COMPARATIVE STUDY OF UNDERSTOREY BIRD DIVERSITY OF SELECTED FOREST RESERVES IN PENINSULAR MALAYSIA

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ABSTRACT

Logging activities have significantly contributed toward changes in habitat structure of many Peninsular Malaysia forests. It affected food resources and lead to reduction in diversity and abundance of forest birds. In this study, diversity, abundance and community composition of understorey birds inhabiting four forest reserves throughout Peninsular Malaysia were studied. These forest reserves are Berembun Forest Reserve, Pasir Raja Forest Reserve, Tekam Forest Reserve and Endau-Rompin Johor National Park. All forests have component of unlogged and logged forests with various regenerating levels (years of left undisturbed since last logging activity was conducted) such as 1-15 years, 16-30 years, and more than 31 years. Thirty-two field visits have been conducted to study areas from August 2009 until December 2011. Twenty mist-nets were setup for three consecutive days at each study areas to sample understorey birds. A total of 1,389 understorey birds that belong to 26 families and 112 species were captured. Berembun Forest Reserve recorded highest number of understorey bird species while Endau-Rompin Johor National Park recorded least species. Generally understorey birds in unlogged forests are more diverse than logged forests (90 species or 24 families and 75 species or 21 families respectively). Insectivorous bird, dominated by Little spiderhunter (*Arachnothera longirostra*) of family Nectariniidae was the most dominant species in the study area. Results indicated that higher number of individuals and species were recorded in old growth forest (> 31 years) than other forest types. Results suggested that forest disturbance and habitat degradation are the factors that caused changes in understorey bird community and species decline. Logging process also had caused reduction in environmental quality which lead to limited food resources. These have caused understorey birds to disperse to other habitats. Diversity and abundance of bird's communities in old growth forest are recovering depending on ecological requirements of the species. The information derives from this study

highlighted the effects of logging on understorey bird species and the management practice of forest reserves in Malaysia.

ABSTRAK

Aktiviti pembalakan menyumbang ke arah perubahan struktur habitat kebanyakan hutan di Semenanjung Malaysia. Pembalakan memberi kesan kepada sumber makanan dan menyebabkan pengurangan kepelbagaian dan kelimpahan burung. Dalam kajian ini, kepelbagaian, kelimpahan dan komposisi burung bawah kanopi di empat hutan simpan Semenanjung Malaysia telah dijalankan. Hutan simpan yang dipilih ialah Hutan Simpan Berembun, Hutan Simpan Pasir Raja, Hutan Simpan Tekam dan Taman Negara Johor Endau Rompin. Kesemua hutan mempunyai komponen hutan belum dibalak dan hutan telah dibalak. Peringkat regenerasi (tahun terakhir tidak terganggu pembalakan) hutan dibahagikan kepada 1-15 tahun, 16-30 tahun, dan lebih daripada 31 tahun. Tiga puluh dua lawatan lapangan telah dijalankan dari Ogos 2009 hingga Disember 2011. Dua puluh jaring kabut dipasang selama tiga hari berturut-turut di setiap kawasan kajian untuk menyampel komuniti burung bawah kanopi. Sebanyak 1,389 burung bawah kanopi yang tergolong dalam 26 famili dan 112 spesies telah ditangkap. Hutan Simpan Berembun merekodkan jumlah tertinggi spesies burung bawah kanopi manakala Taman Negara Johor Endau Rompin merekodkan jumlah spesies terendah. Umumnya, kepelbagaian burung bawah kanopi dalam hutan yang belum dibalak adalah lebih tinggi berbanding hutan yang telah dibalak (90 spesies atau 24 famili berbanding 75 spesies atau 21 famili). Burung pemakan serangga, Kelicap Jantung Kecil (*Arachnothera longirostra*) daripada keluarga Nectariniidae merupakan spesies paling melimpah di kawasan kajian. Keputusan menunjukkan bahawa bilangan individu dan spesies yang tinggi direkodkan di hutan yang telah lama dibalak (> 31 tahun) berbanding hutan lain. Keputusan mencadangkan bahawa gangguan hutan dan kemusnahan habitat adalah faktor yang menyebabkan perubahan dalam komuniti burung bawah kanopi dan kemerosotan spesies. Proses pembalakan telah mengakibatkan kemerosotan kualiti alam sekitar yang menyebabkan sumber makanan terhad. Ini menyebabkan burung bawah

kanopi berpindah ke habitat lain. Kepelbagaian dan kelimpahan komuniti burung di hutan yang telah lama dibalak bergantung kepada keperluan ekologi sesuatu spesies. Maklumat daripada kajian ini menekankan kesan pembalakan kepada spesies burung bawah kanopi dan amalan pengurusan hutan simpan di Malaysia.

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LIST OF SYMBOLS AND ABREVATIONS

IUCN	International Union for the Conservation of Nature
VJR	Virgin jungle reserve
FR	Forest reserve
DBH	diameter at breast height
cm	centimeter
ha	Hectare
m^3	meter cube
%	Percentage
>	More than

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CHAPTER 1

INTRODUCTION

1.1 Birds

Tropical forest contains majority of planet's biota (Wielstra et al., 2011). The forest is unique sources of biodiversity, which can support high species richness among bird's community due to environmental and habitat condition (Johns, 1986). Tropical lowland rainforest provides suitable habitat for various bird species. This forest supplies food, offers protection and shelter for birds to survive and reproduce (Rosli and Zakaria, 2011). Therefore, loss of lowland tropical forests represents one of the greatest threats to bird diversity (Aratrakorn et al., 2006; Sodhi et al., 2008). It has been predicted that most of the currently threatened bird species could disappear by the end of this century if the present rate of deforestation continues (Pimm et al., 2006). The greatest causes for deforestation are the clearance of land for agriculture (Aratrakorn et al., 2006) and timber exploitation (Thinh et al., 2012).

Forests in Peninsular Malaysia play important role in conservation purpose because it harbours many species of plants and animals. Unfortunately, some of these forests are under threat due to logging activity, land clearance for agriculture or development, and human disturbance. To avoid or reduce deforestation, these forests need to be protected. The world conservation union (IUCN) defines protected area as an area of land or sea dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed it through legal or other effective means (Chape et al., 2003). Protected areas include nature reserves, wilderness areas, national park and forest management area. National park was assumed as a central to conservation strategies as it was designed to safeguarding the remaining habitat and forest species. Protected area is considered as an essential component of

conservation strategies. It provides host of services including biodiversity conservation, watershed protection, and carbon storage. There are also few other services offer by protected areas but it is more difficult to quantify especially in term of cultural services such as for recreation purpose and spiritual fulfillment (DeFries et al., 2007).

Recent study indicated that there are 696 species of birds recorded from Peninsular Malaysia (BirdLife-International, 2013). This is an increase from previous records which indicated a total of 656 bird species belong to 87 families were recorded in Peninsular Malaysia while 568 and 550 species are recorded in Sabah and Sarawak respectively (Robson, 2008; MNS-Bird, 2010). These additional species is due to new records to Malaysia and taxonomic revision of current species. Of total, 216 are grouped as aquatic and upper storey birds while 24 are nocturnal birds. In term of status, 445 species are resident, 185 are migrant, while 40 species have both resident and migrant populations (MNS-Bird, 2010).

1.2 Importance of Birds

Birds play important roles as predator, prey and beneficial agents for pollination, germination, and seed dispersal (Sodhi et al., 2005). Members of families Picidae, Megalaimidae, Cuculidae, Laniidae, Muscicapidae, Pycnonotidae, Passeridae and Fringilidae are important in pollination of wild plants (Corlett, 2004). Frugivorous birds are considered important mobile links by functioning as pollinators and seed dispersal agents (Lee et al. 2002).

Birds also effective as bio-indicator in the study of the impacts of forest disturbance and habitat structure on species composition (Karr et al., 1990). Birds can be a very good environmental indicators because of their sensitivity to small changes in habitat structure (Owiunji and Plumptre, 1998) and environmental changes (Schulze et al., 2004). Tropical birds are particularly useful in assessing the impacts of forest disturbance on biodiversity because their ecology and distributions are generally well

known (Mansor and Sah, 2012), and natural and anthropogenic related disturbance can affect tropical bird species diversity and community organization (Newmark, 2006). They also contribute to ecosystem functioning by creating and modifying forest structures through breeding, foraging and roosting activities (Preston, 2006). Forest configuration and diversity, and composition of the habitat affecting the availability of bird's foraging resources, preferred nesting area, roosting or perching sites and therefore influence distribution pattern of forest birds (Laiolo, 2002). Many tropical birds are sensitive to the landscapes alteration than higher latitude bird. A number of reasons for greater sensitivity of tropical forest birds include greater habitat and dietary specialization, lower population density and reduced dispersal capacity (Zanette et al., 2000; Sodhi et al., 2004).

