# THE CONSERVATION VALUE OF FOREST FRAGMENTS AND OIL PALM PLANTATION FOR MAMMALS IN SABAH MALAYSIAN BORNEO

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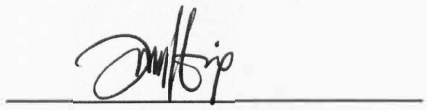

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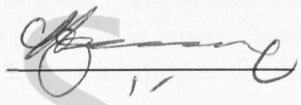

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## ABSTRACT

### THE CONSERVATION VALUE OF FOREST FRAGMENTS AND OIL PALM PLANTATION FOR MAMMALS IN SABAH MALAYSIAN BORNEO

The rapid and extensive expansion of the agricultural sector, especially planting of oil palms in Sabah are affecting the natural resources considerably. Areas under natural forest cover are being reduced and fragmented resulting in many isolated forest islands located within the converted habitat matrix of agriculture crop. The present study was conducted in a lowland dipterocarp rainforest of Tabin Wildlife Reserve, in Lahad Datu, Sabah, and in the surrounding oil palm plantations that were interspersed with highly degraded isolated forest fragments. The objectives were to assess the values of forest fragments in terms of species compositions, richness and diversity of mammals utilizing the forest fragments, and to assess the effects of retaining forest fragments in oil palm plantation on the small mammal species richness, abundance, diversity and compositions. Twelve trapping sessions using camera traps, direct observations and small mammal traps have been successfully carried out from May 2009 to April 2010. The trapping-sites include one primary forest, three of isolated forest fragments (4.84 ha, 16.07 ha and 26.75 ha) and four oil palm plantations. Overall, 1,913 individual photographs representing 28 species and 15 families of mammals have been recorded by camera trapping. When the mammal species richness were compared between forest habitat and forest fragments, there were 49%, 69% and 65% decrease in the number of mammal species recorded respectively in forest fragments in order of increasing distance from the forest habitat. The forest fragments resulted in the changes of species composition with some species that were recorded as abundant in forest habitat were absent in the forest fragments e.g. *Tragulus* sp. and *Cervus unicolor*. However, the *Prionailurus bengalensis* were found to exist in all forest fragments. For small mammal community, based on 5,220 trap-nights of live trapping, there were 349 animals captured represented by 18 species. The oil palm habitats recorded only six species of small mammal and were highly dominated by *Rattus rattus.* The percentage of trap success based on all capture events was 6.69%. In conclusion, the forest fragments have provided some habitats for some species of mammals, but both the forest fragments and oil palm habitats harboured very low mammal species richness. However, retaining the forest fragments in the oil palm plantations do not increase the value of the oil palm plantation with respect to the mammal faunas and does not have any effect on controlling the abundance of pest species (rodent) in oil palm plantation.

