837C (Bushnell Outdoor Products, Kansas, USA), were mounted at the hotspots of terrestrial mammals, i.e., salt lick and passageway, next to the main trail of the North Ta-riu sub-tributary from the forest edge to the forest interior (Figure 1). Locations of terrestrial mammals' hotspots were selected based on the experience of the late Mr. Wang Chomdee, the senior NTFPs collector who used to collect NTFPs in this sub-tributary for over thirty years and who was a key person during the community-based conservation project. At each camera trap station, a camera trap was mounted on a tree with a metal sling. The camera traps were pointed in directions perpendicular to the expected directions of mammals. For wide field of views, camera traps were mounted approximately 5 m from where the terrestrial mammals were expected to be. The installation and maintenance of the camera traps was conducted by the author with support from the Ta-riu wild elephant guarding team which is the self-established local conservation team extended from the community-based conservation project for Pileated Gibbons. All inter-trap distances were over 1 km (Table 1). This is the minimum recommended distance when the target organism's home range size is unknown (Wearn and Glover-Kapfer, 2017). Camera traps were set to take three still pictures after detection of terrestrial mammals, with a one second recovery rate. Camera traps were 24-h operated from 26 October 2018 to 5 November 2019 (376 trap nights). The wet season started in May, resulting in 187 trap nights during the dry season and 189 trap nights during the wet season. Some camera traps electronically malfunctioned which reduced the number of trap nights.

Table 1. Trap night of each camera trap's location in each season, type of camera trap station and distance from the forest edge

Camera trap's location	1	2	3	4	5
Trap night in dry season	187	156	142	186	186
Trap night in wet season	189	Aborted	135	188	188
Total trap night	376	156	277	374	374
Type of camera trap station	SL	PW	PW	SL	SL
Distance from the forest edge (m)	0	2058	3475	5180	6280

