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EFFECT OF LOGGING ON TIMALIIDAE DIVERSITY AND ABUNDANCE IN BERKELAH FOREST RESERVE, PAHANG, MALAYSIA

NOR AZLIN BINTI MOHD FAUZI

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By

NOR AZLIN BINTI MOHD FAUZI

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Chair : Professor Mohamed Zakaria Hussin, Ph.D
Faculty : Forestry and Environment

The composition, structure, and density of bird community of Berkelah Forest Reserve, Maran, Pahang, Malaysia were investigated in selective logged forest and compared with those in primary forest of the same forest reserve. Distance sampling transect count and mist netting methods were carried out in 30, 388.65 ha located at latitude (3.767 degrees) 3° 46' 1" North of the Equator and longitude (103.017 degrees) 103° 1' 1" East. The main objective of this study was to investigate how logging activities affect the species richness, community composition, and microclimate and microhabitat-use pattern of the Timaliidae mainly in forest reserve for future management and conservation efforts. Timaliidae family was selected as the focal family for the study, due to its occurrence in tropical rainforest. Large number of the Timaliidae are specialist, which makes some of the selected species suitable to be used as indicator species for forest ecosystem health. A total of 39,168 individuals were recorded from September 2009 until April 2011. Thus, this showed that the population of birds in the Berkelah Forest Reserve was high. Out of 164 species which have been found in the study area, a total of 20 species (12%) were from Timaliidae's family. All of the 20 species of Timaliidae were found in primary and 19 species of Timaliidae were found in logged areas. Among the 20 species, the Black-throated Babbler *Stachyris nigricollis* was found absent in logged forest. The Horsfield's Babbler *Malacocincla sepiarium* (593 individuals) and Short tailed Babbler *Malacocincla malaccensis* (574 individuals) were found in high number in both primary and logged forest of Berkelah Forest Reserve. The location of the forest itself is an advantage because it is closely located and partly linked to other forest reserves while also being near to national parks in Pahang. The study had found that based from the transect count data, density species in primary forest was 6.62 ± 0.41 birds/ha with total number of observations of 2905. The estimated number of individuals in the primary forest is N=1457 ± 90.795 calculated at 95% of confidence interval. Whereas, the result for logged forest was observation 1525 with the density of 2.7069 ± 0.2317 birds/ha. The number of estimated individuals was N = 433.00

± 37.062 with 95% confidence interval. The result indicated a significant different between density in logged and primary forest with $p < 0.5$. The second objective was to determine the microhabitat and microclimate factors that affect the population size of Timaliidae in primary and logged forest. In this study, the habitat preference was determined by looking at the number of species in the study area of study. The parameters which were tested in the study involved microclimate particularly forest temperature, humidity, soil temperature and lux intensity. Whereas for microhabitat, plant dbh, shrubs, canopy cover and elevation were also measured. Most of the Timaliidae species were strongly associated to trees with dbh of 30 cm–50 cm and above as well as shrubs. Based on the canonical correspondence analysis, General Linear Model Statistic (GLMS) and regression analysis, it was found that there were three (3) parameters that are significantly and strongly associated with the presence of bird species based on their preference namely understorey temperature, soil temperature and humidity. The last objective was to determine the most suitable Timaliidae species to be used as indicator species of forest ecosystem health. Based on the results, five species of Timaliidae species were selected as biological indicator for forest ecosystem health. The study suggested that Black-capped Babbler *Pellorneum capistratum*, Short-tailed Babbler *Malacocincla malaccencis*, Black-throated Babbler *Stachyris nigricollis*, Ferruginous Babbler *Thrichostoma bicolor*, and White Bellied Yuhina *Yuhina zantholeuca* are fit and suitable to be used as forest ecosystem health indicators. The finding of this study indicated that, the main factors affecting the species abundance and distribution can be used by relevant agencies in wildlife and habitat management strategies.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PEMBALAKAN KE ATAS DIVERSITI DAN BILANGAN TIMALIIDAE DI HUTAN SIMPAN BERKELAH, PAHANG, MALAYSIA

Oleh

NOR AZLIN BINTI MOHD FAUZI

Jun 2018

Pengerusi : Professor Mohamed Zakaria Hussin, Ph.D
Fakulti : Perhutanan dan Alam Sekitar