1.3 Importance of Research

Birds are effective as bio-indicator of the impacts of forest disturbance and habitat structure on species composition (Karr et al., 1990). Birds can be environmental indicators because of their sensitivity to small changes in habitat structure (Owiunji and Plumptre, 1998) and environmental changes (Schulze et al., 2004). This study was used ability of birds as the indicator to examine the role of unlogged forest as the buffer of forest dependent species when it is located nearby logged forests. Recovery process along forest succession gradient after logging lead to changes in birds communities through times (Thinh, 2009). This study also discovers the responses of birds based on their species and communities with the different stages of forest recovery.

1.4 Research Objectives

There are three main objectives in this study. First was to study diversity and composition of understorey birds inhabiting four selected forest reserves in Peninsular Malaysia. Second to compare diversity and community composition understorey birds in unlogged and logged forests. Third to study composition of understorey birds inhabiting forests with different regenerating ages.

1.5 Research Hypotheses

The hypotheses of this research are:

i) Bird composition in unlogged and logged forest is different.

ii) Bird composition changes during different stages of forest regeneration.

CHAPTER 2

LITERATURE REVIEW

2.1 The History of Logging Systems in Peninsular Malaysia

In Peninsular Malaysia, systematic forest management and development has been initiated in 1901 (Jusoff and Mustafa, 1996; Latiff, 2011). The forest was selectively logged for naturally durable heavy hardwoods such as Cengal (*Neobalanocarpus heimii)* and various Balau group (*Shorea* sp*).*

In 1911 to 1922, the Improved Felling system was implemented to favour the development of one species, *Palaquium gutta* that was highly priced and demanded. When demand for poles increased in 1922, a review of the management system was made that resulted in two systems; the Department Regeneration Improvement Felling (RIF) and the Commercial Regeneration Felling (Latiff, 2011).

Since 1948, all forested areas in Malaysia were managed under the Malayan Uniform System or MUS (Latiff, 2011). This system has a rotation cycle of 55 years (Taha and Jusoff, 2008). It focused is to remove all mature trees with more than 45 cm dbh without considering the quality or amount of commercial tree species presence in particular logging area (Taha and Jusoff, 2008; Latiff, 2011).

In 1978, a new system known as Selective Management System (SMS) was introduced (Latiff, 2011). Most production forests were managed under this new system to allow more flexible timber harvesting regimes (Samsudin et al., 2010). Pre-felling forest inventory was established to ensure logging process will retain at least 32 commercial trees (with diameter class of 30-45 cm) per hectare. This system is more consistent with the need to protect the environment and produce more timber as demanded. The cutting cycle is approximately 25-35 years after the first logging with an

expected net economic outturn of 40-50 m^3 / ha of dipterocarp species for the next cut (Ahmad and Kamaruzaman, 2003).

Logging affects the ecological processes within timber concessions by removing biomass, changing forest structural characteristics, changing light regimes, and altering microclimatic condition at both ground and canopy levels. Logging also introduces people into forest, increases access via logging roads and generally increase disturbance (Dennis et al., 2008).

2.2 Impacts of Logging on Birds

Forest biodiversity is greatly affected by human activities such as mining operation, agricultural expansion (Canaday, 1997), timber extraction (Thiollay, 1992) and hunting of wild animals. In Peninsular Malaysia, most of the pristine lowland dipterocarp forests have been exploited for timber extraction and planting commercial crops (Caufield, 1991). The most rapidly expanding crops in tropical region are oil palm (*Elais guineensis*) and rubber (*Hevea brasiliensis)* (Clay, 2004). These activities reduced the diversity of fauna and reflects the degree of habitat disturbance (Mansor and Sah, 2012), leading to the extinction of many endemic species (Sheldon et al., 2010).

As pointed out by Aratrakorn et al. (2006), converting forest to commercial plantations had caused severe threat to biodiversity, producing habitat that support communities dominated by a small number of common and widespread species. Two major changes to bird communities are replacement of species rich communities with species poor communities, and replacement of threatened and range-restricted species by species of lower conservation concern and with extensive ranges (Aratrakorn et al., 2006).

Selective logging is the most popular and widely used approach for commercial timber production in Southeast Asia. This approach rarely cut more than 5% of total stems and accidental damage is considerable with stand destruction is usually kept less than 40% (Johns, 1986). However this level of damage is sufficient to cause considerable change in patterns of resources abundance, microhabitat diversity, predator/prey relationship and other controlling factors (Johns, 1986).

Bird community composition is strongly influenced by change in forest vegetation structure (Wiens, 1992; Barlow and Peres, 2004). How the species are affected depends on the species ecology and the intensity of the forest disturbance. Some species benefiting from high disturbance caused by logging process but others are negatively affected by slightest disturbance (Meijaard et al., 2005).

Owiunji and Plumptre (1998) have compared bird community in selectively logged and unlogged sites. They have found that most species found in the unlogged sites also occur in the logged sites but species densities differ. Some species that were frequently observed in primary forest (e.g. *Anorrhinus galericulatus*) survive well in logged forest whereas others (e.g *Rhipidura perlata*) do not (Johns, 1986). Colonizing or secondary forest species such as bulbuls and spiderhunters (families Pycnonotidae and Nectariniidae respectively) increased in number while primary forest species such as babbler (family Timaliidae) decreased when condition shifted from primary to logged forests (Zakaria et al., 2005).

Stryring and Ickes (2001) discovered that Woodpecker (family Picidae) is particularly sensitive to habitat disturbance. Their study in logged and unlogged forest at Pasoh Forest Reserve, Peninsular Malaysia found that woodpecker abundance differed slightly between forest types but relative abundance of certain species differed significantly. Three species (i.e. *Reinwardtipicus validus, Dryocopus javensis,* and *Meiglyptes tristis*) were significantly abundant in primary forest while two species

(i.e. *Picus mentalis* and *Picus puniceus*) are significantly more abundant in logged forest. Other studies on rare, declining and endangered woodpecker had found that woodpecker need a substantial number of mature/dead and dying trees for forage or excavate nest cavities (Rolstad et al., 1998; Flemming et al., 1999). This is because selectively logged tropical forest contains fewer cavities than unlogged forest (Flemming et al., 1999).

Felton et al. (2008) found that bird communities differed significantly in composition between logged and unlogged areas. Over 40% of bird species that exhibit significant association with the unlogged areas is considered to be highly sensitive to human disturbance and have conservation concern. On contrary, species which are significantly associated with logged areas are primarily species that are known to be relatively resilient to human disturbance. Birds in unlogged forest are associated with forest habitats dominated by high diversity of tree, providing dense canopy cover and deep leaf litter.

2.3 Diversity of Birds Inhabiting Regenerated Forest

Birds communities are strongly influenced by habitat change (Terborgh et al., 1990). The recovery process, along forest succession gradient after logging, lead to changes in avian communities through time (Thinh, 2009). The stages of forest growth exert strong effects on bird assemblages. Although many bird species prefer a particular stage of growth, its species richness tends to increase with stand age. Most hole-nesters birds select forest stages with mature trees, while many migrant passerines are confined to the earliest stages when the vegetation is more open (Fuller, 1995).

In Peninsular Malaysia, some studies on the effects of logging on bird communities have focused on the early stages of forest regeneration (e.g. Johns, 1986, Johns 1989). Others have compared the biota of primary forest with those of >20 years old forest (e.g. Wong, 1985, Wong, 1986). Few studies have surveyed more than one unlogged

areas and while others have selected logged areas at different stages of recovery (e.g. Johns, 1996, Peh et al., 2005). Johns (1989) argued that the effects of logging can only be measured accurately if a particular site is monitored before, during, and several years after logging was conducted. However this is not possible since for most logging systems, this will require continuous monitoring for over 30-40 years and possibly up to 60 years after harvesting was done (Owiunji and Plumptre, 1998). Furthermore, different species of bird and communities will responses differently (Thiollay, 1992). The responses may vary few years after logging but become stable several years later (Azevedo-Ramos et al., 2006; Yap et al., 2007). However sensitive species such as woodpecker may take longer time (Styring and Ickes, 2001).

Johns (1989) conducted a study in Tekam Forest Reserve and had found that many terrestrial birds were entirely absent from recently logged forest due to the effects of microclimatic changes on the microfauna of the leaf-litter. Terrestrial birds such as pitta (family Pittidae), partridges (family Phasianidae), some understorey flycatcher (family Muscicapidae) of unlogged forest, and aquatic invertebrate specialists such as White-crowned forktails have failed to recolonize even after 12 years of logging. Increased canopy discontinuity that fragments these low light habitats may reduce the availability of suitable foraging conditions for light sensitive species (Felton et al., 2008).

Thinh (2009) found that recovery rate of forest generalists (species inhabits all succession stages) was very high during the first 15 years of succession and then become asymptotic. He predict that forest generalist (species that mostly inhabit later succession stages) are not affected much by forest logging even at short logging cycles and small amounts of wood were left due to the broad habitat requirements. In contrast, specialist species decrease immediately right after the forest was heavily logged. Intense

logging most likely reduces the complexity of vegetation structure and other resources. However, bird community can recover over the next 40-50 years (Thinh, 2009).