SL=salt lick and PW=passageway

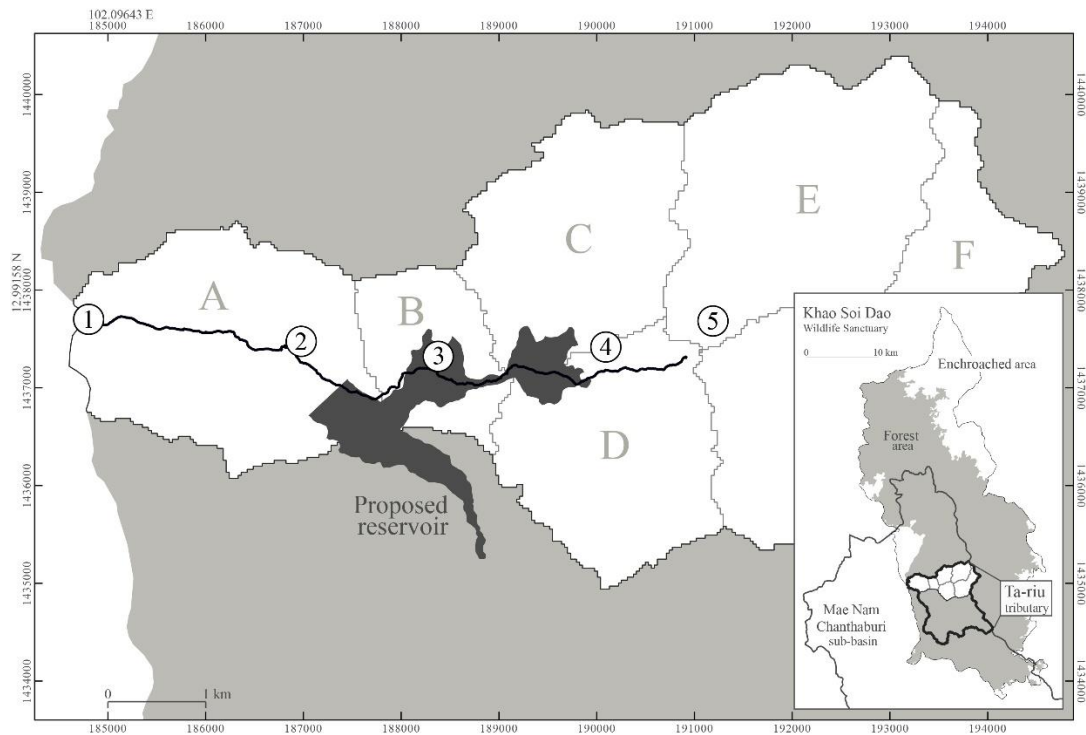


Figure 1. The North Ta-riu sub-tributary which is composed of six watersheds (watershed A to F). Numbers in white circles showed the locations of camera trap stations. Black line showed the main trail of North Ta-riu sub-tributary. The proposed reservoir showed in dark grey area (Adapted from JICA, 1989). (Projection: UTM; Datum: WGS84; Zone: 48P)

2.2 Data analysis

The time interval between independent detection was set as 30 min (Kitamura et al., 2010). The Relative Abundance Index (RAI) which is the number of detections per 100 trap nights sampling were calculated for each species at each camera trap for each season, as in the following equation.

$$\text{Relative Abundance Index (RAI)} = \frac{\text{Number of detection}}{\text{Total trap night}} \times 100$$

The RAI of each species from five camera traps were used to analyze the distribution of each species using the index of dispersion test, i.e., goodness-of-fit of the Poisson distribution (Krebs, 1999) as in the following equations.

$$\text{Index of dispersion (I)} = \frac{\text{Variance of RAI}}{\text{Mean of RAI}}$$

$$\text{Then; } \chi^2 = I(\text{Number of camera traps} - 1)$$

If χ^2 is higher than $\chi^2_{0.025}$, the distribution will significantly resemble a clumped pattern. If χ^2 is lower than $\chi^2_{0.975}$, the distribution will significantly resemble a uniform pattern. If χ^2 is between $\chi^2_{0.975}$ and $\chi^2_{0.025}$, the distribution will significantly resemble a random pattern.

The RAI of each terrestrial mammal at each camera station in each season was used to plot the Lognormal rank abundance graph to illustrate the diversity of terrestrial mammals between each camera trap station.

Elevation, terrain slope, distance from forest edge, annual mean of Normalized Difference Vegetation Index (NDVI) and standard deviation of NDVI between months were the habitat characteristics around the camera trap stations that were used to analyze their relationships with the RAI of each terrestrial mammal species. The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (U.S. Geological Survey) was used to extract elevation and terrain slope was calculated using the slope tool in QGIS 3.10 program. LANDSAT 8 satellite images (U.S. Geological Survey) in November 2018, January 2019, March 2019, and November 2019 were used to extract the NDVI. Satellite images from the other months during the survey period were full of clouds and so could not be used for analysis. The satellite images were atmospherically corrected by the dark Object Subtraction 1 (DOS1) method using the semi-automatic classification plugin in QGIS 3.10 program. The atmospheric corrected images were calculated for NDVI using the raster calculation tool in QGIS 3.10

program. A 500 m radius area surrounding each camera trap station was made using the buffer tool in QGIS 3.10 program to indicate the habitat area surrounding each camera trap station. The mean elevation, slope, and NDVI of these areas were extracted using the zonal statistic tool in QGIS 3.10 program. Correlations between characteristics of habitat and RAI of each terrestrial mammal species were analyzed by the Pearson correlation test using R 4.0.3 program.