Komposisi, struktur serta kepadatan komuniti burung di Hutan Simpan berkelah, Maran, Pahang, Malaysia telah dikaji di dalam hutan yang dibalak secara terpilih dan telah dibandingkan dengan komuniti burung yang terdapat di dalam hutan primer. Kajian menggunakan kaedah persampelan secara transek serta penangkapan menggunakan jaring kabut telah dijalankan di kawasan yang berukuran 30, 388.65 ha latitud (3.767 darjah) 3° 46' 1" utara dan longitude (103.017 degrees) 103° 1' 1" Timur. Tujuan utama kajian ini adalah untuk mengenalpasti tentang bagaimana kesan dari pembalakan yang dijalankan memberi kesan kepada kekayaan spesis, komposisi komuniti, serta corak penggunaan mikro iklim dan mikro habitat Timaliidae di dalam hutan simpan untuk digunakan dalam pengurusan serta korservasi di masa hadapan. Famili Timaliidae telah dipilih untuk kajian kerana ianya senang ditemui di hutan hujan tropika. Kebanyakan Timaliidae merupakan spesis yang khusus kepada hutan menjadikannya pilihan yang sesuai untuk dijadikan sebagai spesis indikator untul kesihatan ekosistem hutan. Sejumlah 39,168 individu telah direkod sepanjang tempoh dari September 2009 hingga April 2011. Daripada keseluruhan sebanyak 164 spesis yang direkodkan, terdapat sebanyak 20 spesis (12%) merupakan spesis dari famili Timaliidae. Kesemua 20 spesies Timaliidae dijumpai di hutan primer dan 19 spesies Timaliidae dari kawasan yang telah dibalak. Diantara 20 spesis dari Timaliidae, iaitu Black-throated Babbler *Stachyris nigricollis* didapati tidak ditemui di dalam hutan yang telah dibalak. Manakala, Horsfield's Babbler *Malacocincla sepiarium* (593 individu) dan Short-tailed Babbler *Malacocincla malaccensis* (574 individu) didapati mempunyai bilangan yang sangat tinggi di keda-dua jens hutan di Hutan Simpan Berkelah, Maran Pahang. Hal ini jelas menunjukkan bahawa populasi burung di Hutan Simpan Berkelah ini adalah tinggi. Lokasinya juga adalah berdekatan dengan Taman Negara, Pahang. Ianya juga berdekatan dengan hutan simpan–hutan simpan yang lain serta berdekatan dengan Taman Negara Pahang, sekaligus memberikan kelebihan kepadanya. Kajian telah mendapati, berdasarkan dari kutipan data transek, anggaran kepadatan

spesis di hutan primer adalah 6.62 ± 0.41 burung/ha dengan jumlah pemerhatian sebanyak 2905. Jumlah anggaran bilangan individu dalam hutan primer tersebut adalah N=1457 ± 90.795 pada 95% selang keyakinan. Manakala, keputusan dari kawasan hutan yang dibalak dengan jumlah pemerhatian sebanyak 1525 dengan kepadatan di hutan tersebut adalah 2.70 ± 0.23 burung/ha serta anggaran bilangan individu adalah N = 433.00 ± 37.06 dengan 95% selang keyakinan. Keputusan menunjukkan terdapat signifikasi terhadap perbezaan di hutan yang telah dibalak dengan hutan primer iaitu $p < 0.5$. Objektif kedua adalah untuk mengenalpasti faktor mikro iklim serta mikro habitat yang memberi kesan terhadap saiz populasi Timaliidae di hutan primer dan hutan yang telah dibalak. Dalam kajian ini, pemilihan habitat telah dikenalpasti dengan melihat bilangan spesis yang terdapat dalam kawasan kajian. Parameter yang telah digunakan dalam kajian ini melibatkan suhu hutan, kelembapan, suhu tanah, serta keamatan cahaya. Manakala, bagi mikro habitat pula, diameter ketinggian paras dada pokok (dbh), tumbuhan rimbun, kanopi serta ketinggian juga diukur. Kebanyakan Timaliidae didapati lebih tertarik kepada faktor pokok yang mempunyai ukuran sekitan dbh 30-50cm ke atas serta tumbuhan rimbun. Berdasarkan analisa menggunakan canonical correspondance, General Linear Model Statistic GLMS serta analisa regrasi, didapati bahawa terdapat 3 parameter yang signifikan serta menarik kehadiran burung ke kawasan tersebut seperti suhu bawah kanopi, suhu tanah serta kelembapan. Objektif yang terakhir adalah untuk melihat kesesuaian spesies Timaliidae untuk digunakan sebagai spesies petunjuk bagi kesihatan ekosistem hutan. Berdasarkan keputusan kajian, lima (5) spesies Timaliidae telah dipilih sebagai spesies petunjuk kesihatan ekosistem hutan. Kajian mencadangkan bahawa spesis seperti Black-capped Babbler *Pellorneum capistratum*, Short-tailed Babbler *Malacocincla malaccencis*, Black-throated Babbler *Stachyris nigricollis*, Ferruginous Babbler *Thrichostoma bicolor*, dan White Bellied Yuhina *Yuhina zantholeuca* adalah sesuai untuk dijadikan sebagai spesis indicator biologi untuk kesihatan ekosistem hutan. Keputusan kajian ini menunjukkan bahawa faktor utama yang memberi kesan kepada bilangan dan penyebaran spesies burung boleh digunakan oleh agensi berkaitan dalam strategi pengurusan hidupan liar dan habitat.