Many primary forest species that have been initially affected by logging are capable of recolonizing the logged forest over time. Bird species that were recorded in unlogged forest of Ulu Segama have been recorded in the forest that was logged 6-12 years ago and in addition there was an invasion of non forest species into logged forest (Johns, 1996). Study by Peh et al., (2005) at Bekok and Belumut showed that avifauna differed between disturbed and undisturbed sites in both species richness and community structure. Suprisingly, they have recorded two species (i.e. *Rinomyas umbritailis* and *Cuclicipa ceylonensis*) in 30 years logged forest. Both species were absent from one and twelve years old logged forests in earlier studies by Johns (1986) and Johns (1989). Bird diversity in the logged forest usually consists of second growth species (such as *Prinia rufescens*) or forest edge species (such as *Pycnonotus plumosus*) (Peh et al., 2005). Most of the ground dwelling species are still absent in the relatively old logged forest despite the lack of any apparent barriers between logged and primary forests. They suggest that ground dwelling birds are more sensitive to disturbance and at higher risk than species that occupied other strata.

2.4 Feeding Guilds

Yap et al., (2007) studied the effects of selective logging and food resources on understorey birds in regenerated and unlogged forests in Bekok and Belumut. He found that there were no significant differences in abundance, relative species richness, breeding and moulting occurrence, and food abundance of birds between different forest types. He concluded that phenology, composition and food resources of birds in 30 years of selectively logged forest were comparable to adjacent primary forest, which possibly indicates advanced stages of forest regeneration.

It was suggested that among feeding guild, terrestrial insectivorous was the most adversely affected guild by forest disturbance (Newmark, 2006). Large and small terrestrial birds species were the most affected by forest disturbance and their abundance had decreased (Thiollay, 1997). Newmark (2006) found that the relative abundance of terrestrial insectivorous birds was approximately twice in primary than disturbed forests. These studies discovered that many species of understorey birds require longer recovery time after disturbance had occurred. The studies also concluded that common species of terrestrial insectivorous which most adversely affected by forest disturbance did not vary significantly in population growth rates. Most terrestrial insectivorous birds population have small chances to recover in moderately disturbed forest.

Reduction in abundance was more pronounced among terrestrial insectivorous and insectivores-frugivores birds (Johns, 1996). Bark gleaning insectivorous (such as woodpecker) was also experienced reduction in species richness and abundance following logging activities (Johns, 1989; Lambert, 1992). However, species incorporating nectar into their diet are generally not adversely affected by logging activity. Many generalist insectivorous-frugivorous species such as canopy frugivores were affected by logging activities. The population size of fifteen species of

insectivores-frugivores birds was decreased following logging. These include *Rhipidura perlata, Culicicapa ceylonensi* (sallying insectivorous) and *Harpectes diardi* (sallying foliage-gleaning insectivore) (Johns, 1996).

Pearman (2002) suggested that variation in species richness for some bird species (e.g. hummingbird) is related to variation among study sites in term of physical characteristics and vegetation structure. Species may differ in term of strongly influenced by local environmental variation or by habitat variability at landscape level (Pearson, 1993), or affected by the distribution of habitat types which can vary among functional groups (Robinson, 1992). A correlation between local vegetation's characteristics and species richness is present in some guilds and not in others. In contrast, species richness in some guilds is closely depends on primary forest cover than local environment or vegetation structure (Pearman, 2002).

CHAPTER 3

METHODOLOGY

3.1 Sites Description

Four study sites, located throughout Peninsular Malaysia were selected for this study. These are Berembun Forest Reserve (Berembun FR), Pasir Raja Forest Reserve (Pasir Raja FR), Endau-Rompin Johor National Park (Endau-Rompin JNP) and Tekam Forest Reserve (Tekam FR) (Figure 3.1-1). Field samplings were conducted from September 2009 to October 2011 (Table 3.1-1). All study sites were chosen based on few criteria including:

i. Each study site must have patch of unlogged forest surrounded by selectively logged forest.

ii. The selected logged forest have different regenerating ages;

    a. Early regenerated forest (have been logged between1-15 years ago)

    b. Intermediate regenerated forest (have been logged between16-30 years ago)

    c. Old growth forest (have been logged more than >31 years ago)

All chosen sites share similar topographical characteristics and types of habitat (Table 3.1-2). It is assumed that the structure and composition of understorey bird community of all study sites were similar before forest was disturbed.

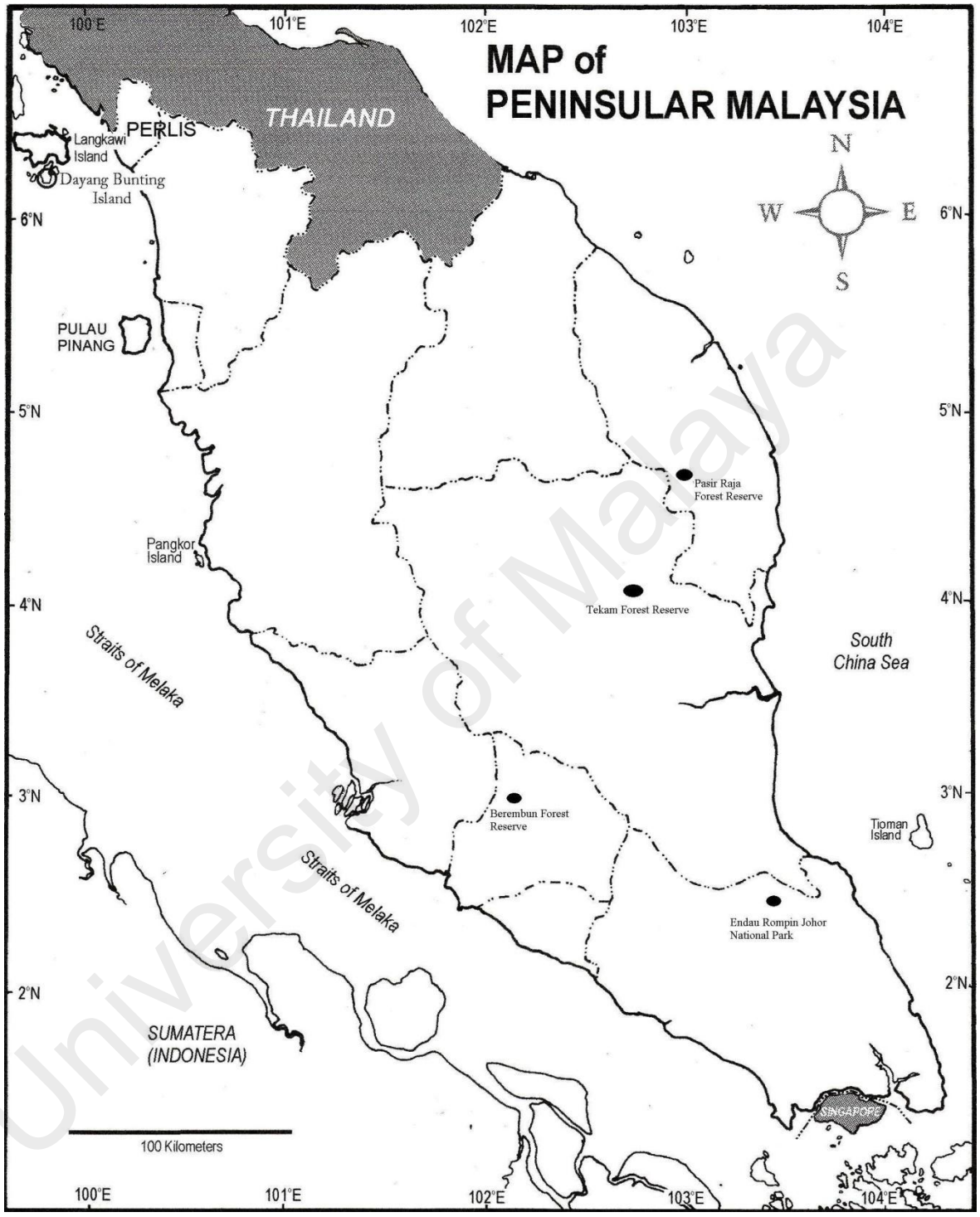


Figure 3.1-1: Location of four study sites in Peninsular Malaysia.

Table 3.1-1: Details of coordinates of study sites.

