THE DETECTION RATE OF MALAYAN TAPIR IN RELATION TO VEGETATION AND LANDSCAPE ATTRIBUTES AT NORTH SELANGOR PEAT SWAMP FOREST, PENINSULAR MALAYSIA

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ABSTRACT

Malayan tapir (*Tapirus indicus*) is a Southeast Asia megafauna species that is at risk of extinction due to habitat loss and fragmentation. Forests in Southeast Asia are being extensively cleared for rubber, oil palm plantation and other cropland, therefore limited suitable habitat is available for a viable population of Malayan tapir. We assessed the North Selangor Peat Swamp Forest (NSPSF) potentially as a suitable habitat for Malayan tapir and detailed some of the species' habitat selection. To estimate the Malayan tapir occurrence, the presence and absence data were analysed using the Bayesian Single-Season Occupancy model, while the Regression-based model was used to determine factors of habitat selection on the R platform. We detected Malayan tapir in 49.5% of camera trap sites. Canopy cover, number of standing trees and wild palm show significant correlation with the detection of Malayan tapirs. Our data also revealed that distance to rivers and main roads influences the detection rate with tapirs recorded more frequently in close proximity to rivers and far from main roads. NSPSF is not listed as the critical habitat of Malayan tapir in Peninsular Malaysia. This study suggests that preserving the NSPSF to conserve biodiversity should be a priority in the future.

Keywords: Malayan tapir, habitat selection, vegetation attributes, landscape metrics, North Selangor Peat Swamp Forest

Received (7-March-2022); Accepted (9-May-2022); Available online (25-September-2022).

Citation: Arumugam, K.A., Luncha, A.C.A., Selvarajah, K., Selvadurai, S., Jambari, S., Azhar, B. & Annavi, G. (2022). The detection rate of Malayan tapir in relation to vegetation and landscape attributes at North Selangor Peat Swamp Forest, Peninsular Malaysia. *Journal of Wildlife and Parks,* **37***:* 69-81.

INTRODUCTION

Malayan tapir (*Tapirus indicus*) is the largest among other extant of the Tapiridae family (Holden *et al.,* 2003). With only 1,500 to 2,000 individuals in the wild (Traeholt *et al.,* 2016), this species may face future extinction if efforts are not scaled up to save it. Habitat loss and increased road kills are the two main reasons for this species to decline in the wild (Arumugam & Annavi, 2019). Malayan tapir habitat is also affected by human disturbance (Shwe & Lynam, 2012) and landscape changes like habitat fragmentation and conversion (Kinnaird *et al.,* 2003). Thus, conserving Malayan tapirs across Southeast Asia requires better land-use management to prevent its habitat from being converted to rubber and oil palm plantations and other types of cropland (Linkie *et al.,* 2013). As part of this, identifying suitable habitats constitutes an important part of Malayan tapir conservation.

Peat swamp forests are found extensively in Southeast Asia, occurring on the flat coastal plains of East Sumatra, Borneo and Malaysia (MacKinnon & MacKinnon, 1986). In 1990, a total of 1.03 million hectares of peat swamp forest were recorded in Malaysia. However, by 2018 the country had lost over 700,000 hectares for development and agriculture (Ministry of Energy and Natural Resources, 2020). In Peninsular Malaysia alone, only 250,00 hectares (1.89 percent) of peat swamp forests remained in 2019 (Peninsular Malaysia Forestry Department, 2019). Currently, peat swamp forests can be found in Terengganu, Pahang, Johor and Selangor. Peat swamp forest has a unique ecosystem and is a hotspot area for biodiversity; it has distinct floral compositions and provides a habitat for large mammals, primates, crocodiles and avifauna (Prentice & Parish, 1992). Unfortunately, this forest is actively threatened by logging, fire and land conversion (Posa *et al.,* 2011). Most of the peat swamp forests in Malaysia have been cleared for agricultural purposes, mainly for oil palm plantations. Therefore, government agencies should take action to preserve peat swamp forests to conserve their biodiversity. North Selangor Peat Swamp Forest (NSPSF) covers approximately 779km^2 and comprises the Sungai Karang Forest Reserve, the Sungai Dusun Wildlife Reserve and the Raja Musa Forest Reserve (Parish et al., 2014). The forest is one of the largest remaining patches of the peat swamp forest in Peninsular Malaysia, and is home for more than 60 threatened animal species including Malayan tapir (*Tapirus indicus*), leopard (*Panthera pardus*), sun bear (*Helarctos malayanus*), and bearded pig (*Sus barbatus*) (Sasidhran *et al.,* 2016). Malayan tapirs occupied 40% of the NSPSF (Sasidhran *et al.,* 2016), indicating

that peat swamp forests could be one of the suitable habitats for this species. However, the development of oil palm plantations in NSPSF keeps expanding (from 249km^2 in 1989 to 700km^2 in 2016; Charters et al., 2019) which make up 60% of the forest perimeter (Sasidhran *et al.,* 2016; Adila *et al.,* 2017).