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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 Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Mohamed Zakaria bin Hussin, PhD
Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Chairman)

Kamziah Abd. binti Kudus, PhD
Associate Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Member)

Abdullah bin Mohd, PhD
Associate Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Member)

ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 9 September 2021

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Name and Matric No.: Nor Azlin Binti Mohd Fauzi GS24103

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Signature:	
Name of Chairman of Supervisory Committee:	Professor Dr. Mohamed Zakaria Hussin
Signature:	
Name of Member of Supervisory Committee:	Associate Professor Dr. Kamziah Abd. Kudus
Signature:	
Name of Member of Supervisory Committee:	Associate Professor Dr. Abdullah bin Mohd

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%	Percent
&	And
^{o}(C)	Degree centigrade
ANOVA	Analysis of Variance
CCA	Canonical Correlation Analysis
cm	Centi meter
GPS	Global Positioning System
Ha	Hacter
IUCN	International Union for Conservation of Nature
IBA'S	Important Bird areas
Km	Kilometer
Km^2	Kilometer Square
m	Meter
mm	Mili meter
NGO'S	Non-governmental Organization
SE	Standard error

CHAPTER 1

INTRODUCTION

1.1 General Background

Tropical rainforest is the most precious heritage owned by any countries in the world regardless of the size and diversity of its flora and fauna. However, due to the increased of mankind population, many part of the forested areas has been scarified in order to make way for forestation, agriculture, settlements and many other anthropogenic activities. Along the way, many of described and undescribed species of biodiversity depleted and soon moving towards extinction.

Malaysia's tropical rainforest is one of the country with the highest biological diversity. No doubt that the rich diversity of the forest has contributed directly and indirectly to the economic growth in both timber and non-timber sectors. Numbers of forests in Malaysia have been converted into various kind of developments to cater the needs of humankind. Some of the forests were clearly logged while some others were partially logged with selective logging systems. Nevertheless, the size of the forest is shrinking and its biodiversity is depleting from time to time. Various species of fauna is losing their habitats and many have turn into endangered, vulnerable and some has gone extinct.

Malaysia is a home to 742 species of birds. Primary and logged forests plays vital roles for bird species. However, not all species can become adapted in the same forest type. Understorey insectivores are considered to be particularly sensitive to forest disturbance and fragmentation (Karr 1982, Wong 1985, Lambert 1992, Thiollay 1992, Johns 1996, 1997, Laurance *et al.* 2002). Birds are good bio-indicator in study on the impact of forest disturbance (Karr et al. 1990).

Bird are categorized into two categories such as specialist species and generalist species. Specialist species can live only in small or narrow range environmental conditions with limited diet. The specialist species also have its own preferences, especially in terms of their microhabitat and microclimate. While generalist species, they can thrive in wide range of environmental conditions, and able to make use different kind of sources for their diet. Most of generalist can adapt in many kind of environment, regardless of the changes in microhabitat and microclimate of the area.

Each of the forest types has its own microhabitat (the smallest part of ecology which supports flora and fauna in particular area includes soil types and altitudes) and microclimate (local atmospheric climate; temperature,

precipitation, humidity, and light intensity) condition. The microhabitat and microclimate of particular area can be influence by many types of activities conducted close to the surrounding areas. For example, logging activity in the forest area which may affect many of the environmental factors in the forest such as number of plant diversity, fauna diversity, soil structure, soil moisture, humidity, micro-temperature, light temperature and many other factors which will directly or indirectly influence the condition of the habitat and ecosystem.

There are many other anthropogenic activities that can severely affect wildlife includes hunting, selective logging at varying degrees of intensity, plantation forestry, selective removal of the understory to produce shade tolerant crops, and outright logging for large-scale livestock operations. In other words, the resulting faunal assemblages can be drastically disfigured in highly modified forest landscapes compared to those in truly undisturbed forest lands containing a full complement of plant and animal species that are being promptly confined to the best-guarded strictly protected areas or the remote, road less wildlands in the last pristine forests patch.

There is intense reductions in the forest cover of Malaysia due to logging and land alteration causing the forest margins to move gradually towards higher elevations. It is very likely that this loss of habitat (Walter *et al.*, 2004b), as well as increased hunting levels (O'Brien & Kinnaird 1996, 2000; Rosenbaum *et al.*, 1998), and possibly pollution (Thiollay & Rahman, 2002), have caused declines in Malaysia's terrestrial vertebrate fauna.

