EFFECTS OF URBAN FOREST FRAGMENTATION ON NATIVE MAMMALS IN SELANGOR, MALAYSIA

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By

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EFFECTS OF URBAN FOREST FRAGMENTATION ON NATIVE MAMMALS IN SELANGOR, MALAYSIA

By

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JUNE 2018

Chairman : Badrul Azhar Md Sharif, PhD
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Rapid urbanisation has caused major deforestation and habitat fragmentation in the tropics. Yet, the ecological impacts of forest fragmentation on biodiversity are understudied in urban landscapes particularly those that are heavily surrounded by anthropogenic activities. To date, little is known about the conservation value of the patches for maintaining mammalian biodiversity, as each species requires different habitat characteristics. This study uses the camera trapping method to (1) determine the composition of medium- to large-sized mammal species present; (2) identify the dominant species of mammalian community; (3) compare the mammal species composition; and (4) determine the key habitat variables that affect the mammal species richness in three forest patches: AHFR, BCFR, and BFR and one contiguous forest, SLFR. All forest areas are located in Selangor, the most developed and urbanised state in Malaysia. The study was conducted from September 2016 to October 2017 by deploying 30 wildlife cameras at each forest area. A total number of 19 mammal species comprising 11 omnivores, four herbivores, three carnivores and one insectivore from 120 sampling points were recorded. SLFR had the highest number of species compared to the urban forest patches. Only three conservation priority species were recorded, namely the Sunda Pangolin in AHFR and BFR, the Asian Tapir in BCFR and SLFR and the White-handed Gibbon was recorded in the SLFR. Top predators such as Tigers and Leopards were completely absent from the forest patches. This was reflected by hyper-abundance of wild boars. In SLFR, Eurasian Wild Boar, Barking Deer, Long-tailed Macaque and Lesser Mousedeer represented 93% of the species composition. While in AHFR, 98% of the majority species composition made up of Pig-tailed Macaque and Lesser Mousedeer. Eurasian Wild Boar and Pig-tailed Macaque represented 91% and 94% of the species composition in BCFR and BFR respectively. Omnivorous species was the most common found in all study areas may explained by their high tolerance towards modified environments. The mammal species richness responded positively with the number of trees with DBH less than 5 cm, trees with DBH more than 50 cm,

and the number of dead standing trees. Sufficiency of food resources provided by trees with DBH less than 5 cm, hiding places provided by trees with DBH more than 50 cm, and food resources and nesting sites provided by dead standing trees are crucial for every species' persistency. Improving the connectivity between the urban forest patches and continuous forest may be impossible due to land scarcity and urban expansion. This is true particularly for facilitating the movement of ground-dwelling and arboreal mammals. Hence, government stakeholders are recommended to take intervention measures such as species reintroduction and restocking the wild populations in the urban forest patches.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PENGASINGAN HUTAN BANDAR TERHADAP MAMALIA DI NEGERI SELANGOR, MALAYSIA