## ABSTRAK

*Perluasan dalam sektor pertanian yang semakin pesat khususnya penanaman kelapa sawit di Sabah telah menjejaskan sumber alam semulajadi. Kawasan yang dilitupi hutan semulajadi semakin berkurang dan mengakibatkan pembentukan banyak fragmen hutan kesan daripada penukaran habitat hutan kepada ladang pertanian. Kajian ini dilaksanakan di hutan tanah rendah dipterokap Rezab Hidupan Liar Tabin di Lahad Datu, Sabah dan di sekitar kawasan ladang kelapa sawit yang mempunyai fragmen hutan yang terganggu. Objectif kajian adalah untuk menilai kepentingan fragmen hutan dari segi komposisi, kekayaan dan kepelbagaian spesis mammalia yang menduduki fragmen hutan dan juga menilai kesan pengekalan fragmen hutan ke atas komuniti mammalia kecil di ladang kelapa sawit yang berkaitan dengan kekayaan, kelimpahan, kepelbagaian dan komposisi spesis mammalia kecil. Terdapat 12 sesi persampelan yang menggunakan perangkap kamera, pemerhatian secara langsung dan pemerangkapan mamalia kecil telah berjaya dilaksanakan pada Mei 2009 sehingga April 2010. Kawasan persampelan adalah mewakili hutan primer, tiga fragmen hutan (4.84 ha, 16.07 ha dan 26.75 ha) dan empat kawasan di ladang kelapa sawit. Secara keseluruhan, sebanyak 1,913 gambar yang mewakili 28 spesis dan 15 famili mamalia telah direkodkan daripada perangkap kamera. Perbandingan kekayaan spesis antara habitat hutan dan habitat fragmen hutan masing-masing menunjukkan 49%, 69% dan 65% pengurangan bilangan spesis mamalia mengikut turutan daripada yang paling hampir dengan habitat hutan. Fragmen hutan memberi kesan perubahan terhadap komposisi spesies terutamanya kepada spesies yang mempunyai kelimpahan yang tinggi di habitat hutan tidak direkodkan sama sekali di habitat ini, contohnya, Tragulus sp. dan Rusa unicolor. Walau bagaimanapun, Prionailurus bengalensis mempunyai pertambahan positif dan didapati di semua fragmen hutan. Bagi pemerangkapan mamalia kecil berdasarkan 5,220 perangkap-hari, sebanyak 18 spesis yang mewakili 349 individu telah berjaya ditangkap. Habitat kelapa sawit merekodkan sebanyak enam spesies mamalia kecil dan didominasikan oleh tikus perosak iatu Rattus rattus. Peratusan kejayaan tangkapan secara keseluruhan adalah 6.69%. Sebagai kesimpulan, fragmen hutan menyediakan habitat bagi sesetengah spesis mamalia di mana secara amnya, hutan fragmen dan ladang kelapa sawit melindungi mamalia dengan kekayaan spesis yang rendah. walau bagaimanapun, pengekalan hutan fragmen di ladang kelapa sawit tidak meningkatkan nilai ladang kelapa sawit berkenaan dengan mamalia serta tidak memberi kesan ke atas pengawalan species perosak (tikus) dalam ladang kelapa sawit.*

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| | |
|---|---|
| **TWR** | Tabin Wildlife Reserve |
| **OPF** | Oil palm plantation with degraded Forest Fragments |
| **OP** | Oil palm plantation |
| **ha** | hectare |
| **hr** | hour |
| **km** | kilometre |
| **df** | degree of freedom |
| **dbh** | diameter at breast height |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

The rapid and massive expansion of areas planted with oil palm, *Elaies guineensis* have threatened the biodiversity resources in Southeast Asia (Edwards *et al.*, 2010; Sodhi *et al.*, 2010). The conversion of natural forests to large-scale plantations of oil palm has led to significant loss and degradation, and fragmentation of continuous forest habitats, leading to changes in the biological communities living within them. In the Malaysian state of Sabah, in northern Borneo, more than 50% of the forests habitats have been logged at least once (Fitzherbert *et al.*, 2008; Edwards *et al.*, 2010). Much of these logged areas were then cleared to make way for agricultural development especially for planting of oil palm. The history of modern agriculture in Sabah began only in the early 1970s, but at present more than 1.3 million hectare of land areas have been planted with oil palm (Fitzherbert *et al.*, 2008; Danielsen *et al.*, 2009). This area is close to 15% of the total land area of Sabah. The clearance of forests for oil palm plantation development has resulted in many small isolated forest fragments located within the matrix habitat of oil palms. These forest "islands" usually consist of highly degraded forest patches on steep slopes and rocky soils that are unsuitable for planting oil palms. Since these forest fragments may remain as a permanent feature in the oil palm plantations landscape, it would be useful to ascertain whether the forest fragments within the oil palm plantations could provide some benefits, such as increasing the prospect for biodiversity conservation in this habitat or as part of an effective pest management system to control the population of rodent pests in the oil palm plantations, as the forest fragments in the oil palm habitats may provide some useful resources for the rodent predators in the form of nesting or refuge sites. This information would allow for a "win-win" solution for biodiversity conservation and oil palm plantation development.