Wildlife habitat selection is an important aspect of ecology. It consists of identifying a species's preferred or avoidable habitat because it can tell us the information on environmental characteristics needed by the animals (Calenge, 2007). A preliminary study of habitat selection by Malayan tapir was undertaken in Krau Wildlife Reserve, Malaysia showed that canopy height and the abundance of climbers might be the factors determining habitat preference and utilisation of the Malayan tapir (Mohamed & Traeholt, 2010). The current study expands on the previous study by Sasidhran *et al.* (2016) by including additional areas for estimating Malayan tapirs' current dispersal in NSPSF and analysis of habitat selection based on vegetation and landscape attributes for this species in NSPSF.

MATERIAL AND METHODS

Study Area

The NSPSF (GPS coordinate: 33'40'26.56''N, 101'4'29.52''E and 3'32'4.40''N, 101'27'33.36''E) is located in Peninsular Malaysia in the north-western part of Selangor State. The NSPSF covers an area of about 76,000 hectares and comprises the Sungai Karang Forest Reserve (50,106 ha), the Sungai Dusun Wildlife Reserve (4,330 ha) and the Raja Musa Forest Reserve (23,486 ha).

Data Collection

A total of sixty camera trap sites were established across the NSPSF (Figure 1). Every site was selected based on the presence of animal trails, footprints or tree marks by wildlife. One of the most important factors in choosing the camera trap sites was the distance and accessibility to the sites from the highway (Sasidhran *et al.,* 2016). Of all the camera-trap sites that had been selected, the furthest distance between each site was 40 km and the closest one was 500 m depending on the accessibility of the forest (Sasidhran *et al.,* 2016). Camera traps were set up for each site and left for a minimum of two months. The camera traps were deployed along former logging roads and at selected access sites. The first 45 camera-trap sites were conducted from March 2013 to October 2014, whereby the other 15 cameras were deployed and collected between August 2016 and February 2017. The Bushnell Trophy Cam and Bushnell Trophy Cam HD used in this study were infrared and triggered by a heat or motion sensor. In order to study the microhabitat attributes of the Malayan tapir, an area of 20m x 50m was

plotted at each camera trap site. Compass was used to measure the corner and red caution tape to mark every corner of the plot. The following vegetation variables were counted and measured: (i) the number of saplings with a diameter at breast height (DBH) of 1-5cm, (ii) the number of palms species, (iii) the number of trees, (iv) the percentage of canopy cover, (v) tree canopy height and (vi) number of fallen trees. Geographic Resource Solutions (GRS) Densitometer was used to measure the percentage of canopy cover at each camera trap site. Two landscape variables; the distance of the camera-trap site to the nearest (i) river and (ii) main road were measured using the measuring tool in Google Earth Pro.

Figure 1 Sixty camera trap sites across the North Selangor Peat Swamp Forest

Data Analysis

Habitat occupancy of Malayan tapir

Images from camera traps were examined to detect the presence of Malayan tapir at the site. The common practice for analysing camera trap time series was using detections grouped within daily or weekly sampling occasions (Efford, 2004). However, short sampling occasions may lead to zero inflation, hence causing frequent model convergence failures. To minimise the risk of zero-inflation and

model convergence failures (Guillera-Arroita *et al.,* 2010), we set the detection period to seven days of sampling. All sites with detected images of Malayan tapir were denoted as '1' while no-detection sites were denoted as '0' with the assumption the Malayan tapir did not occupy the sites. The malfunction and inactive camera traps were recorded as not available (NA) in the analysis.

To estimate the Malayan tapir occurrence, presence and absence data were analysed for Bayesian Single-Season Occupancy, which allows priors to be specified as beta distributions for the probability of occupancy and probability of detection by using "*BoccSS0*" function in R package *wiqid* (Meredith, 2019). The defaults, c (1, 1), were used to correspond to uniform priors on the probabilities of occupancy and detection. To achieve a potential convergence of RHAT (potential scale reduction factor) = 1, a total of 30,000 iterations samples were used after a discarded burn-in of 100 iterations (Meredith, 2019; Tan *et al.,* 2018).