This study mainly focused on the effect of logging onto Timaliidae's species in Berkelah Forest Reserve, Maran, Pahang. The Timaliidae understory bird which has the biggest number of species compare to other families of bird in Malaysia. There are studies have been conducted focusing on various species richness and abundance of understory bird but there is no study has ever been conducted focusing on the effect of logging onto Timaliidae. There are studies conducted looking on foraging factor where the ways in which ecologically different species partition their sources in habitat and revealed how guilds of forest birds respond to disturbance (Styring & Zakaria 2004). It has been discovered that resource partitioning reduces the competition rates by decreasing the amount of niche the overlaps between the competitor species (Wiens 1989).

1.2 Problem Statement

Environment stability in the tropical rainforest lends itself to high species diversity. Berkelah Forest Reserve is situated in Maran, Pahang, Malaysia and is consist of mixed forest land structure. Even though the forest reserve is located closed to Kuala Tahan National Park, little known about the ecology of

this forest, and only a few studies have been made in the area of Berkelah Forest Reserves.

Part of the forest is still intact and well preserved while another part of it has already been logged once from 1986 to1987. However, this forest reserves is very much visible to logging activity. Therefore, there are several patches occurred within the section per se. Meanwhile, these activities also tentatively created gaps between each patches which will definitely influence the wildlife especially birds inside the forest. This Berkelah

Forest Reserve in Maran, Pahang has been identified as a red meranti forest (Wyatt Smith, 1961). It is a selectively logged mixed hill dipterocarp forest stand and but due to logging activities, there were breaches created in the logged over forest such as skid trails, and gaps.

Many of the studies which has been conducted are mainly focusing on the detrimental effect of habitat degradation due to logging activity, the declines of species richness and abundance as well as genetic diversity of the species in the forest. However, not many of the study are looking at differential responses of individual species towards habitat degradation or specifically on logging activities. Individualistic species responses to habitat degradation and easily to defy the characterization of habitatdriven effect on species richness and abundance.

The aim of this research is to look at Timaliidae in their role as important biological indicators, and the factors affecting their survival. Insectivorous bird or specifically Timaliidae were used as the focal species in this study. Birds were counted and detection of distances, behaviour and habitat data, and several field parameters were recorded. To this end, this study is also examining the density estimates of babblers, and at the possibility of using the babblers as an indicator of forest ecosystem health, in relation to forest management.

Therefore, it is hypothesized that understorey bird species richness and abundance of Timaliidae will vary according to both of the overall amount of remaining forest cover in the different plots and the types of forest modification and location in the different habitats studied.

Previous studies on the impact of logging and fragmentation on avifauna of forested sites throughout the region regularly indicated that large areas of logged forest retain the majority of species present prior to logging, but those forest fragments still lose parts of their original species (Lambert & Collar, 2002).

Due to logging activities, the gaps were created and thus, most of the wildlife was forced to move into remnants patches that still remain within the study areas. In the absenteeism of the intensive hunting pressure that sometimes accompanies and follows in the wake of selective logging operations (Robinson 1996), the common of bird species that inhabit primary forests persist in the commercially logged forest (Bennett & Dahaban 1995; Danielsen & Heegaard, 1995; Johns, 1986, 1988b, 1989a,1989b, 1996; Lambert 1990, 1992; McClure & Hussein, 1965; Round & Brockelman, 1998). Though, even when areas of intact forest persist nearby, most studies have suggested that some species continue either absent from intensively logged areas or present at densities so low as to be ecologically extinct (Redford 1992, Bennett and Robinson 2000).

Longer term studies in Malaysia by Johns (1997) and by Lambert (1992) indicated that such declines were generally experienced by species of bird fit in to particular feeding guilds. Both these studies revealed that terrestrial or understory insectivorous species were predominantly vulnerable to the effects of logging, and to a lesser extent, some insectivores, mainly sallying species that inhabit the lower to mid-levels of the forest. Birds typical of the canopy however, appeared to be much more resilient. These studies showed comparable patterns in which they observed how species richness and abundance change as ecological niches appear or disappear due to disturbances that alter the habitat, but demonstrated a general decline in avifauna biodiversity, which subsequently reflected a decline in total biodiversity.

In Berkelah Forest Reserve, there are not many studies on fauna which have been conducted. Most of the studies were mostly focusing on flora and impact of logging activities in the nearby areas. Therefore, it is important for us to carry out the study in order to gain some knowledge on the fauna in order to determine the situation of the forest ecology for conservation purposes and subsequently striving towards the sustainable forest ecosystem.