The value of forest fragments within oil palm plantation for terrestrial mammal conservation has not been well studied before, although studies on birds and the bat fauna have been carried out in this habitat in the past (Stuebing & Gasis, 1989; Rajaratnam & Vaz, 1998; Bernard, 2003). Studies have shown that retaining forest fragments in oil palm plantations may increase the value of oil palm plantations as habitats for some species of birds and bats (Rajaratnam & Vaz, 1998). Nonetheless, it is assumed that different animal community may react differently to the presence of forest fragments in oil palm plantations. In addition, there is a possibility that some animal communities, especially rodents, in the oil palm plantation may be influenced by the abundance of rodent predators that may utilise the forest fragments. Therefore, the value of forest fragments in oil palm plantations does not depend on aspect concerning the presence or absence of the forest fragments alone, but also on the interactions of various animal communities utilizing the forest fragments in the oil palm plantations. Understanding the patterns and processes associated with the interactions between the different animal communities with the forest fragments, and between the animal communities themselves, may advance our understanding of how to effectively manage crop plantations with a view to reduce the impact of pests species while at the same time increase the prospect for biodiversity conservation in this habitat.



The present study was aimed at assessing the value of isolated and highly degraded forest fragments in oil palm plantations for terrestrial mammal conservation and to investigate the effects of retaining forest fragments in oil palm plantation on the dynamics of the small mammal community, with specific reference to the rodent pests species i.e. the rats (Family: Muridae). The previous study which was done at the same study area by Rajaratnam *et al.* (2007) has often observed the leopard cat as predators of rodent species in the oil palm plantation. However, the present study tests the hypotheses that the forest fragments are valuable for supporting higher species richness and composition of mammals especially rodent predators that may utilise the forest fragments within the oil palm plantation and thus, the abundance of the rodent predators in the forest fragments may reduce the number of rodent pest species in the oil palm plantation.

This study was conducted in the lowland dipterocarp rain forest of Tabin Wildlife Reserve and the surrounding oil palm plantations that are dotted by several small isolated forest fragments, on the eastern part of Sabah, Malaysia. Tabin WR is a near-rectangular protected area of approximately 120, 500 ha in size surrounded by large oil palm estates on its entire boundary. Tabin was gazetted as a Wildlife Reserved in 1984 primarily to provide a sanctuary for the Sumateran Rhino (*Dicerorhinus sumatrensis*) which is known to inhabit the area. Although Tabin was logged in the past (1960-1989), being relatively large, it is still very rich in wildlife. The lands surrounding Tabin WR have progressively been converted to agricultural crop plantations since the early 1960 particularly for planting oil palm. At present, the age of the oil palms around Tabin ranges from recent plantings to more than 25 years old. Most interestingly, the plantations landscape is characterized by the presence of several highly degraded forest fragments located at various distances away from the Tabin forest.

## 1.2 Study objectives

The specific objectives of this study are as follows:

i. To assess the values of forest fragments in oil palm plantation for mammals conservation i.e., in terms of species richness, diversity and composition of the mammals utilizing the forest fragments;

ii. To assess the effects of retaining forest fragments in oil palm plantation on the small mammal (<1kg) community, in particular the rodents (Family: Muridae), with respect to small mammal species' richness, abundance, diversity and compositions;

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 The history of oil palm plantation development in Malaysia

Tropical rainforest is one of the most diverse ecosystems in the world. Yet, they are highly threatened by human activities (Turner, 1996). Although tropical rainforests cover only about seven percent of the world's land mass, they are inhabited by half to two-thirds of plant and animal species on earth (Erlangung, 2001). Malaysia and Indonesia together hold more than 80% of Southeast Asia's remaining primary forests and harbours numerous endemic or rare species which are restricted to forest habitats (Koh & Wilcove, 2008). However, in Malaysia particularly, is having the highest global rate of deforestation due to the expansion of the palm oil cultivation. Palm oil is the number one product in the oils and fats trade which result in Malaysia becoming one of the largest producers of palm oil (Fitzherbert *et al.*, 2008). The remaining forested areas that are suitable for oil palm will be cleared sooner or later as the demand for palm oil continue to increase.