	Forest	GPS Coordinates	Sampling Date
Berembun FR	Unlogged	N 02°49.931' E 102°02.610'	11-13 Sept 09
		N 02°48.124' E 102°01.314'	14-16 Nov 09
		N 02°50.245' E 102°03.377'	18-20 Apr 10
		N 02°48.182' E 102°01.365'	8-10 May 10
	Logged (16-30 years)	N 02°51.852' E102°00.844'	8-10 Jan 10
		N 02°52.457' E102°01.222'	20-22 Jan 10
		N 02°51.961' E102°00.636'	17-19 Aug 11
		N 02°52.307 E 102°00.805'	20-22 Aug 11
Pasir Raja FR	Unlogged	N02°49.996' E 102°02.915'	7-9 Oct 09
		N 04°43.199 E 102°57.879'	17-20 June 10
		N 04°35.574 E 102°56.627'	14-16 Sept 11
		N04°35.726' E 102°56.531’	12-14 Oct 11
	Logged (1-15 years)	N 04°41.659 E 102°58.887'	5-7 Feb 10
		N 04°41.996 E 102°53.454'	28-30 Mar 10
		N 04°37.683 E 102°56.511'	27-30 July 10
		N 04°42.445 E 102°57.461'	21-24 Sept 10
Endau-Rompin JNP	Unlogged	N 02°30.768' E 103°21.145'	28-31 Aug 09
		N 02°30.815' E 103°21.287'	19-22 Feb 10
		N 02°30.693 E 103°21.109'	28-30 Apr 10
		N 02°30.587' E103°21.928'	3-5 July 10
	Logged (>31 years)	N 02°31.212 E 103°20.906'	5-9 Aug 09
		N 02°31.869' E103°22.571'	9-13 Apr 10
		N 02°31.967 E 103°23267'	26-29 May 10
		N02°31.992' E 103°23.734'	2-5 Nov 10
Tekam FR	Unlogged	N04°00.259' E 102°301.368'	5-7 Mar 10
		N03°59.403' E 102°36.034'	27-29 Aug 10
		N04°00.358' E 102°30.162'	24-26 Feb 11
		N04°00.242' E 102°30.294'	20-22 June 11
	Logged (16-30 years)	N04°01.405' E 102°29.484'	23-26 Jan 10
		N04°00.348' E 102°30.397'	19-21 Mar 10
		N04°01.428' E 102°29.476'	13-15 July 10
		N04°00.242' E 102°30.294'	17-19 June 11

Table 3.1-2: Location and habitat description of each study sites.

State	Forest Reserve	Description of habitat
Johor	Endau-Rompin JNP	Logged forest, unlogged forest, lowland dipterocarp forest
Negeri Sembilan	Berembun FR	Logged forest, unlogged forest, lowland and hill dipterocarp forest
Terengganu	Pasir Raja FR	Logged forest, unlogged forest, lowland dipterocarp forest
Pahang	Tekam FR	Logged forest, unlogged forest, lowland dipterocarp forest

3.1 a) Berembun Forest Reserve

Berembun FR is located in Negeri Sembilan. The forest was managed by Department of Forestry, Negeri Sembilan. Forested areas covered approximately 21,939 hectares with altitude ranges from 144 meters to 1194 meters. The unlogged forest was conserved as Virgin Jungle Reserve (VJR) in 1993. This area assigned as Compartment 32 and 33 which cover 1834 hectares. The adjacent area (Compartment 31) which covers 155 hectares. The selected study area consists of lowland and hill Dipterocarp forests. Few timber species such as keruing (*Dipterocarpus* sp.) and meranti (*Shorea* sp.) were found in the forest reserve. In addition, other fruit tree species such as wild banana (*Musa* sp.), wild cempedak (*Artocarpus* sp.), ginger (*Zingerber* sp.), and figs (*Ficus* sp.) can also be found. There are plentiful of wild banana (*Musa* sp.) and tepus (*Amomum* sp.) along logging road.

3.1 b) Pasir Raja Forest Reserve

Pasir Raja FR is located approximately 80 km west from Dungun, western part of Terengganu. This forest is managed by Department of Forestry Terengganu. Terengganu is one of state that used Selective Management System (SMS) since 1979 (Na'aman Jaafar, 2006). The forest reserve consists of unlogged and logged forests. The unlogged forest was located at compartment 5, where the biggest cengal (*Neobalanocarpus heimii*) was found (Aziz and Borhan, 2010). Other timber species such as keruing (*Dipterocarpus* sp.), meranti *(Shorea* sp.), kulim (*Scorodocarpus dorneensis*) and kembang semangkok (*Scaphium* sp.) have survived in the forest reserve.

3.1 c) Endau-Rompin Johor National Park

The Endau-Rompin JNP is located at southern part of Peninsular Malaysia. The park is managed by Johor National Park Corporation and covers an area of approximately 48,905 hectares at the border of two states, Johor and Pahang. This park was established in 1989 and was gazzeted as National Park in 1993. Forested areas within the park consists of a mixture of both primary and secondary forests (disturbed by logging or destruction by human activities), lowland and dipterocarp tropical rainforests. Most of the forests were generally classified as mixed dipterocarp forest. Tree species presence in the forest include the keruing (*Dipterocarpus* sp.), kapur (*Dryobalanops aromatic*), and red meranti (*Sho*rea sp.).

The logged and cleared areas can be found at Kuala Jasin. In logged forest, species such as *Macaranga gigantei*, *Calicarpa longifolia* and *Musa garcilis* were commonly found. The forest around Kuala Jasin and Upeh Guling was logged in 1977. These logged areas have received some post-harvest silvicultural treatment under the Malayan Uniform System. Four sampling sites were chosen for unlogged areas. The samplings were conducted at Kuala Marong, along the trail to Tasik Air Biru and Buaya Sangkut. While four sampling sites were choosen for logged area. The samplings were conducted around Nature Education Research Centre (NERC) to Kuala Jasin.

3.1 d) Tekam Forest Reserve

Tekam FR is part of the main range which was situated in the district of Jerantut, Pahang, Malaysia. The forest covers 11,034 hectares and was rich with *Shorea curtisii* (Samsudin et al., 2010). It is accessible from old logging road and located closed to oil palm plantation. The forest type of the area is defined as hill and lowland dipterocarps, which is common at elevations between 300 to 500 m above sea level.

3.2 Sampling Design

3.2.1 Mist netting

The study was conducted from August 2009 until October 2011. Twenty mist nets, located approximately 20 meter apart, were randomly setup within the study area. The nets were erected along available tracks (animal track or old logging road) that were used as transect. All mist nets in logged forests were set up 100 meters from logging roads to avoid edge effects. The nets have similar dimension (12 x 3 meters) and mesh size (36 mm) with three pockets. The nets were supported by two aluminum poles and setup 0.5 meters above the ground to avoid ground predators such as snakes, monitor lizard, and ground squirrel (Ramli et al., 2004). The nets were setup under close canopy to avoid sun reflection which produced silhouette. Cutting the undergrowth were kept to a minimum to ensure habitat structure remain intact (Rahman et al., 2002). Mist nets were erected in birds flying pathway or near the water source (Bibby et al., 1998).

All nets were operated from 0800 hours until1800 hours within the study area for three consecutive days. Previous study indicated that netting for more than two days in the same areas will lead to drastic reduction in the number of captures (Karr, 1981). Besides, deploying mist nets for more than five days also will dramatically increase recapture rate (Wong, 1985; Wong, 1986; Rahman et al., 2002). The nets were checked hourly to minimize bird's injury and mortality due to ground predator, exposed to heat or cold and seriously tangled. All nets were closed during extreme weather condition such as heavy rain, extreme temperature or strong wind (McCracke, et al., 1999).

Mist netting is a good sampling method to study understorey birds (Seaman and Schulze, 2010). Mist nets relatively easy to use and it is simplify species identification. Mist netting data are used in determining species richness in the study areas by trapping cryptic species (Ramli et al., 2004). This technique provides the most efficient and reliable way to document diversity of understorey birds inhabiting the tropical forest

(Derlindati and Caziani, 2005). In addition, mist netting tends to sample inconspicuous and vocally inactive bird species (Hawes et al., 2008).

However, not all species present in the forest will be captured by mist nets (Willson and Moriarty, 1976). Mist nets are known to be biased against canopy species (Terborgh and Weske 1976).This method introduced bias in data on community structure (Karr, 1981) but it enable identical sampling of different habitat (reducing the observer bias inherent in bird census) (Barlow et al., 2006).

3.2.2 Field sampling

All captured birds were identified up to species level using information derived from standard field guides (such as Jeyarajasingam and Preston, 1999; Robson 2008). Standard morphological characteristics such as tarsus length, culmen, bill height, bill width, wing length, and body length were measured using caliper and steel ruler (McCracken et al., 1999). In addition, information related to age, body mass and sex were gathered before birds were released at the point of capture. Body mass was measured using Pesola' scale (100g and 600g). These informations were used in species identification. Captured birds (except kingfisher) were marked with aluminum ring that bear specific serial number on their tarsus. This will facilitate identification of recaptured individuals.

3.2.3 Feeding guilds

Captured species were classified into different feeding guild based on their diets. A total of nine feeding guilds were classified based on previous studies (Johns, 1986; Johns, 1989; Wells, 1999). These are miscellaneous (MIP), foliage gleaning insectivorous (FGI), terrestrial frugivorous (TF), arboreal frugivorous (AF), sallying insectivorous (SaI), arboreal insectivorous frugivorous (AIF), terrestrial insectivorous (TI), insectivorous nectarivorous (IN), and bark gleaning insectivorous (BGI).