3. RESULTS AND DISCUSSION

None of camera traps were destroyed or damaged by local people. Fifteen species of terrestrial mammals were found in this study. Two species have endangered status and seven have vulnerable status (Table 2; IUCN (2020)). Sambar was only found at camera 1 while Leopard Cat, Crab-eating Mongoose

and Clouded Leopard were only found at camera 4 (Table 3). The distribution of Wild Boar was significantly clumped to the forest interior in both seasons. The distribution of Sambar was significantly clumped to the forest edge in both seasons. At least four male Sambars were found, three of which were adults, and one was a sub-adult with one-point antlers. The distribution of Gaur was significantly clumped to the forest edge during the dry season. Two adult males, one adult female, one sub-adult male, and two sub-adult females were found. Two adult males were mostly found at camera 1 while the females were found only at camera 3. The distribution of Northern Red Muntjac was significantly clumped to the forest edge during the wet season. The distribution of Greater Hog Badger was significantly clumped to the forest edge during the dry season.

Table 2. Common name, scientific name, IUCN status (IUCN, 2020) and total Relative Abundance Index (RAI) of terrestrial mammals found in this study.

Common name	Scientific name (IUCN status)	Total RAI
Wild Boar	<i>Sus scrofa</i> (LC)	6.17
Sambar	<i>Rusa unicolor</i> (VU)	5.65
Northern Pig-tailed Macaque	<i>Macaca leonina</i> (VU)	4.62
Gaur	<i>Bos gaurus</i> (VU)	3.92
Northern Red Muntjac	<i>Muntiacus vaginalis</i> (LC)	3.60
Greater Hog Badger	<i>Arctonyx collaris</i> (VU)	3.08
Malayan Porcupine	<i>Hystrix brachyura</i> (LC)	1.16
Asian Elephant	<i>Elephas maximus</i> (EN)	1.16
Asiatic Black Bear	<i>Ursus thibetanus</i> (VU)	0.45
Common Palm Civet	<i>Paradoxurus hermaphroditus</i> (LC)	0.45
Leopard Cat	<i>Prionailurus bengalensis</i> (LC)	0.32
Sun Bear	<i>Helarctos malayanus</i> (VU)	0.13
Dhole	<i>Cuon alpinus</i> (EN)	0.13
Crab-eating Mongoose	<i>Herpestes urva</i> (LC)	0.06
Clouded Leopard	<i>Neofelis nebulosa</i> (VU)	0.06

Table 3. The Relative Abundance Index (RAI) at each camera trap in each season.

Common name	Season	RAI at each camera					Distribution
		1	2	3	4	5	
Wild Boar	Dry		1.28	4.93	9.68	13.98	I
	Wet		-	2.96	3.72	17.02	I
Sambar	Dry	17.65					E
	Wet	29.10	-				E
Northern Pig-tailed Macaque	Dry	2.14	1.28	8.45	3.76	6.45	
	Wet	6.35	-	8.15	3.72	2.66	

Table 3. The Relative Abundance Index (RAI) at each camera trap in each season (cont.).

Common name	Season	RAI at each camera					Distribution
		1	2	3	4	5	
Gaur	Wet	6.35	-	8.15	3.72	2.66	E
	Dry	26.20		2.11			
	Wet	2.65	-	1.48	1.06		
Northern Red Muntjac	Dry	2.67	1.92	2.82	0.54	2.69	E
	Wet	18.52	-	1.48		0.53	
Greater Hog Badger	Dry		0.64	2.82	1.61	3.23	E
	Wet	2.65	-	9.63	4.26	4.26	
Malayan Porcupine	Dry	0.53	5.77		1.61		
	Wet	0.53	-	2.96			
Asian Elephant	Dry	4.28	1.28	0.70			
	Wet	3.17	-	0.74			
Asiatic Black Bear	Dry	0.53	1.28	0.70		1.08	
	Wet		-		0.53		
Common Palm Civet	Dry		0.64	2.11	0.54		
	Wet		-		1.06		
Leopard Cat	Dry				1.08		
	Wet		-		1.60		
Sun Bear	Dry			0.70		0.54	
	Wet		-				
Dhole	Dry	0.53					
	Wet		-	0.74			
Crab-eating Mongoose	Dry				0.54		
	Wet		-				
Clouded Leopard	Dry						
	Wet		-		0.53		