Oil palm was first planted in Peninsular Malaysia for commercial purpose in 1917 where it leads to the conversion of forest and rubber plantations. Expansion of oil palm were then shifted to Sabah and Sarawak which increased the overall area of oil palm to 4.2 million ha in Malaysia until 2005 (Fitzherbert *et al.*, 2010). The latest total hectarage of oil palm in Malaysia according to the MPOB website state that it reached 5 million hectares in 2011. About 55-59% of oil palm expansion estimated to have been at the expense of forest in this country (Koh & Wilcove, 2008; Yaap *et al.*, 2010). Demand for palm oil is predicted to increase globally, thus, most of the remaining areas suitable for oil palm plantations are forested (Fitzherbert *et al.*, 2008). Nonetheless, environmentalists' claim that the expansion of oil palm plantation in Malaysia were not acceptable to be carried out in virgin tropical forests, thus most of the oil palm areas were expanded by replacing other agricultural crops which have lower market values like cocoa, rubber and coconut (Tan *et al.*,2009). The Malaysian government and oil palm

companies argued that oil palm plantations are beneficial to biodiversity and that agriculture is now being established in logged-over forests or degraded habitats (Koh & Wilcove, 2008).

Since early 1980's, huge areas of degraded forests in Sabah were cleared for oil palm cultivation (Dayang Norwana *et al.,* 2011). Sabah has become the biggest palm oil producer in Malaysia which contributes approximately 31% of the total national output (Dayang Norwana *et al.,* 2011). The IOI Corporation has recorded a total of 112,580 ha of oil palm plantation in Sabah (IOI Corporation Berhad, 2008). Forests which were not identified as forest reserves were unprotected, thus, such lands were usually cleared or logged and developed for agriculture (Toh & Grace, 2006).

## 2.2 The impact of forest disturbance on biodiversity

Forest disturbance is defined as a change in the behaviour or/and properties of a forest ecosystem (Hais *et al.*, 2009). The forest disturbance i.e. clear-cutting forest, harvesting timber and biomass burning can influence many landscape processes including changes in microclimate, hydrology and soil erosion (McMorrow & Mustapa, 2001; Hais *et al.*, 2009). Logging can influence wildfire, changing microclimates which can dry the understorey and ground layers and in turn, alter fuel characteristics (Lindenmayer, 2010) and often associated with increased hunting pressures and arrival of colonist (Dunn, 2004). Forest disturbance also lead to a transformation of forest into a series of forest fragments. These forest fragments differ ecologically from the natural contiguous forest in terms of species diversity, richness and composition (Fitzsimmons, 2001).

A study by Peh *et al.* (2005) which compares the bird community between primary forest and selectively logged forest shows that the bird species richness was lower in logged forest than in the virgin forest. The study also states that the complete regeneration of the logged forest will need a longer time i.e more than 35 years to recover to their original diversity. Similar patterns held for forest butterflies in Borneo where Koh & Wilcove (2008) compared their sampled butterflies from 98 sites in two oil palm in Sabah with the sampled butterflies in primary forest of

Danum Valley Field Centre by Hamer *et al.* (2003) and sampled butterflies in logged forest of Ulu Segama Forest Reserve by Dumbrell & Hill (2005). Their findings showed that the conversion of primary forests and logged forests to oil palm plantations decreases species richness of forest butterflies by 83% and 79%, respectively. Dunn (2004) also found that ants, birds and lepidoptera respond similarly in terms of species richness to both forest clearance and the logged sites but he also stated that the forest conversion to agriculture reduced the richness of ants, birds and lepidotera more so than did logging.

Habitat loss due to habitat disturbance and modification are the major causes that lead to diversity loss. The selective logging activity will result in fragmentation and that will increase the canopy openings and tree fall rates in the logged forests (Schulze & Zweede, 2006). Basically, the sizes of tree are also very important for many forest taxa. Trees provides habitats and food resources for all levels of taxa, thus loss of trees in the forest result in the reduction and extinctions of floras and faunas in the long term (Whitney *et al.*, 1998).

## 2.3 The impact of forest fragmentation on biodiversity

Habitat fragmentation and clear cutting are among the major factors triggering changes in the structure of remnant forest patches (Faria *et al.*, 2009). Most of the remaining forests in Sabah were fragmented and isolated as a result of human activities, including logging and expansion of crop cultivations (Kitamura *et al.*, 2010). Many of the greatest impacts result from the initial process of land clearance and preparation. Although there have been relatively few studies of the biodiversity of small fragments of lowland rain forest that have been isolated for more than a decade, fragmentation may have both negative and positive effects on biodiversity (Turner & Corlett, 1996). Fragmentation have reduce the probability of successful dispersal and establishment that affect on species richness as well as reducing the capacity of a patch of habitat to sustain a resident population (Echeverria *et al.*, 2006). As well as decreasing area and connectivity, fragmentation increases the length of forest edge exposed to harmful edge effects (Faria *et al.,* 2009). Pardini *et al.* (2005) also stated that habitat loss

and fragmentation lead to less abundant, less rich and more spatially variable communities.