Regression-based Modelling

Regression-based modelling was used to determine the relationship between the habitat preference of Malayan tapir with the vegetation attributes and landscape metrics; therefore, the three-malfunctioned camera was excluded from this analysis. Modelling was performed using Generalised linear models glm() function and model averaging based on information criteria, AICc (Burnham & Anderson, 2004) in MuMIn package R Statistical Package. The fixed effects were the vegetative attributes (canopy cover, canopy height, total standing tree, total fallen tree, number of sampling and number of wild palm) and landscape metrics (distance to river and main road). Malayan tapirs' detection was modelled as the response variable on the Y-axis. To estimate the overall importance of each fixed effect and select the plausible model we used the information theoretic (IT) approach (Burnham *et al.,* 2011). A model was considered plausible only if it alone ranked $\Delta AICc \leq 7$ and each model's relative Akaike weight (ω) was calculated as the model's relative likelihood ($\exp[-0.5 * \Delta AICc]$), divided by the sum of the likelihoods for all models. 'Average method' was then used to estimate model-averaged parameters and the 95% confidence intervals for model-averaged parameter estimates were calculated. All means were reported as mean (95% confidence interval, CI). The significant fixed effects were selected if the confidence interval did not overlap with zero.

RESULTS

Detection

In total, this study captured 1068 photographs of Malayan tapir (45 cameras produced 928; 15 cameras produced 140). The highest detections of Malayan tapir were 18% at camera sites 26 and 39 (Table 1) and most of the images

captured the night activity of Malayan tapir (Figure 2). The results showed that the average detection of Malayan tapirs in NSPSF were 49.5% (Figure 3), showing an increase from the initial report of 44.4% by Sasidhran *et al.* (2016).

Table 1 Model average parameter (Poisson) for each explanatory variable of Malayan tapir in North Selangor peat swamp forest. SE= Standard error. CI = Confidence Interval. Significant values are in Bold.

Parameters	**Estimate**	**SE**	**Lower CI**	**Upper CI**
Intercept	2.66	0.04	2.58	2.74
Number of Sapling	-0.07	0.04	-0.15	0.01
Canopy Cover	0.13	0.04	0.05	0.21
Canopy Height	0.06	0.04	-0.02	0.13
Number of Wild Palm	0.07	0.03	0.02	0.12
Number of Standing Tree	0.13	0.04	0.05	0.21
Number of Fallen Tree	-0.38	0.04	-0.47	-0.29
Distance to Main Road	0.85	0.05	0.74	0.96
Distance to River	-0.91	0.08	-1.07	-0.76

Figure 2 Most images of Malayan tapir were captured at night-time. This is expected, as it is known to be nocturnal species.

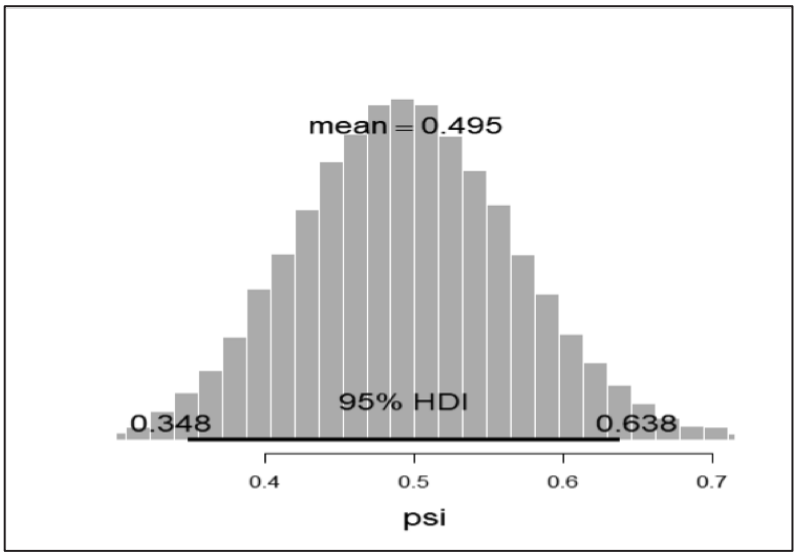

Figure 3 The graph shows the mean detection probability of Malayan tapir from a total of 60 cameras deployed.