3.3 Data Analysis

3.3.1 Capture rate

Capture rate was used to measure bird relative abundance and to account for differences in number of netting hours among samples. Capture rate was calculated to minimize biases in sampling. Capture rate was calculated based on the total number of netting hours multiply by the number of mist net which was deployed at each study sites (Rahman et al., 2002; Ramli et al., 2004). Capture rate is represented by formula below:

$$\text{Capture rate} = \frac{\text{Number of individuals captured}}{\text{Netting hours}}$$

Netting hours was calculated using formula = (a) x (b) x (c) where

(a) = total of mist nets erected in each sampling site (e.g. 20 nets)

(b) = number of sampling day (e.g. 3 days)

(c) = total hours of mist-net operated (e.g. ranges from one to 12 hours a day)

3.3.2 Diversity indices

Diversity values were calculated using Species Diversity and Richness Program (SDR IV) (Seaby and Henderson, 2006). Several indices were used to calculate diversity value. Simpson index was used to measured relative importance of dominant species. This index is heavily weighted towards species abundant but less sensitive to species richness (Magurran, 2007). If Simpson index value increases, species diversity will decrease. Shannon-Weiner index assumed that individuals are randomly sampled from infinite large community, and all species are represented in the sample (Magurran, 2007). Margalef index was used to calculate species richness value. Evenness index, calculated by Pielou equation, was used to determine the degree of equitability among species. The value of this index can vary between 0-1 (where all species in the area are equally distributed).

3.3.3 Statistical analysis

A species accumulation curve was plotted to assess completeness of sampling effort in each study site. To estimate bird species richness for each study sites, three nonparametric species estimator were calculated. These were incidence-based estimator (Chao 2), incidence based coverage estimator (ICE), and Michaelis-Menten model estimator (MMMean) (Colwell, 2000). Previous studies have proven these three estimators were the best performance for predicting tropical bird species richness (Herzog et al., 2002; Peh et al., 2005).

Significant difference between two means (average) from two sets of data was determined using Mann-Whitney U test while non parametric Kruskal-Wallis tests was performed to compare the number of species found in the three habitat zones.

Jaccard similarity index was used to compare similarity in species assemblages among habitat. This analysis measure the similarity of species composition based on binary data (species presence = 1 while species absence = 0). Similarity percentage was calculated by dividing the total number of recorded species. Statistical analysis was done using Species Diversity and Richness (SDR IV), SPSS Statistic 11.5 and EstimateS.

CHAPTER 4

RESULTS

4.1 Understorey Birds Assemblage of Selected Forest Reserves in Peninsular Malaysia

4.1.1 Overall

A total of 1,389 understorey birds (recapture birds were excluded) that belong to 26 families and 112 species were captured during sampling. Pasir Raja FR recorded highest captured (403 individuals, 18 families) but least understorey birds were netted in Tekam FR (247 individuals, 14 families). Meanwhile, Endau-Rompin JNP recorded 359 individuals which belonging to16 families. Berembun FR has recorded 380 individuals belong to 22 families (Figure 4.1-1). There is no significant different in abundance of birds within study sites ($\chi^2 = 6.171$ d.f = 3 $p>0.05$).

Overall, family Timaliidae has the highest number of individuals (26%) followed by family Nectariniidae (24.8%) and Pycnonotidae (16.5%). Six families were represented by single individual at each sampling site. These are Camphephagidae, Corvidae, Cuculidae, Irenidae, Laniidae and Sittidae. Most diverse species were represented by family Timaliidae (23 species), family Muscicapidae (15 species) and family Pycnonotidae (15 species) (Figure 4.1-2).

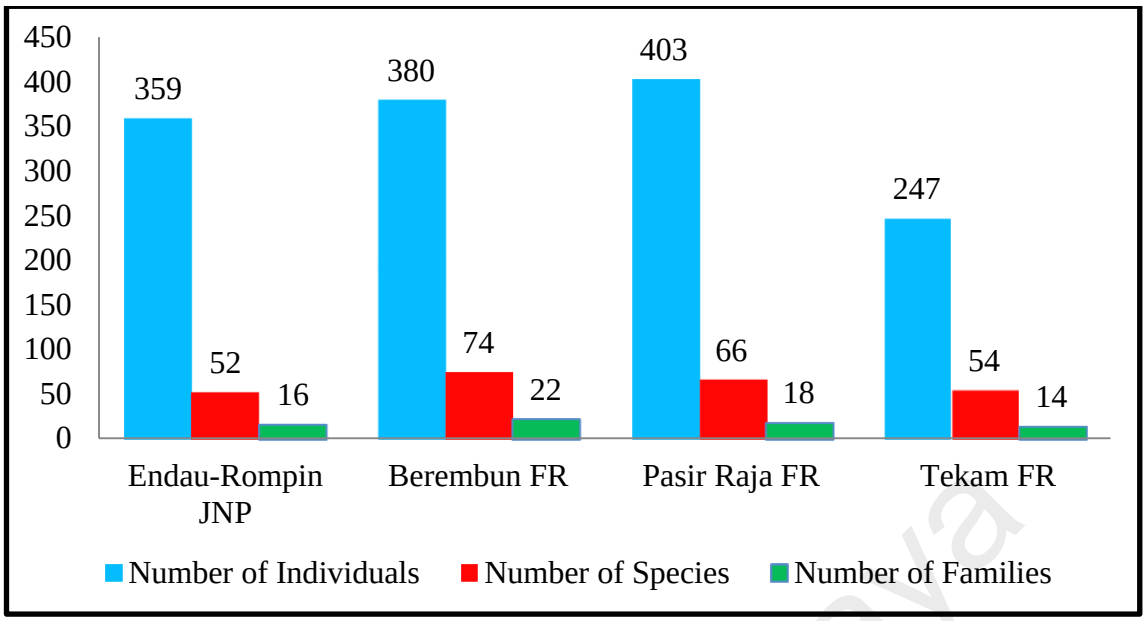


Figure 4.1-1 : Number of birds captured in four forest reserves in Peninsular Malaysia.

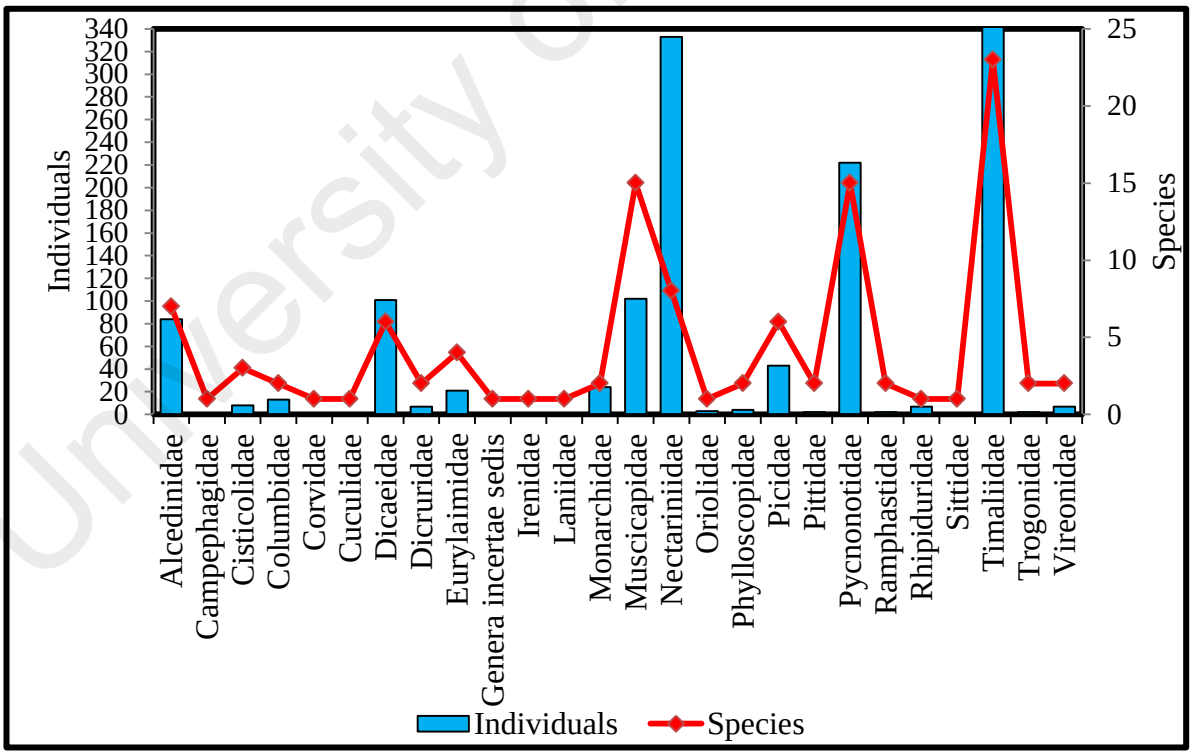


Figure 4.1-2: Family and species composition of birds in four forest reserves in Peninsular Malaysia.