Most of forest fragments that exist in Malaysia vary in size yet categorised as natural forest habitat. Some of the fragments remain unlogged because the areas may not be suitable for agricultural purpose due to the extremely steep slopes. However, isolated forested areas especially fragments within oil palm plantation that are located adjacent to large contiguous forest may be occupied by some animal species such as migratory birds and mammal predators that may benefit from the existence of forest fragments in terms of providing food resources and shelter during certain period of the year (Bernard *et al.*, 2009).

For mammals that are able to move through the oil palm matrix, forest fragments can act as "corridors" for dispersal, especially if they are large and not too isolated from other forests (Persey & Anhar, 2010). Although forested areas of tens of thousands of hectares will be needed to avert the extinction of many wildlife, fragments which are small in size and degraded may still hold biodiversity and complement the roles of larger reserves (Fitzherbert *et al.*, 2008).



It is evident from a study by Danielsen *et al.* (1995) that conversion of natural forest to oil palm plantations area having the negative impact on primates, squirrels and tree shrews. A further study by Bernard *et al.* (2009) demonstrated about 88% difference in the community composition of non-volant small mammals in oil palm habitats as compared to natural forest. Similarly, bat species richness and diversity have been shown to be significantly lower in oil palm plantations than in nearby forest, with the population that persists in the plantations being dominated by a few species that are able to feed on the oil palm fruits (Persey & Anhar, 2010). A study of the response of bat species to forest fragmentation found that isolation had little influence on variation between forest patches and that species with specific habitat requirements were more severely affected by declining patch size than species with more general habitat requirements (Persey & Anhar, 2010; Struebig *et al.* 2008).

## 2.4 The impact of oil palm plantation development on biodiversity

In general, the biodiversity value of oil palm plantations is severely depleted in comparison to natural forest and is also frequently lower than disturbed forest and other plantation crops (Fitzherbert *et al.*, 2008; Persey & Anhar, 2010). Oil palm has structurally less complex habitats that support only 23% in average of the forest species (Persey & Anhar, 2010). This is indicated by a significant decrease in total number of species richness and changes in the community composition. Most studies found large differences in faunal species composition between oil palm and forests as well as other tree crops (Fitzherbert *et al.*, 2008). Studies on a diverse taxa including insects, arthropods, birds, lizards and mammals show a decline in species richness and a reduction in overall abundance from other habitats to oil palm, indicating a high loss of biodiversity as a result of the oil palm expansion (Turner *et al.*, 2010).

In some studies, the impact forest conversion to oil palm plantations has resulted in a reduction in the number of individuals with a few species dominating the samples (Turner & Foster, 2009). A study on ants that was done by Fayle *et al.* (2010) found that the impact of conversion to oil palm plantation was greatest for canopy and litter ant. The species density decreased and the relative abundance distributions also became less even. They conclude that the microclimate in oil palm plantations tends to be hotter and drier than that in forest areas. A study done by Bernard *et al.* (2009) on the small mammal community in Tabin Wildlife Reserve, Sabah also show a decline in terms of diversity and abundance when compared to the small mammal community in the primary and secondary forest to oil palm plantations.

Some of the negative impacts due to the development of oil palm plantations include habitat fragmentation and pollution, including greenhouse gas emissions and decline in biomass carbon stocks (Fitzherbert *et al.*, 2008; Dayang Norwana *et al.,* 2011). Other studies showed that the establishment of plantations on peat soils and where they replace forest contributes substantially to greenhouse gas emissions, and thus to climate change, a growing global threat to biodiversity (Fitzherbert *et al.*,2008; Faria *et al.,* 2009; Persey & Anhar, 2010). Some animal