The extent of the secondary forest continues to increase every year, and this is attributed particularly to shifting cultivation and in the last few decades, was to mechanize logging activities. Environment stability in the rain forest lends itself to high species diversity. The present study is investigating the adaptation of terrestrial interior species towards the forest alteration due to logging activity. Several species of forest birds (Timaliidae) were used as part of the biological indicator to investigate on the factors that may affect the occurrence of the species. Biological indicator species are now quite crucial in order to sufficiently indicate the health of the forest with respect to the forest types. Each of forest type has its dependable species that represent the stability of their ecosystem. In other words, the loss of indicator species serves as a forewarning that particular forest are at stakes or losing at an alarming rate.

Timaliidae is considered as forest birds which are mainly specific inside the forest. Most of the species feed on insects and they sometimes can be found near forest edges. Since avifauna is one of the best indicators to indicate forest health, the instability of species number will certainly reflect the current status of the forest health. For example, the high numbers of insectivorous birds in one particular forest will show that the forest is abundant with insects as its food resources.

Recently, insects, due to their small length, diversity, and sensitivity to environmental stress have been considered as good indicators of habitat heterogeneity, ecosystem diversity, and environmental stress. They are also used as indicators (or surrogates) of biodiversity and endemism, prioritization for establishment of protected areas, biogeographic relationships, bio-indicators of anthropogenic changes in the forest, water quality, and areas of pertinent for bio-prospecting. According to a study by Sekercioglu (2000) forest under story insectivores seems to have high habitat specificity with low mobility, and are more restrained to forest interior than other forest passerine guilds. These days, many of insectivorous bird species have received attention because of their role as mortality agents of forest insect pests. Climatic condition is a situation in a comparatively small area, within a few feet above and below the Earth's surface and within canopies of vegetation. Microclimates are affected by many sort of factors, for example; humidity, wind and turbulence, temperature, evaporation, heat balance, dew, frost, the nature of the soil and vegetation, the local topography, latitude, elevation, and season. Weather and climate are sometimes influenced by microclimatic conditions, especially by variations in surface characteristics.

1.2.1 Logging Situation in Malaysia

In Malaysia, the logging activity is conducted by using selective logging system methods. This methods have been practice by forestry since 1970's to keep the forest in a better state rather than clearly logged the stand all at once. They will extract the commercially value trees and leaving the other trees intact. Apart of it, this selective logging is an integral part for wildlife management action plan, to keep the forest intact in order to conserve and preserve the wildlife habitat and its whole ecosystem.

Due to selected logging system method, a certain amount and percentage of forest were left and causing isolated patches inside the forest while at the same time forming gaps in between one patch to another.

The logging is executed on the ground, but in order to not harm the contiguous forest, it is usually done by helicopter. Selective logging has been well-documented to mend forest health and reduce the dangers of wildfire and has been endorsed by the National Forest Service as the better alternative to clear-

cutting. Another advantage is that through the selection of which trees to log, rare species can be saved from logger's saw.

According to report from ITTO (1999), Malaysia is one of the largest supplier of tropical saw-log and holds among the most important enduring natural forests in the world. Malaysia is the second largest supplier after Indonesia for tropical plywood (ITTO, 1999). In 2008, total of 2.3 million or 1.4 m^3 value of timber have been export to other countries (Anon, 2009). Timber industry has become one of the largest income to Malaysia economy with an input of 8% to total GDP amounted to RM 9791 million in 2008.

Starting in the early 1990s, illegal logging in Peninsular Malaysia started to become a concern due to growing demand for timber and timber products that are formed legally and from sustainably-managed sources by the international market especially from environmentally sensitive markets such as European Union (EU) and the United States.

Non-government Organizations also claimed that forest practices in some parts of Malaysia are not sustainable and timber harvesting are over harvested. In addition, it is also reported that Malaysia has 35% of illegal logging rate and 40% of Malaysia's consumption and export of timber was expected to have been assimilated illegally (Greenpeace/WWF, 2004; EIA/Telapak, 2004).

Presently, the total forested land in Malaysia is 5.8 million hectares and the timber productions from 2005 to 2010 are 24.5 million m^3. Forest policy and legislation in Peninsular Malaysia is under the Article 74(2) of the Malaysian Constitution, in which land and forestry come under the jurisdiction of the individual state governments. As such, each state is authorized to enact laws on forestry and to formulate forestry policy independently (Anon, 2009). The management of lands and forests are also defined by the constitution as state matters and forests are managed by the state forestry department. The federal government only provides technical advice and assistance on forest management, training, the conduct of research and in maintenance of experimental and demonstration stations.