RAI: Blank=0; - =not surveyed

Distribution: I=significantly clumped at forest interior; E=significantly clumped at forest edge; Blank=significantly random distribution

The lognormal rank abundance plot of terrestrial mammals that used each habitat in each season is shown in [Figure 2](#). In both seasons, the habitat with the highest species richness and most evenly distributed \log_{10} RAI, i.e., the log normal distribution, was the habitat around camera 3, so it can be inferred that this habitat was used by highest diversity of terrestrial mammals in both seasons. Habitats located further from camera 3 at both the forest edge and interior directions tended to have lower species richness and lesser evenly distributed \log_{10} RAI, i.e., the dominance preemption model, so it can be inferred that these habitats were used by a lower diversity of terrestrial mammals.

Characters of habitat around each camera trap station are shown in [Table 4](#). There were some significant correlations among habitat characteristics. Distance from forest edge was significantly correlated

with SD of NDVI between months and mean elevation. Habitats in the forest interior had significantly lower SD of NDVI between months (Pearson correlation coefficient=-0.94; p-value=0.02) and significantly higher mean elevation (Pearson correlation coefficient=0.97; p-value=0.01) than habitats at the forest edge. Mean elevation and SD of NDVI between months were also significantly correlated with each other (Pearson correlation coefficient=-0.93; p-value=0.02). The RAI of Asian Elephant in both seasons and Gaur in the wet season were significantly higher in habitats at the forest edge, low elevation and high SD of NDVI between months, than habitats in the forest interior. The RAI of Wild Boar in the dry season was significantly lower in habitats at the forest edge than habitats in the forest interior ([Table 5](#)).

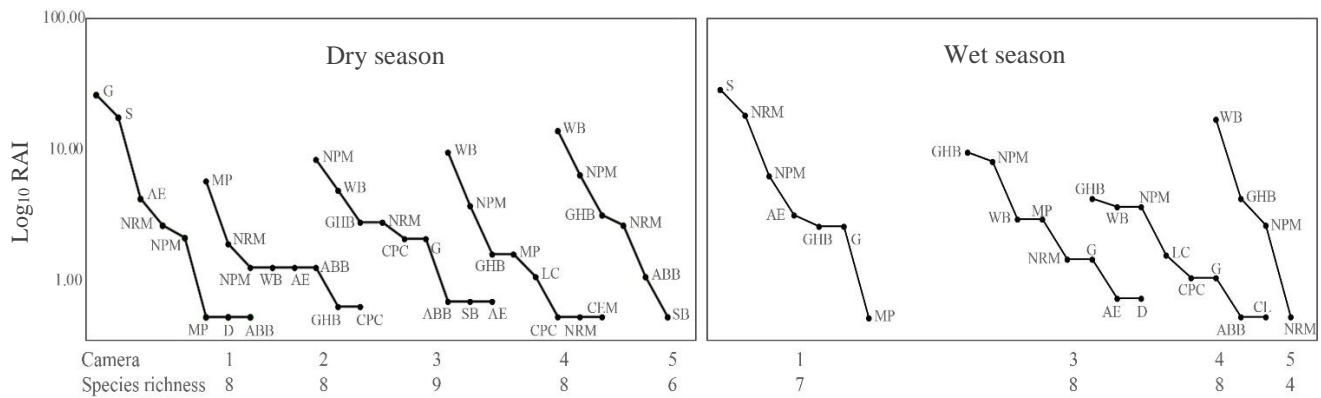


Figure 2. Lognormal rank abundance plot of terrestrial mammals that used each habitat in each season with the abbreviation of each species; ABB: Asiatic Black Bear, AE: Asian Elephant, CEM: Crab-eating Mongoose, CPC: Common Palm Civet, CL: Clouded Leopard, D: Dhole, G: Gaur, GHB: Greater Hog Badger, LC: Leopard Cat, MP: Malayan Porcupine, NPM: Northern Pig-tailed Macaque, NRM: Northern Red Muntjac, S: Sambar, SB: Sun Bear, WB: Wild Boar.