Oleh

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JUN 2018

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Pembangunan bandar yang pesat telah menyebabkan kemusnahan hutan dan fragmentasi habitat di kawasan tropika. Namun, kesan ekologi akibat daripada frgamentasi hutan terhadap biodiversiti masih kurang dikaji di landskap hutan bandar terutamanya hutan bandar yang dikelilingi oleh aktiviti pembangunan. Sehingga kini, hanya sedikit diketahui tentang nilai pemuliharaan fragmen hutan dalam mengekalkan biodiversiti mamalia, kerana setiap spesis memerlukan ciri-ciri habitat yang berlainan. Kaedah perangkap kamera digital telah digunakan dalam kajian ini untuk (1) menentukan komposisi spesis mamalia yang bersaiz sederhana dan besar; (2) mengenal pasti spesis dominan dalam komuniti mamalia; (3) membandingkan komposisi spesis mamalia; dan (4) menentukan kriteria habitat yang mempengaruhi kekayaan spesis mamalia di tiga fragmen hutan: Hutan Simpan Ayer Hitam (HSAH), Hutan Simpan Bukit Cerakah (HSBC) dan Hutan Simpan Bangi (HSB) dan satu hutan berterusan, Hutan Simpan Sungai Lalang (HSSL). Semua kawasan kajian terletak di negeri Selangor, negeri yang paling maju dan pesat di Malaysia. Kajian ini telah dijalankan dari September 2016 hingga Oktober 2017 dengan menggunakan 30 buah kamera hidupan liar di setiap kawasan hutan. Sejumlah 19 spesis mamalia dari 120 plot pensampelan terdiri daripada 11 omnivor, 4 herbivor, 3 karnivor dan 1 insektivore telah direkodkan. Hanya tiga spesis keutamaan pemuliharaan iaitu Tenggiling yang didapati hadir dalam HSAH dan HSB, Cipan ditemui dalam HSSL dan HSBC dan Ungka-Tangan Putih dijumpai di HSSL. Pemangsa teratas seperti harimau belang dan harimau kumbang tidak dijumpai di fragmen hutan. Ini dapat ditunjukkan oleh bilangan babi hutan yang tinggi. Komposisi spesis di HSSL diwakili oleh babi hutan, rusa, kera dan kancil sebanyak 93%. Manakala komposisi spesis di HSAH sebanyak 98% diwakili oleh beruk dan kancil. Komposisi spesis di HSBC dan HSB diwakili oleh babi hutan dan beruk sebanyak 91% dan 94% masing-masing. Spesis omnivor merupakan spesis yang paling kerap dijumpai di semua kawasan kajian. Ini boleh dihubungkaitkan dengan tahap toleransi

mereka yang tinggi terhadap persekitaran yang telah diubah suai. Kekayaan spesis mamalia menunjukkan hubungan positif dengan bilangan pokok yang mempunyai DBH kurang daripada 5 cm, pokok yang mempunyai DBH lebih daripada 50 cm, dan bilangan pokok mati yang berdiri. Pokok yang mempunyai DBH kurang daripada 5 cm, pokok yang mempunyai DBH lebih daripada 50 cm, dan pokok mati yang berdiri dapat memberi sumber makanan yang mencukupi, membekal tempat lindung dan tempat tinggal kepada semua spesis yang masih hidup dalam hutan terpisah. Sekiranya ingin menyambungkan fragmen hutan di bandar dengan hutan yang berterusan mungkin sangat mustahil disebabkan kekurangan tanah dan pengembangan bandar yang pesat. Ini adalah benar terutamanya untuk membenarkan pergerakan mamalia arboreal dan yang duduk atas tanah. Oleh itu, pihak kerajaan disyorkan untuk mengambil tindakan untuk melaksanakan langkah-langkah seperti pengenalan semula spesis tertentu dan menebus semula populasi liar di kawasan hutan bandar.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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CHAPTER 1

INTRODUCTION

1.1 General Overview of Forest Alteration

The current world population is approximately 7.5 billion. Population growth correlated directly with deforestation (Sodhi et al., 2010). In Southeast Asia, tropical rainforests have become the easiest prey for land transformation (Abdullah & Nakagoshi, 2007; Seto et al., 2012). Malaysia has a total land area of 32.855 million hectares inhabited by 31.7 million people. Among all the other states, Selangor has the highest population of 6.3 million people (19.9%) (Department of Statistics Malaysia, 2017). In Peninsular Malaysia, out of a total land area of 13.2 million hectares, 5.77 million hectares (43.7%) are forested area (Department of Forestry Malaysia, 2017). These areas are under constant threat of being converted into agricultural lands followed by urban areas (Abdullah & Nakagoshi, 2007; Fitzherbert et al., 2008; Lucey et al., 2014).

Landscape modification is the spatial process of changing the landscape through vegetation alteration or anthropogenic modification (Lindenmayer & Fischer, 2006). The landscape can be altered by natural processes or anthropogenic activities (Lindenmayer & Fischer, 2006; Fischer & Lindenmayer, 2007). Natural disasters such as wildfires, flooding, typhoon and lightning are examples of an event that can alter the landscape, but the effects are minor as the landscape can recover in relatively short periods. Anthropogenic-induced modifications (i.e. construction of residential areas, agricultural lands, recreational areas, urbanisation and timber industrialization) are more likely to cause significant impacts on landscapes in terms of degrading landscape quality and uncontrollable expansions with maximum usage (Laurence & Bierregaard, 1997; Lindenmayer & Fischer, 2006).