Assessment of Vegetation Attributes and Landscape Metrics

All the vegetation attributes and landscape metrics at the camera trap sites were analysed in Poisson distribution. Overall, the occurrence of Malayan tapir in each site was correlated to several vegetative attributes such as canopy cover, wild palm, standing trees and fallen trees (Table 1). The distance to the main road and river impacted Malayan tapir habitat selection (Table 1). The detection probability of Malayan tapir increases when the canopy heights are higher. Similarly, the increasing number of wild palms and standing trees increases the detection of Malayan tapirs. In contrast, as the number of fallen trees increases, the presence of Malayan tapir decreases. Whereas for landscape metric, we found that the detection probability of Malayan tapir increases when the distance to the main road (range = 0.05 - 9.11km) increase and the distance to the river (range = 0.05 - 8.37km) decrease, suggesting that Malayan tapir prefers a habitat which is close to the river but far from the main road.

DISCUSSION

Habitat Selection of Malayan Tapir

The results showed that Malayan tapir could only be found at specific sites within the NSPSF. Out of 58 functional cameras, only 26 captured Malayan tapir's presence. This may be due to the fragmentation process occurring within NSPSF where most of the land has been converted for agricultural use, such as for oil palm plantations and cattle farms. The development of oil palm plantations within the NSPSF has affected the detection probability of mammals, especially in terms of resource availability such as food, salt lick and cover (Sasidhran et al., 2016). Food availability determines large mammals' habitat use and distribution (Wong et al., 2012). The absence of Malayan tapir at several sites may be due to low food availability.

The Relationship Between the Presences of Malayan Tapir, Vegetation Attributes and Landscape Metrics in Their Habitat

Our study is in line with the previous study by Samantha *et al.* (2020), where the number of saplings influenced the probability of detection of Malayan tapir. A high number of specific saplings increased the detection probability of Malayan tapir. This was in line with the foraging behaviour of the species as they tend to feed on various plant species especially herbaceous plants and young shoots (Mohamed & Traeholt, 2010). Therefore, the higher the number of saplings was expected to increase the detection probability of Malayan tapir. A denser canopy cover increased the probability of detection of Malayan tapir, possibly because it

could provide space for more saplings to grow. In addition, dense canopy cover provides better shade cover and lower air temperature preferred by Malayan tapir (Mohamed & Traeholt, 2010).

In mountain tapirs, certain types of trees, for example, the genus *Gunnera* is used as the source of shelter and food where the fallen or decomposing trunks are frequently eaten (Downer, 2001). Thus open areas with more fallen trees are expected to attract tapir. However, in our study, fallen trees appeared to reduce the detection probability of Malay tapir. We assume it could be an indicator of a disturbed forest for tapirs; thereby, it avoids this type of habitat as it would be close to human predators.

Some large-seeded plants are dispersed effectively by neotropical tapirs, especially palms (Giombini *et al.,* 2009). Our study area is a secondary mixed swamp forest which is abundant with many species of trees and palm trees such as *Crytostachys sp.* Our results suggest that the detection probability of Malay tapir is positively correlated with the number of wild palms in an area. This may indicate that wild palm is an important food source for Malay tapir in a peat swamp forest.

The relationship between the presence of Malayan tapir and landscape metrics was as expected. The longer the distance of the river from the camera trap site, the lower the probability of detecting the Malayan tapir, which indicates the preference of Malayan tapir to stay close to the river as a source for drinking and possibly to wallow in order to regulate their body temperature, especially during hot days. Furthermore, the longer the distance to the main road, the higher the probability of detecting the Malayan tapir. Despite the fact that our findings be consistent with other studies that also suggest tapirs tend to avoid disturbance (Cruz *et al.,* 2014; Samantha *et al.,* 2020), we heard many roads killing cases of Malayan tapirs occurred in Selangor (Magintan *et al.,* 2021), possibly tapirs want to explore for a broader range of food resources as most of the forest area where they lived has been developed into oil palm plantations and being disturbed by human activities.

CONCLUSION AND RECOMMENDATION

In this study, we detected Malayan tapir in 49.5% of camera trap sites. However, expanding more sampling sites and covering different parts within the NSPSF may result in better achievement in detecting possible habitats selected by the Malayan tapir. Nonetheless, the habitat preference of Malayan tapir could be more detailed if various other vegetation attributes and landscape metrics are tested in future studies such as presence/distance of saltlick, number of herbs, elevation and slope. In addition, the proximities to human disturbance were only

the distance to the main road in this study; therefore, adding distance to electric infrastructures and settlements should be added for further information.

ACKNOWLEDGMENTS

We are grateful to field assistance and volunteers for their kind support in this research. We thank the Forestry Department of Peninsular Malaysia for permitting us to conduct our research at NSPSF. This research is supported by the Malaysia Nature Society (MNS) through the Young Environmental Research Grant (YERG16-16) awarded to the second author. We also thank iM4U for their DRe1M Fund for '*Program Sukarelawan: Care for Malayan Tapir*' awarded to the last author to support volunteers.

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