Table 4. Characters of habitat around each camera trap station

Camera trap's location	1	2	3	4	5
Mean elevation (m MSL)	162	218	239	266	333
Mean terrain slope (degree)	20	17	12	9	13
Distance from the forest edge (m)	0	2058	3475	5180	6280
Annual mean of NDVI	0.77	0.80	0.80	0.79	0.80
SD of NDVI between months	0.08	0.06	0.05	0.06	0.05

Table 5. Significant correlations between habitat characters and the RAI of terrestrial mammals

Dry season	Habitat character	Coefficient	p-value
Asian Elephant	Distance	-0.92	0.03
	NDVI SD	0.95	0.01
Wild Boar	Distance	0.96	0.01
	Elevation	0.96	0.01
Wet season	Habitat character	Coefficient	p-value
Asian Elephant	Distance	-0.97	0.03
	NDVI SD	0.96	0.04
Gaur	Distance	-0.97	0.03
	Elevation	-0.99	<0.01

At the forest edge, grazers and browsers were mostly found. The habitat around camera 1 had a unique pattern of mean NDVI between months that favored Gaur and Asian Elephant during the dry season. In March 2019, the mean NDVI of habitat around camera 1 decreased more than the other habitats. This was the only habitat that had a mean NDVI lower than 0.7 and Gaur and Asian Elephant were frequently detected only at this habitat around that time (Figure 3). Since NDVI can reflect the amount of chlorophyll at the canopy, a low NDVI can imply leaf senescence or shedding at the canopy, resulting in higher light penetration to the ground. This condition can result in the graminoids to thrive, which

are the main diet of Gaur and Asian Elephant. During the wet season when the NDVI increased, Sambar and Northern Red Muntjac began to be detected more often than Gaur and Asian Elephant. Northern Red Muntjac and Sambar were the main prey of Dhole (Intaraprasit et al., 2017; Kamler et al., 2020), so Dhole should be one of the carnivores that is specific to the forest edge, especially during the wet season. One point of concern is that Dhole may potentially catch certain diseases from domestic dogs at the forest edge, since Dhole is susceptible to Canine Distemper (Sillero-Zubiri et al., 2004), a lethal disease among domestic dogs which is prevalent in the villages.