Forest alteration is either complete or partial. Complete forest alteration commonly results from forest clearing and burning which removes all the vegetation on the land surface. This type of clearing is often used for urban developments such as the construction of residential areas, industrial areas and highways which require huge areas. The adverse impacts of forest clearing are more severe than partial clearing (Meijaard & Sheil, 2008). Partial forest modification includes selective logging system (SMS) in the timber industry, integrated human activities in forest areas, and forest conversion which dissect the forest into trails and smaller patches surrounded by different matrices. All alteration results in forest shrinkage, fragmentation and isolation which have positive and negative effects on the local ecosystem. Although a considerable amount of forest area survives through conversion and hosts some animal species, their conservation value in maintaining the biodiversity remains unclear.

1.2 Forest Fragmentation and Isolation

Due to agricultural expansion and urbanisation, vast expanses of forested areas are undergoing deforestation (Fitzherbert et al., 2008; Sodhi et al., 2010; Pozo-Montuy et al., 2013). In Malaysia, about 74% of the population is living in urban areas, and that population is growing. Hence, conservationists predict that more forested areas will be cleared to meet the demand of population growth and national development. Forest fragmentation occurs when the forest connectivity is broken due to disturbances from landscape alterations, smaller isolated patches and smaller populations (Fahrig, 2003; Fischer & Lindenmayer, 2007). The effects of forest fragmentation caused by urbanisation on ecology and biodiversity have not been studied as much as the agricultural impacts. The construction of beltlines for highways, recreational trails inside forested areas, residential areas, industrial areas and telecommunication towers are examples of projects that require large construction areas (Pirnat & Hladnik, 2016). The contiguous forests are now segregated by these anthropogenic landscapes which result in further forest isolation due to urban sprawling. It means that forest shrinkage and fragmentation threaten environmental and terrestrial biodiversity (Abdullah & Nakagoshi, 2007).

Forest isolation is a growing issue. It is caused by forest fragmentation and shrinkage (Fischer & Lindenmayer, 2007). An isolated forest patch is defined as an island surrounded by different matrices. They remain restricted areas, solitary and have lost the connectivity with other habitats (Haddad et al., 2015). It is difficult to determine whether the isolated forest patch is still suitable for wild animals to inhabit and how it affects the species remaining in these patches. Until now, the conservation value of the forest patches is still unidentified. It can vary according to the geographical range, adaptability of each species, the complicated inter-relationships between species and the outer pressures exerted by surrounding matrices (Pardini, 2004; Villaseñor et al., 2015).

1.3 Impacts of Forest Landscape Modification on Mammal Biodiversity

The impacts triggered by forest landscape modification on biodiversity level include habitat loss, habitat fragmentation, habitat isolation, degradation in habitat quality, changes in natural behaviours, imbalance ecosystem and local species extinction (Fischer & Lindenmayer, 2007).

Forest clearance causes the loss of natural habitats and limits the availability of their home range. Wildlife is forced to migrate from the degraded or open areas to other suitable habitats. If they fail to migrate, some species will be trapped in an isolated ecosystem which is detrimental to their long-term survival. The alteration of forest landscapes will also modify the native vegetation species by promoting the growth of fast-growing species. Some forest-specialist mammals that are strongly dependent on the native vegetation might come under stress due to insufficient food resources and nesting sites (Sodhi et al., 2010).

Isolated forest patches also have limited genetic transmission. As time passes, the species might be unable to reproduce leading to inbreeding which will produce low-quality progeny. Without a suitable mate or sufficient food resources, the entire species will be wiped out in this urban race. Yet, modified forest landscapes can act as a population catalyst for generalist species such as *Macaca spp.* and *Sus scrofa* (McShea et al., 2009). With a wide range of adaptability, they successfully thrived in the human-modified landscapes.