Timber harvesting rights are assigned to private timber contractors firms through a system of forest licenses. Licenses are tendered to the private firms for periods of 5 to 20 years to the individuals (companies) or state entities. The most important policy related legislation in terms of forest law and enforcement is the National Policy, 1978 (NFP,1992). NFP was formulated and implemented by all states in Peninsula Malaysia and has remained the basis for forestry practices. The NFP forms the basis for the classification of roles and hence the use and management of the forest although only the states in Peninsular Malaysia subscribe to the NFP. The critical concept in the NFP is the constitution of a Permanent Reserved Forest (PRF) which must be determined

by the states and its security assured. Under the forestry laws, the PRF is classified into categories depending on the degree of protection and use (NFP, 1992).

Malaysia has experienced loss in forest areas since the 1970's, causing in fragmentation of forests (NPP, 2010). According to Malaysia's Second National Communication to the UNFCCC, 56% of the country was covered in forests in 2000 and 55% keep on covered by 2007 (NRE, 2011) while forest cover in 2012 is expected to be closer to 53%. These figures contain permanent reserve forests, state land forests, national parks and wildlife and bird sanctuaries (NRE, 2011).

In accordance to the Federal Constitution, land and forestry matters are under the jurisdiction of their respective states, and each Federal Government has sovereignty over their forest resources (NRE, 2011). Forest management started in Malaysia as early as 1900s, and Malaysia has since improved and refined the system to incorporate selective and sustainable forest management in their forestry practices. In developing a national in the effort of the country to reduce emissions from deforestation and forest degradation (REDD+) process, the national government will provide policy guidance while the management and implementation of REDD+ activities would occur at the federal and state government level. The regionalized management of forest resources has been identified as a potential challenge for executing REDD+ in Malaysia.

1.3 Bird as Indicator for Forest Ecosystem Health

Bird is one of the best indicators to indicate forest ecosystem health. Forest health ecosystem and fauna diversity depends on each other mutually. The maintenance of forest health ecosystem depends on the ability of the ecosystem function of the forest itself on how fast it can recover back from any sort of disturbance or perhaps adapt to its current condition. The fluctuation in number of species will certainly reflect the current status of the forest health because the numbers of biotic community plays an important roles determining ecosystem structure and function. While the decline of the forest health ecosystem may cause a degradation on environmental quality. For example, the high numbers of insectivorous birds in one particular forest will somehow reflect that the forest is still viable to live in and probably due to highly abundance of insects as its food resources.

Due to the small length, diversity, and sensitivity to environmental stress, insects have been considered as good indicators of habitat heterogeneity, ecosystem diversity, and environmental stress. Conferring to previous research (Sekercioglu, 2000), understory insectivores seem to have high habitat specificity with low mobility, and are more confined to forest interior than other forest passerine guilds. The insects will respond predictably to environmental

disturbance or to a change in environmental state. An ecological indicator is a characteristic taxon or collection that is sensitive to identified environmental stress factors, which demonstrates the effect of these stress factors on biota, and whose response is representative of the response of at least a subset of other taxa present in the habitat. The tropic areas are the most obvious where forest fragmentation and its consequences are most dramatic. Many of insectivorous bird species have received attention due to their role as mortality agents of forest insect pests.

All sort of changes due to habitat degradation are contributing to indirect effects on bird from humans such as climate change and other conflicts. Certain species are more influenced than others when these factors are coupled with confines based on specialization, (Julliard et al 2003). It is suggested that island or mountain top species will be particularly vulnerable to climate changes (Newton, 1998). It is assumed on a general rule, that if a habitat of wildlife is reduced in area by 50%, about 10% of the species will be lost, and if the habitat area is reduced by 90%, about 50% of the species will be lost (Newton, 1998). Organisms in tropical forests are in particular risk due to their high rates of habitat destruction (Newton, 1998).

1.3.1 Studied Species (Timaliidae)

Among tropical forest birds, understory insectivores are mainly sensitive to habitat uproar and fragmentation despite their relatively small sizes and freedom from hunting pressure. Why these birds are especially susceptible to fragmentation is not known

(Sekercioglu *et al*., 2000). Insectivorous birds' diets are influence by the availability of arthropods. And the availability of arthropods and other insects are dependent on the host plants. McFarlane (1976) provided a good review of several quantitative studies dealing with effect of birds on forest insect pest. Some birds can extremely effect populations of some pest but in other cases, impact of avian predators on pests seems negligible. According to Sekercioglu *et al*. (2001), the food insufficiency hypothesis states that small fragments are impoverished in prey favoured by understory insectivores while the microclimate hypothesis proposes that these birds are particularly sensitive physiologically to changes in microclimate related with forest fragmentation. The habitat specificity hypothesis states that the loss of some microhabitat elements (such as army ant swarms, curled leaves, and dead trees) from fragments may affect many understory insectivores negatively.