In term of species, Berembun FR has the highest species recorded (74 species), compared to Pasir Raja FR (66 species), followed by Tekam FR (54 species) and Endau-Rompin JNP (52 species). Berembun FR had more bird species compared to other forest reserves (Margalef's=12.289, Menhennick's=3.796) (Table 4.1-1). However, the highest bird diversity was recorded in Endau-Rompin JNP (Shannon-Weiner index=3.366) and the lowest in Tekam FR (Shannon-Weiner=3.322). The distribution of individuals among the species was highest in Endau-Rompin JNP (Pielou J=0.852) and lowest in Berembun FR (Pielou J=0.773) (Table 4.1-1).

Species accumulation curve showed that new species are still being added in Pasir Raja FR and Tekam FR (Figure 4.1-3). Recording of new species was initially fast but slowing down after fourth sampling. However, bird population in Berembun FR and Endau-Rompin JNP nearly reach the asymptote after eight sampling. The curve had not reached asymptote indicated that not all species presence in the study sites were sampled. Generally, the curve showed that the sampling effort had provided a good representation of the species. Newly added species were increased dramatically during early sampling but slowly decrease after third sampling, only few species were added into the curve. Species richness estimator indicated that Endau-Rompin JNP had been well sampled (more than 90%) compared to other study sites (Table 4.1-2).

The number of capture per mist-nets (1mnh) was standardised. Among four forests reserves, Berembun had the highest cumulative capture rates (1.482) followed by Pasir Raja (0.764), Endau-Rompin JNP (0.659) and Tekam (0.492) (Figure 4.1-4).

Table 4.1-1 : Diversity values for understorey birds inhabiting different forest reserves.

	Berembun FR	Pasir Raja FR	Endau-Rompin JNP	Tekam FR
No. of individuals	380	403	359	247
No. of families	22	18	16	15
No. of species	74	66	52	54
Richness				
Margalef's Index	12.289	10.835	8.669	9.62
Menhennick's Index	3.796	3.288	2.74	3.436
Diversity				
Simpson's Index (D)	0.092	0.068	0.051	0.06
Shannon-Weiner (H')	3.326	3.349	3.366	3.322
Evenness				
Pielou J	0.773	0.799	0.852	0.833

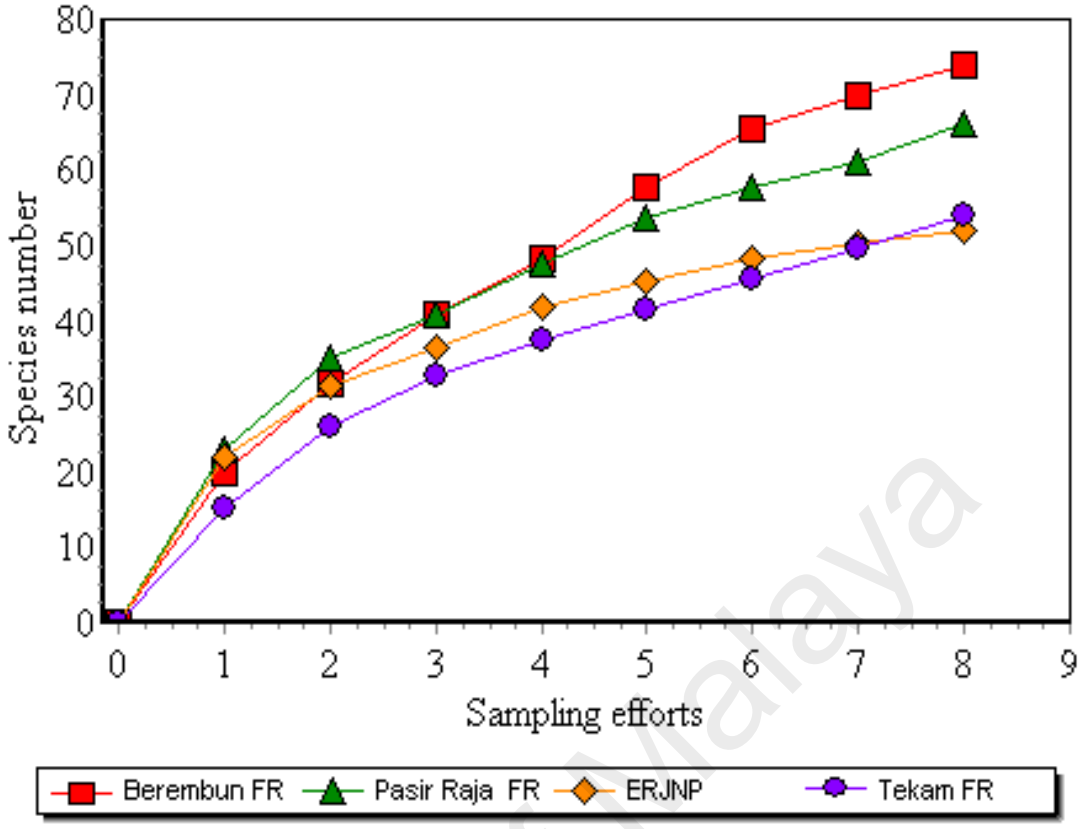


Figure 4.1-3: Species accumulation curves for understorey birds inhabiting different forest reserves in Peninsular Malaysia.

Table 4.1-2: Species richness estimation of different habitats based on non-parametric tests (Chao 2 refers to incidence-based estimator, ICE refers to incidence based coverage estimator, and MMMeans refer to Michaelis-Menten model estimator).

Site	No. of species	Richness estimators			% total richness estimated (Chao 2)
		Chao 2	ICE	MMMeans	
Berembun FR	74	126.53	140.01	124.5	54.48
Pasir Raja FR	66	109.68	108.7	92.21	60.175
Endau-Rompin JNP	52	55.78	59.7	66.96	93.22
Tekam FR	54	99.56	93.09	78.86	54.24

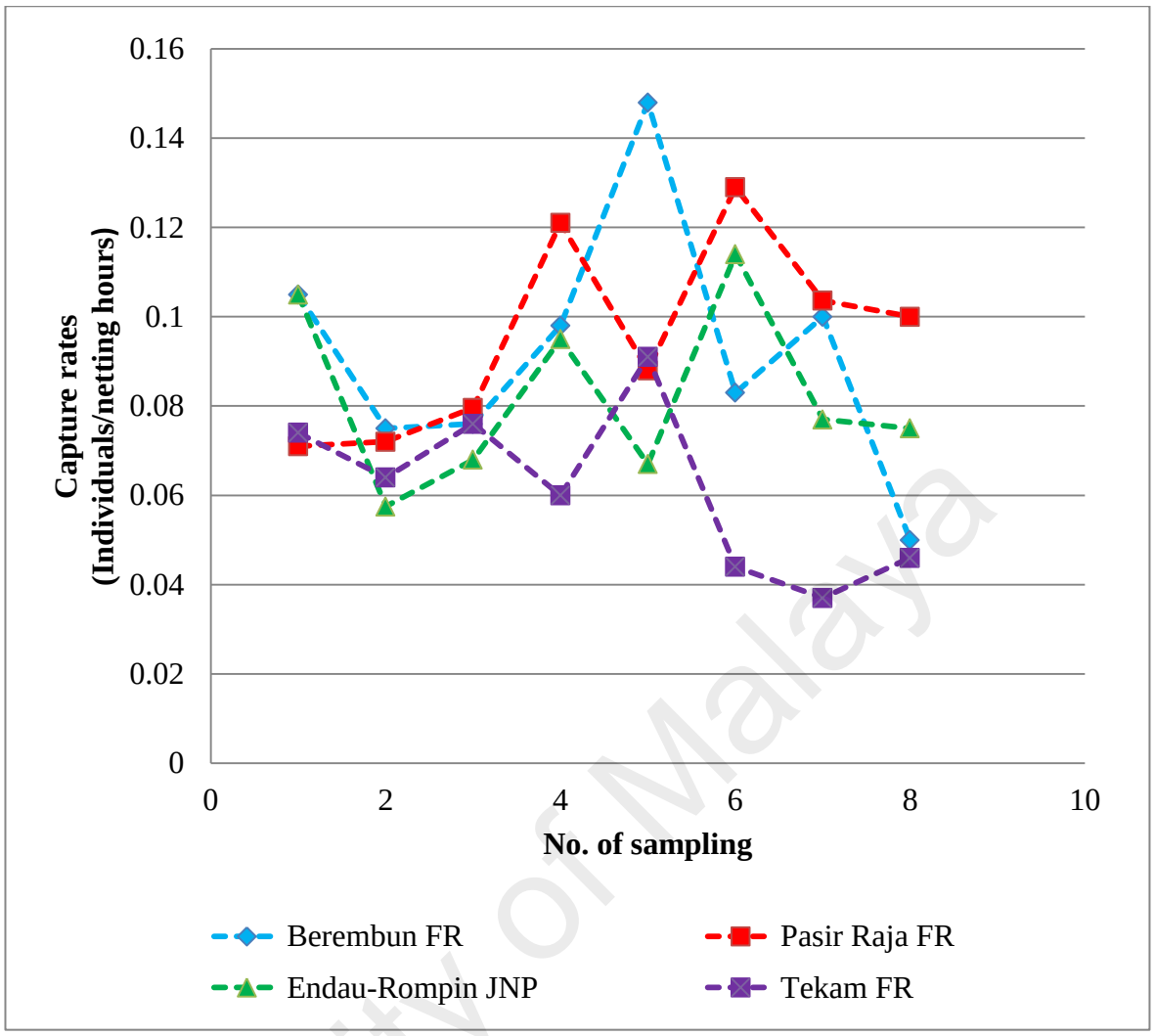


Figure 4.1-4: Capture rates of understorey bird in four forest reserves in Peninsular Malaysia.