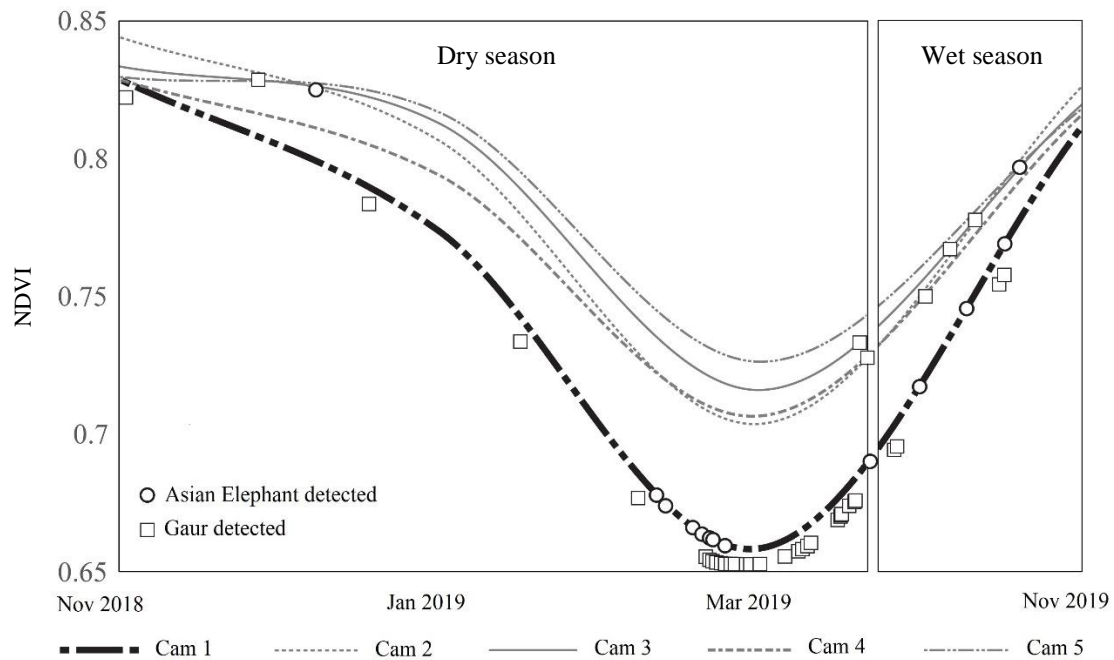


Figure 3. Trendlines of NDVI at each habitat and dates that Asian Elephant and Gaur were detected.

In the forest interior, Wild Boar, Northern Pig-tailed Macaque and Greater Hog Badger were most detected in both seasons (Figure 2). These terrestrial mammals are omnivores and frugivores. The lower SD of NDVI between months in the forest interior may make these habitats less favored to grazers and browsers than at the forest edge. The leaf canopy in the forest interior should be more evergreen than at the forest edge which makes less light penetrate to the ground. This condition should be more suitable for the shade-tolerant understory plants to thrive rather than the graminoids. Clouded Leopard was found once at camera 4 during the wet season. Wild Boar, Northern Pig-tailed Macaque and Greater Hog Badger were the most detected species of prey for Clouded Leopard (Davies, 1990; Ngoprasert et al., 2012). In April 2010, the author directly found a Clouded Leopard which had hunted on a Greater Hog Badger in the area near camera 5. According to the distribution of these three most detected species, Clouded Leopard should be one of the carnivores that is specific to the forest interior. The study at Khlong Saeng - Khao Sok Forest Complex, Thailand showed the same trend. The estimated density of Clouded Leopard in the core area was higher than in the edge area (Petersen et al., 2020). According to the geographic range of Clouded Leopard in the IUCN Red List of Threatened Species database, it was present in the Khao Angruenai Wildlife Sanctuary but was absent in the Khao Soi Dao Wildlife Sanctuary (Grassman et al., 2016). Thus, the

results from this study can be a new record of its occurrence (Figure 4).

The results from this study reveal that the North Ta-riu sub-tributary is not degraded forest and is regularly used by a diverse range of terrestrial mammals. Further, greater distance from the forest edge does not appear to correlate with a higher diversity of terrestrial mammals, since each habitat had unique characters. Habitat at the forest edge (camera 1) had a unique NDVI pattern which favored grazers and browsers. Meanwhile, habitat located in between forest edge and the forest interior (camera 3) was used by the highest diversity of terrestrial mammals. Additionally, habitats in the forest interior (camera 4 and 5) were mostly used by omnivores and frugivores. According to the dam construction plan (JICA, 1989), the habitat around camera 3 would be inundated (Figure 1). The forest outside the inundated area could also be destroyed during the dam construction process. The rock-filled dam would be constructed at watershed A using rocks quarried from a mountain between watersheds B and D. The habitat around camera 1 would be the filter and drain area. Habitats around cameras 1, 2, and 3 would be destroyed, including the area of highest terrestrial mammal species diversity around camera 3. The terrestrial mammals that specifically use these habitats include Sambar, Gaur, Northern Red Muntjac, Asian Elephant, and Dhole. Among these species, Asian Elephant and Dhole have endangered status. The



Figure 4. Clouded Leopard found in this study.