Insectivores are more sensitive to such subtle changes because unlike fruits, flowers, and seeds, invertebrates actively avoid insectivores and as a result, insectivorous birds have evolved into many specialized niches and seek prey in certain microhabitats.

Finally, according to the limited dispersal hypothesis, understory insectivores, because of their relatively sedentary habits and possible psychological avoidance of clearings, may be less likely to disperse into more favourable habitats after forest fragmentation and may disappear from fragments as a result of stochastic events and other negative consequences of fragmentation.

Modifications in invertebrate communities as a result of forest fragmentation are well documented. Leaf-litter and soil-dwelling invertebrates decline as a result of desiccation in small forest fragments and generalist edge species that select the dense vegetation near fragment edges increase in number. Since many understory insectivores forage in the dark and humid leaf litter in relatively open understory and avoid dense vegetation, these changes can diminish the birds' prey base.

The species which were selected for this study were from the Family of Timaliidae (Babblers). Timaliidae is a huge bird family of tropical forest birds in the Old World. In general, they are residents of virgin and secondary forest but do come out to the clearing.

There is much diversity within the family with a good chunk (50 species; 19%) are called laughing thrushes in the genus *Garrulax*. Babblers are well-thought-out as arbitrary grouping of largely insectivorous birds with soft and loose plumage. The species is mostly sedentary with some species being gregarious while others are either in pairs or solitary. In term of sexes, it is quite hard to tell because they look almost similar for both sexes. Due to the wide distribution and having large species diversity in a family, this Timaliidae have been chosen as focal species. By having large species diversity, it will easier to determine and analysed the affected species due to logging activities.

In the world, there are about 253 occurring species while in West Malaysia and Singapore, there are about 49 species that can be divided into six groups based on their physical characteristic and behaviour; 1) Jungle Babblers, 2) Scimitar- Babblers, 3) Wren-Babblers, 4) Tree and Tit-Babblers, 5) Song Babblers, and 6) Rail babblers. Laughing thrushes (in the category of Song Babblers), however, are elusive species that reside in thick jungle and are best located by voice. Asia is the centre of babbler distribution but they occur more widely than that.

Some babblers are small and colourful like the Silver-eared Mesia, White Bellied Yuhina and Chestnut-tailed Minla. They and other small babblers can be found in mixed species flocks or isolated pairs inside the forest. Babblers that are known as yuhinas are like titmice in their behaviour and have small crests but many are much more colourful, like the Chestnut-crested Yuhina in the montane forests of Borneo. Most babblers have a rather subdued plumage form but bright rufous also appears in many species. Another example of fairly

typical babbler type scattered among the wide geographic range of babblers include Chestnut-capped Laughingthrush of montane forests in Borneo, Sumatra & Malaysia. This insectivorous birds are ground-loving species, elusive, and difficult to observe in the forest understory. Some are quite specialized (limestone hills, swamps, bamboo, humid fern forest) and a fair number are rare and local while others are endemic to Borneo, Philippines, or Sumatra.

The rainforests in Southeast Asia are being logged for timber at such a rapid rate that understanding the effects of logging on plant and animal species in these forests is timely and imperative. Although selective logging for timber is often considered sustainable, the long term effects of selective logging on plant and animal communities are not well known (Johns, 1988; Vincent, 1995).

Effects are also likely to vary depending on harvest limits and damage caused by extraction techniques. Studies of bird communities in peninsular Malaysia and Borneo as well as other tropical locations indicated that bird diversity and species composition are affected by selective logging (Aleixo, 1999; Johns, 1989; Johns, 1996; Lambert, 1992; Wong, 1985) with some understory insectivores vanishing or becoming rare and edge species probing the interior of logged stands and increasing in abundance.

1.4 Microclimate Study

Microclimate is a state of local atmospheric or also known as topo-climate, such as temperature, precipitation, and incoming solar radiation (insolation), which is a fundamental determinant of habitat suitability. Changes of gradients of microclimate, with marked variation over short distances, can be characterized by a combination of sensor measurements and GIS-based models, and in turn related to ecological processes.

Among the challenges are understanding how fundamental climate and microclimate regimes are influenced by topography, water bodies, local energy balance, vegetation cover, and local air/water flow patterns. In addition, microclimate changes can provide either positive or negative impact on the populations of the insectivorous birds. For example, the increase of insectivorous population in some plantation forest will benefit the farmer where these insectivorous birds can effectively become a pest controller for their plantation farm. However, these phenomenon will depend on particular factor that need to be determined more in the study. The factors could be the temperature, humidity, or vegetation cover and patterns.

Classen *et al*, (2005) argued that any possible fluctuations in vegetation due to drought influenced herbivory may influence microclimate in ecosystems.