4.1.2 Birds composition

Of 112 species that were recorded in this study, 26 species were commonly found in all study sites. Little Spiderhunter (*Arachnothera longirostra)* was the most abundantly distributed with 287 individuals (20.66%) were captured. The second highest species captured was Yellow-bellied Bulbul (*Alophoxus phaeocephalus)* with 93 individuals (6.70%), followed by Yellow-breasted Flowerpecker (*Dicaeum maculates)* with 86 individuals (6.19%), Moustached Babbler (Malacopteron *magnirostre)* and Scaly-crowned Babbler (*Malacopteron cinereum)* both with 56 individuals or (6.19 %) and Grey-headed Babbler (*Stachyris poliocephala)* with 51 individuals (3.67%). Other species were recorded less than 50 individuals.

Most (91.01%) ofcaptured species are resident birds which mean they can be found in study areas throughout the year. Few species (6.25%) are migrants while some have both resident and migrant populations (2.68%). According to protection status, 95% species are categorized as totally protected while two species are protected (1.79%). These species are Oriental White-eye (*Zosterops palpebrosus*) and Emerald Dove (*Chalcophaps indica*). Twenty-six species are categorized as Near-threatened and two species are categorized as vulnerable by IUCN (Table 4.1-3). These latter species are Brown-chested Jungle-flycatcher *(Rhinomyias brunneata)* and Blue-banded Kingfisher (*Alcedo euryzona*).

Table 4.1-3: List of species which were categorized as Near-threatened by IUCN.

Family	Common Name	Scientific Name
Alcedinidae	Rufous-collared Kingfisher	*Actenoides concretus*
Campephagidae	Fiery Minivet	*Pericrocotus igneus*
Dicaeidae	Scarlet-breasted Flowerpecker	*Dicaeum thoracicus*
Dicruridae	Crested Jay	*Platylophus galericulatus*
Eurylaimidae	Asian Green Broadbill	*Calyptomena viridis*
Muscicapidae	Rufous-tailed Shama	*Trichixos pyrropyga*
Muscicapidae	Grey-chested Jungle-flycatcher	*Rhinomyias umbratilis*
Muscicapidae	Rufous-chested Flycatcher	*Ficedula dumetoria*
Muscicapidae	Chesnut-naped Forktail	*Enicurus ruficapillus*
Oriolidae	Dark-throated Oriole	*Oriolus xanthonotus*
Picidae	Buff-necked Woodpecker	*Meiglyptes tukki*
Pittidae	Garnet Pitta	*Pitta granatina*
Pycnonotidae	Finsh's Bulbul	*Alophoixus finschii*
Pycnonotidae	Buff-vented Bulbul	*Iole olivacea*
Pycnonotidae	Streaked Bulbul	*Ixos malaccensis*
Ramphastidae	Red-throated Barbet	*Megalaima mystacophanos*
Timaliidae	White-necked Babbler	*Stachyris leucotis*
Timaliidae	White-chested Babbler	*Trichastoma rostratum*
Timaliidae	Chesnut-rumped babbler	*Stachyris maculata*
Timaliidae	Black-throated Babbler	*Stachyris nigricollis*
Timaliidae	Rufous-crowned Babbler	*Malacopteron magnum*
Timaliidae	Brown Fulvetta	*Alcippe brunneicauda*
Timaliidae	Short-tailed Babbler	*Malacocincla malaccensis*
Timaliidae	Sooty-caped Babbler	*Malacopteron affine*
Timaliidae	Grey-bellied Bulbul	*Pycnonotus cyaniventris*
Trogonidae	Scarlet-rumped Trogon	*Harpactes duvaucelii*

4.1.3 Birds community in each study site.

4.1.3.1 Berembun FR

A total of 380 birds belong to74 species and 22 families were recorded. The capture success in Berembun FR was contributed by 4,100 hours of netting efforts. The most dominant species recorded are members of family Timaliidae (14 species), followed by family Pycnonotidae (12 species). The most abundant species belong to family Nectariniidae (126 individuals) and family Timaliidae (77 individuals). Little spiderhunter (*Arachnothera longirostra*) was the highest species captured followed by Grey-cheeked Bulbul (*Alophoixus bres*) and Grey-throated Bulbul (*Stachyris negriceps*). Of 74 species, 16.2 % (12 species) were categorized as Near-threatened.

4.1.3.2 Pasir Raja FR

A total of 403 birds belong to 66 species and 18 families were captured in Pasir Raja FR. The capture success in Pasir Raja FR was contributed by 4,220 hours of netting efforts. The highest recorded species and individual in this area are members of family Timaliidae with 17 species, and 116 individuals. Three species were commonly recorded in this area. These are Little spiderhunter, Yellow-breasted Flowerpecker (*Dicaeum maculates*) and Yellow-bellied Bulbul (*Alophoixus phaecephalus*). From total species, 24.2% (16 species) were categorized as Near-threatened and a single species (i.e. Blue-banded Kingfisher) as vulnerable.

4.1.3.3 Endau-Rompin JNP

A total of 359 birds belong to 52 species and 16 families were captured in Endau-Rompin JNP. The capture success in this area was contributed by 3,520 hours of netting efforts. Family Timaliidae has the highest species captured (15 species) and most abundance individuals recorded (101 individuals). Little Spiderhunter, Yellow-bellied Bulbul and Yellow-breasted Flowerpecker have most representatives. Of total species, 17 species (32.6%) were categorized as Near-threatened while two species were categorized as vulnerable. These are Brown chested Jungle Flycatcher and Blue-banded Kingfisher.

4.1.3.4 Tekam FR

A total of 247 individuals belong to54 species and 14 families were captured in Tekam FR. The capture success in Tekam FR was contributed by 3,000 netting hours. Family Timaliidae was abundantly captured in this area (58 individuals and 14 species). Tekam FR was dominated by Litter spiderhunter, Yellow-bellied Bulbul and Yellow-breasted Flowerpecker. Fifteen species (27.8%) inhabiting this forest are categorized as Near-threatened.

Jaccard Index indicated that, the highest similarity in species assemblages were found between Pasir Raja FR and Endau-Rompin JNP (0.662). The lowest similarity was found between Berembun Forest Reserve and Endau-Rompin JNP (0.37) (Table 4.1-4).

Table 4.1-4: Values of species similarity index between different forests.

Sites compared		Shared Species Observed	Jaccard Index
Berembun FR	Pasir Raja FR	37	0.359
Berembun FR	Endau-Rompin JNP	34	0.37
Berembun FR	Tekam FR	35	0.376
Pasir Raja FR	Endau-Rompin JNP	47	0.662
Pasir Raja FR	Tekam FR	42	0.538
Endau-Rompin JNP	Tekam FR	39	0.582

4.1.4 Migratory species

In total, seven migratory species consist of 42 individuals that belong to three families were captured from all study sites (Figure 4.1-5). The most abundant migratory species were captured at Endau-Rompin JNP (17 individuals), followed by Berembun FR (11 individuals) and Tekam FR (10 individuals). Pasir Raja FR was the least abundant migratory species captured (four individuals) (Figure 4.1-5). Migratory species was dominated by Black-backed Kingfisher (*Ceyx erithacus*) with 16 individuals (4.0 ± 3.83) and Siberian blue Robin (*Luscinia cyane*) with 14 individuals (3.5 ± 1.73) (Figure 4.1-6). In addition, two species represented by 12 individuals that have both resident and migratory populations were also recorded (Figure 4.1-7). For resident/migratory bird, it was dominated by Asian-Paradise Flycatcher with 11 individuals (2.5 ± 2.5).