habitat around camera 4 would have indirect negative impacts and the habitat around camera 5, which was used by the lowest species richness of terrestrial mammals, would be the least impacted by the dam construction. From the perspective of the Pileated Gibbon conservation, the Khao Soi Dao Wildlife Sanctuary is an important habitat for the Cardamom Mountains rain forests population in Thailand. The North Ta-riu sub-tributary has been a historic study site for Pileated Gibbon since 1979 (Srikosamatara, 1980; Srikosamatara, 1984) and conservation evidence has only been found at this sub-tributary (Kolasartsanee, 2014; Kolasartsanee and Srikosamatara, 2014; Kolasartsanee, 2016). Pileated Gibbon was not only found at watersheds E and F (camera 5) but also at watersheds C and D (camera 4) (Kolasartsanee and Srikosamatara, 2014). During this study, watershed B (camera 3) was found to be a new colonizing area of Pileated Gibbon (Kolasartsanee and Srikosamatara, 2019), meaning that dam construction would negatively affect the recovery of Pileated Gibbon in this sub-tributary. From both national and global scale policy perspectives, the dam should not be constructed within the protected forest. At the national policy scale, the national forest policy aims to prevent forest loss and seeks to increase forest areas to 40% of the country's area. At the global policy scale, the Aichi target 5 aims to reduce forest loss and

fragmentation, while target 11 aims to protect 17% of terrestrial land and inland water areas. From diversity and habitat use of terrestrial mammals, community-based conservation on Pileated Gibbon and policy perspectives, water resource development projects outside the wildlife sanctuary area would be the best solution and can ensure synergy between wildlife sanctuary ecosystem services and water management.

4. CONCLUSION

The detected terrestrial mammals were unique between habitat at the forest edge and the forest interior. Sambar, Northern Red Muntjac, Gaur and Asian Elephant which are grazers and browsers were mostly detected at the forest edge, while Wild Boar, Greater Hog Badger and Northern Pig-tailed Macaque, which are omnivores and frugivores, were mostly detected in the forest interior. Based on distribution of prey, Dhole should be one of the carnivores that is specific to the forest edge while Clouded Leopard should be in the forest interior. North Ta-riu sub-tributary was regularly used by diverse terrestrial mammals. Dam construction will permanently destroy the habitats, especially at the habitat around camera 3 which was used by the highest diversity of terrestrial mammals, and habitat around camera 1 which its unique characters favored grazers and browsers.

ACKNOWLEDGEMENTS

This research was supported by Mahidol University (project ID: A18/2561) under the permission of the Department of National Parks, Wildlife and Plant Conservation (project ID: 6110701). The animal ethic in this study was approved by the Faculty of Science, Mahidol University Animal Care and Use Committee (protocol No. MUSC60-035-385). Grant for camera traps acquisition was supported by the Faculty of Science, Mahidol University. Thanks to Mr. Sittichai Bunphot, manager of Khao Soi Dao Wildlife Sanctuary. Thanks to the Ta-riu wild elephant guarding team, especially the late Mr. Wang Chomdee (Uncle Von), Mr. Peera Chomdee, Mr. Watcharin Ketrachong and Mr. Watcharakorn Ketrachong for their supports in the field and hospitality. Thanks to the editors and the anonymous reviewers for comments and suggestions to improve this manuscript. Finally, I would like to thank Assoc. Prof. Sompoad Srikosamatara for inspirations.