Forest clearance accelerates the extinction of local species through hunting, poaching and road-kills. The Department of Wildlife and National Parks reported that 1784 wildlife were killed in road accidents since 2011 until 2015. These cases were found commonly on the highways located next to the forested areas. Human activities such as logging and recreational activities also modify the internal structure of forests by constructing logging trails and tracks. With the aid of ready pathways, illegal hunters and poachers can easily go deep inside the forests without worried about future consequences.

1.4 Conservation Efforts in Urban Forest Patches

In addition to conserving a large area of forest, urban forests should be given more attention in order to understand the ecological effects and patterns on tropical rainforest species (Sodhi et al., 2010; Granados et al., 2016). Fragmented forest patches that persist in human-modified landscapes have become a new target for ecologists to identify the significance of urban forest patches in providing refuge sites for wildlife species (Laidlaw, 2000; Meijaard & Sheil, 2008; McShea et al., 2009; Sodhi et al., 2010; Ahumada et al., 2011; Brodie et al., 2015; Granados et al., 2016; Sasidhran et al., 2016; Adila et al., 2017). By having more information about the urban forest patches, a more well-established management system can be implemented to mitigate the ecological impacts caused by forest fragmentation.

1.5 Problem Statement

Medium- to large-sized mammals are classified as umbrella species which are susceptible to ecosystem changes as their life mostly relies on forest resources. They also have a larger home range compared to other animal taxa (Azlan & Sharma, 2006; Tobler et al., 2008; Gardner et al., 2009). Hence, they can be used to determine the effects of forest fragmentation. By identifying their existence in urban forest patches, their ecological acceptance level can be updated, and the habitat quality that affects can be verified. Mammals directly represent the health of the ecosystem which helps formulate targeted ecosystem services such as seed dispersal and nutrient cycling. Hence, quantifying their status in the fragmented urban forest is crucial for conservation measures (Granados et al., 2016).

Forest conversion from agricultural expansion is discussed widely, and its impacts on the ecosystem have been identified (Fitzherbert et al., 2008). Yet,

there is limited study about the impacts brought by urbanization on the forest ecosystems. To date, little is known about the urban forest patches that persist in the urban areas. There is no certain answer as to whether urban forest patches can sustain the mammal biodiversity. Even though some species still survive after forest conversion, another question arising is how long they can persist. Past research showed that disturbed forests retain their biodiversity value by becoming a refuge site for mammal species. However, the key environmental drivers which contribute to species survival and the conservation value of these urban patches remain unclear.

Unfortunately, little is known about the habitat quality and faunal biodiversity in forest patches which are surrounded by urban areas in Malaysia. Hence, there is an urgent need to determine the conservation value of these fragmented urban forests in terms of biodiversity especially in the most developed state in Peninsular Malaysia. The effects of habitat disturbance within forest fragmentation on native mammals were examined in this research by using non-intrusive motion-triggered camera traps. The findings of this study are crucial to justify the conservation of forest patches within urban matrices.

1.6 Hypotheses

Urban forest patches have significant conservation values for biodiversity. The species composition and richness in the forest patches represent the ecosystem health.

Three predictions have been made for this research:

1. Urban forest patches favour generalist species as they have wider ecological acceptance range.
2. Higher ecological disturbances in the urban forest patch decrease mammal species richness.
3. Large forest areas have diverse mammal species composition compared to small forest patches as more food resources and shelter choices are available.

1.7 Research Questions

In this study, the effects of urban forest fragmentation on native mammals are examined using non-intrusive motion-triggered camera traps.

The following research questions were assessed:

1. Is there any difference in the mammal species richness between each forest patch?
2. Is there any difference in the mammal species composition between each forest patch?
3. What are the key environmental drivers of mammalian biodiversity in

these urban forest patches?

1.8 Objectives of the Study

This study investigates the faunal biodiversity in urban fragmented forest patches. Mammal assemblages in each forest patch will be identified to understand better the effects of urban forest fragmentation on the native terrestrial mammals in the most urbanised state in Peninsular Malaysia.

The specific objectives of this study are:

1. To identify the medium- to large-sized mammal species present in each forest patch;
2. To identify the dominant species of mammalian community in each forest patch;
3. To compare the mammal species composition between each forest patch; and
4. To determine the key habitat variables that affect the mammal species richness in each forest patch.

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