Herbivory was used in order to test the general hypothesis on alteration of plant architecture that will affect the soil microclimate, which is considered as a major driver of ecosystem-level processes. The attack of herbivory insects on the juvenile shoot will develop an open crown. This situation will affect the temperature of the area, as well as other wildlife such as birds. Meanwhile, Martin (2000) argued that species are commonly isolated along gradient of microclimate change and vegetation. He explored four ground– nesting bird species that are ground-nesting along a microclimate and vegetation area where he found that the birds shifted their nest position of their nests on the microhabitat and microclimate gradient in response to changing precipitation over the course of nine years. These results indicated that abiotic and biotic costs can strongly interact to influence microhabitat choice and abundances of coexisting species. Therefore, this situation will cause a microclimate change in that particular area. In this study, we are focusing on how the microclimate and microhabitat affects insectivorous birds in both logged and primary forest.

A study by Bigelow and Malcolm (2004) came out with several hypotheses on how different levels of canopy decrease affect microclimate, fuels and forest succession. Specifically, they examined the following ideas and test specific hypotheses for each:

1) The relationship between canopy cover and microclimate is linear (Weatherspoon, 1996). Alternatively, there may be a canopy cover inception where rapid changes in microclimate occur, or an asymptotic approach to maximum levels. 2) Changes in understory plant communities, and rates of recovery, are relative to changes in canopy cover and stem density from thinning and restoration treatments. Alternatively, there may be disturbance thresholds which when exceeded result in new, enduring plant and animals communities.

Sometimes, microclimate changes give a lot of benefits especially to human in agriculture industrial. A microclimate change can offer an opportunity as a small emergent region for crops that cannot thrive in the broader area and this concept is often used in permaculture practiced in northern temperate climates.

Microclimates can be used to the advantage of gardeners or farmer who carefully choose and position their plants. Incidentally, plantation estates such as oil palm plantations benefit a lot from microclimate change, where the changes of certain factor will decrease the numbers of insects as well as insectivorous birds. This is mainly because, the increase of insectivorous birds depends on both the availability of insects and the changes of microclimate in that particular area.

1.5 Microhabitat Study

Habitat preferences are expected to be adaptive, such that fitness is higher in preferred habitats, causing natural selection to maintain preferences if they have a genetic basis (Jaenike & Holt, 1991). However, clear demonstration of adaptive habitat preferences are uncommon. According to previous studies, the adaptiveness of host plant choice by insects have shown higher larval performance (a fitness component) on desired hosts, but many other studies have shown lower or no change in performance (Etges, 1993; Jaenike & Holt, 1991; Thompson, 1988; Valladares & Lawton, 1991). Most of these tests with insects were conducted in laboratory environments where effects of enemies i.e. predators and parasites on fitness are understated. Tests in field situations where enemies are present may provide more appropriate tests of the adaptiveness of preferences, but such tests are rare and particularly so for vertebrates.

Studies of habitat preference in birds often did not examine fitness and instead measured density because density is expected to be positively associated with habitat preference (Brown, 1969; Cody 1985, Fretwell, 1972; Whitham, 1980; Petit & Petit, 1996). However, density may not reflect preference or be positively correlated with suitability (Pulliam, 1988; van Horne 1983) since they need to be measured.

Such approaches ignore variation in fitness of individuals associated to variation in microhabitat quality within habitats (Martin, 1986). The regularity that a microhabitat type is chosen represents preference, such that the most frequently chosen microhabitat is the preferred one for each bird species in this study system. Microhabitats are defined based on vegetation, but birds could have been choosing another environmental feature (microclimate) associated with plants. Estimate of phenotypic variation in study site are assumable. Selection can only act on this phenotypic variation if it has a genetic basis. Few data are available showing genetic bases of habitat selection, because some evidence suggested that habitat preferences do indeed have a genetic basis (Jaenike & Holt, 1991).

1.6 Research Objectives

The aim of this study is to investigate how selective logging activity affects the species richness, species composition, and microclimate and microhabitat use pattern of the Timaliidae mainly in forest reserve for management and conservation efforts.

The research objectives of this study are as follows:

- To determine the Timaliidae species diversity and abundance in primary and logged forest using distance sampling and mist netting methods.

- To determine the microhabitat and microclimate factors that affecting the population size of Timaliidae in primary and logged forest.

- To determine which species of the Timaliidae suitable to be use as biological indicator of forest ecosystem health.

1.7 Hypothesis

1. Timaliidae species richness and abundace is higher in primary forest than in logged forest.

2. The microclimate and microhabitat-use patterns of Timaliidae differ between primary and logged forest.

3. The Timaliidae species are particularly sensitive to changes in microclimate and microhabitat associated with primary and logged forest.

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