REFERENCES

- Davies R. Sighting of a clouded leopard (*Neofelis nebulosa*) in a troop of pigtail macaques (*Macaca nemestrina*) in Khao Yai National Park, Thailand. *Natural History Bulletin of the Siam Society* 1990;28:95-6.
- Grassman L, Lynam A, Mohamad S, Duckworth JW, Bora J, Wilcox D, et al. *Neofelis nebulosa* the IUCN red list of threatened species 2016 [Internet]. 2016 [cited 2020 Sep 7]. Available from: <https://www.iucnredlist.org/species/14519/97215090>.
- Intaraprasit S, Sukmasuang R, Duengkhae P. Abundance and prey selection of dhole (*Cuon alpinus*) in Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani Province. *Journal of Wildlife in Thailand* 2017;24:63-74 (in Thai).
- International Union for Conservation of Nature (IUCN). The IUCN red list of threatened species [Internet]. 2020 [cited 2020 Sep 7]. Available from: <https://www.iucnredlist.org/>.
- Japan International Cooperation Agency (JICA). The Feasibility Study on the Agricultural Water Development Project of Chanthaburi River Basin. Japan: Japan International Cooperation Agency; 1989.
- Kamler J, Thatdokkham K, Rostro-García S, Bousa A, Caragiulo A, Crouthers R, et al. Diet and prey selection of dholes in evergreen and deciduous forests of Southeast Asia. *Journal of Wildlife Management* 2020;84:1396-405.
- Kateworachai S. Using the king's philosophy to extend the Bhakti Rambhai Canal [Internet]. 2017 [cited 2020 Sep 7]. Available from: <https://www.dailynews.co.th/agriculture/578620> (in Thai).
- Kitamura S, Thong-Aree S, Madsri S, Poonswad P. Mammal diversity and conservation in a small isolated forest of Southern Thailand. *Raffles Bulletin of Zoology* 2010;58:145-56.
- Kolasartsanee I. Networking Non-Timber Forest Product (NTFP) Collectors for the Population Recovery of Pileated Gibbon (*Hylobates pileatus*) [dissertation]. Bangkok, Mahidol University; 2014.
- Kolasartsanee I, Srikosamatara S. Applying "Diffusion of innovation" theory and social marketing for the recovery of pileated gibbon *Hylobates pileatus* in North Ta-riu watershed, Khao Soi Dao Wildlife Sanctuary, Thailand. *Conservation Evidence* 2014;11:61-5.
- Kolasartsanee I. Patrol area determination using the prediction from pileated gibbon (*Hylobates pileatus*) distribution in Ta-riu watershed, Khao Soi Dao Wildlife Sanctuary, Thailand. *Srinakharinwirot Science Journal* 2016;32:152-60.
- Kolasartsanee I, Srikosamatara S. Evidence of pileated gibbons *Hylobates pileatus* recolonization in an area proposed for water resource development in Khao Soi Dao Wildlife Sanctuary, Thailand. *Asian Primates Journal* 2019;8:41-4.
- Krebs C. *Ecological Methodology*. California, USA: Addison-Wesley; 1999.
- Ngoprasert D, Lynam A, Sukmasuang R, Tantipisanuh N, Chutipong W, Steinmetz R, et al. Occurrence of three felids across a network of protected areas in Thailand: prey, intraguild, and habitat associations. *Biotropica* 2012;44:810-7.
- Petersen W, Steinmetz R, Sribuarod K, Ngoprasert D. Density and movements of mainland clouded leopards (*Neofelis nebulosa*) under conditions of high and low poaching pressure. *Global Ecology and Conservation* 2020;23:e01117.
- Sillero-Zubiri C, Hoffmann M, Macdonald DW. *Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan*. Gland, Switzerland and Cambridge, UK: IUCN/SSC Canid Specialist Group; 2004.
- Srikosamatara S. *Ecology and Behavior of the Pileated Gibbon (Hylobates pileatus) in Khao Soi Dao Wildlife Sanctuary, Thailand* [dissertation]. Bangkok, Mahidol University; 1980.
- Srikosamatara S. *Ecology of pileated gibbons in South-east Thailand*. In: Preuschoft H, Chivers D, Brockelman W, Creel N, editors. *The Lesser Apes: Evolutionary and Behavioural Biology*. Edinburgh: Edinburgh University Press; 1984. p. 242-57.
- Wearn O, Glover-Kapfer P. *Camera-trapping for Conservation: A Guide to Best-practices*. UK: World Wildlife Fund; 2017.