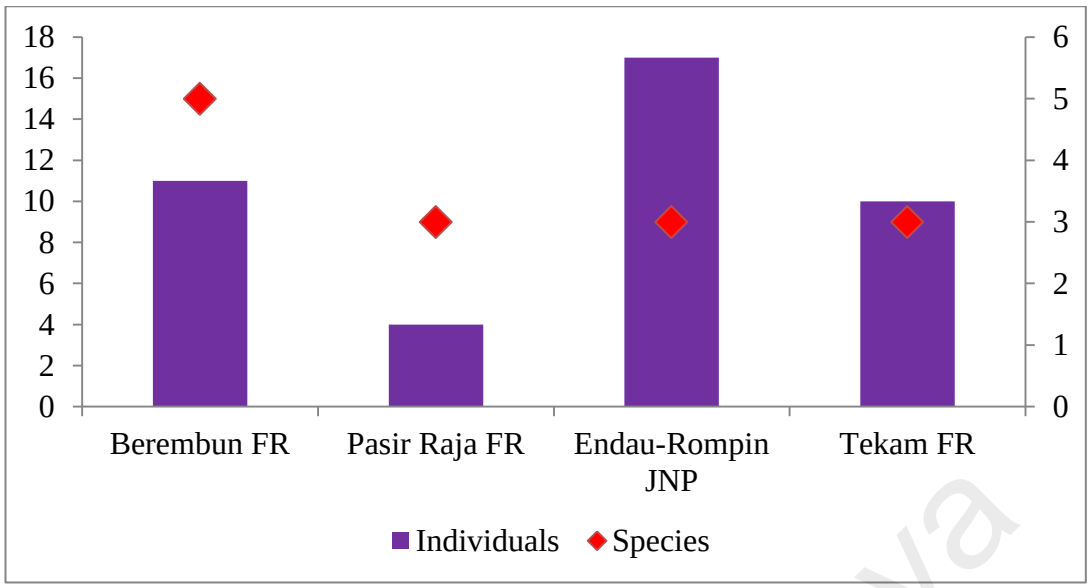


Figure 4.1-5: Number of individual and species of migratory birds recorded in all four forest reserves.

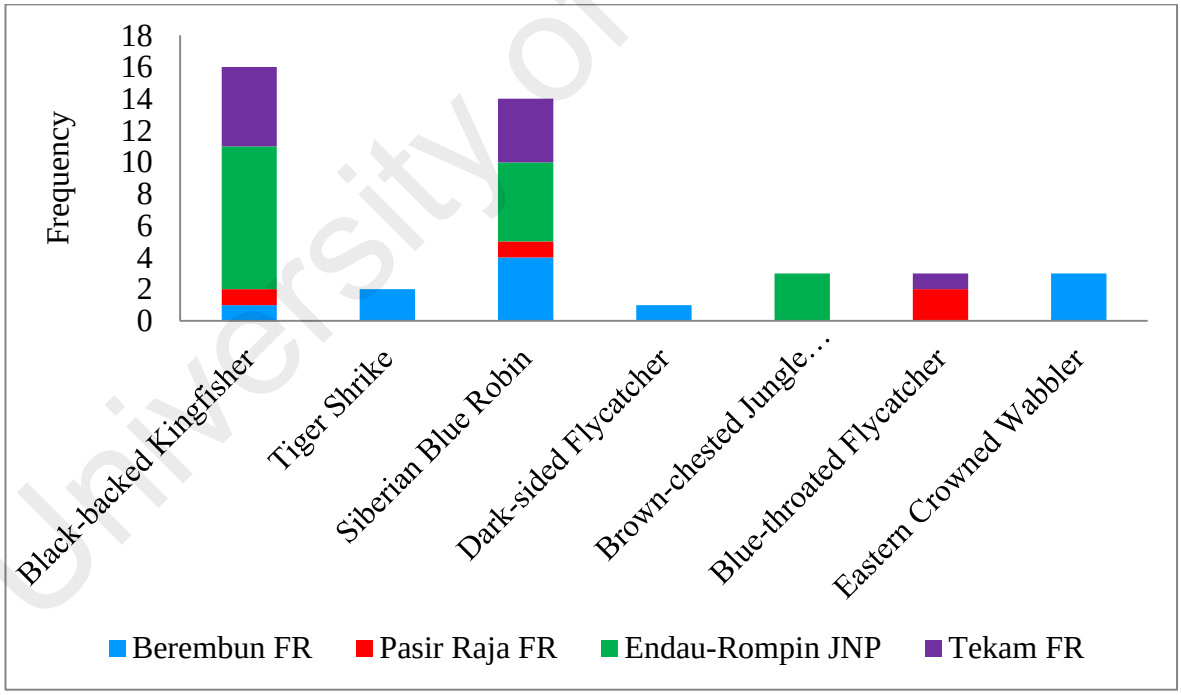


Figure 4.1-6: Composition of migratory bird species at each study site.

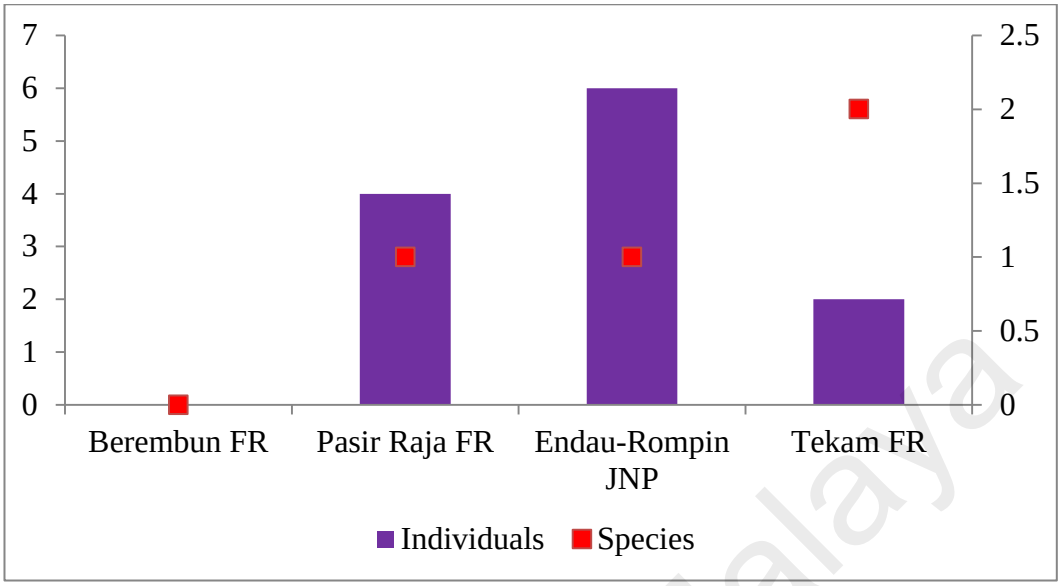


Figure 4.1-7: Number of individual and species of resident/migratory birds in four selected forest reserves.

4.2 Understorey Birds Assemblages in Unlogged and Logged Forests

4.2.1 Overall

More birds were captured in logged forests (725 individuals) than unlogged forests (664 individuals) (Figure 4.2-1). However, more species and families number were recorded in unlogged forests (90 species belong to 24 families) than logged forests (75 species belong to 21 families). Statistical analysis indicated that there is no significant differences in term of species number between unlogged and logged forest (Man-Whitney U test, p=0.380).

Higher birds diversity was recorded in unlogged forest and lower in logged forest (Shannon-Weiner, Table 4.2-1) except Pasir Raja FR. The highest bird species richness was recorded in all unlogged forests while the lowest value was recorded in all logged forests (Margalef index, Table 4.2-1). The distribution of individuals among species was higher in unlogged forest at Endau-Rompin JNP and Tekam FR while in logged forest was higher in Berembun FR and Pasir Raja FR (Pielou J) (Table 4.2-1). According to the Simpson index, the unlogged forest at Endau-Rompin JNP and Tekam FR were the two most diverse sites while Pasir Raja FR the least diverse site (Table 4.2-1).

Family Timaliidae recorded highest abundance in unlogged forest (181 individuals), followed by Nectariniidae (159 individuals) and Pycnonotidae (99 individuals). In logged forest, family Nectariniidae recorded highest abundance (174 individuals) followed by Timaliidae (171 individuals) and Pycnonotidae (123 individuals) (Figure 4.2-2). Family Timaliidae recorded highest species captured in both habitats with 21 species in unlogged forest and 16 species in logged forests. This is followed by Muscicapidae which recorded 13 species in unlogged forest and 11 species in logged forest (Figure 4.2-3).

For birds inhabiting unlogged forests, Berembun FR recorded highest abundance with 220 birds (33.1%) and 55 species (55%) while Tekam FR has the least abundance with 114 individuals (17.2%) and 41 species (21.6%). For logged forest, Endau-Rompin JNP has highest abundance with 225 individuals (31%). The least abundance of individuals and species were recorded in Tekam FR with 133 individuals (18%) and 37 species (22.4%) (Figure 4.2-4). The total capture rate for logged forest was higher in Endau-Rompin JNP (0.1 ± 0.01) while for unlogged forest was highest in Berembun FR (0.11 ± 0.03) (Table 4.2-2).

Species accumulation curve for all study areas do not reached asymptote yet. The new species are still being added and increased slowly. The curve had not reached asymptote yet which indicated that not all species presence in these areas were successfully sampled (Figure 4.2-5). Estimator species richness indicated that sampling efforts was insufficient due to their rapid approach asymptote. The result showed that unlogged forests were not adequately sampled compared to logged forests (Table 4.2-5).

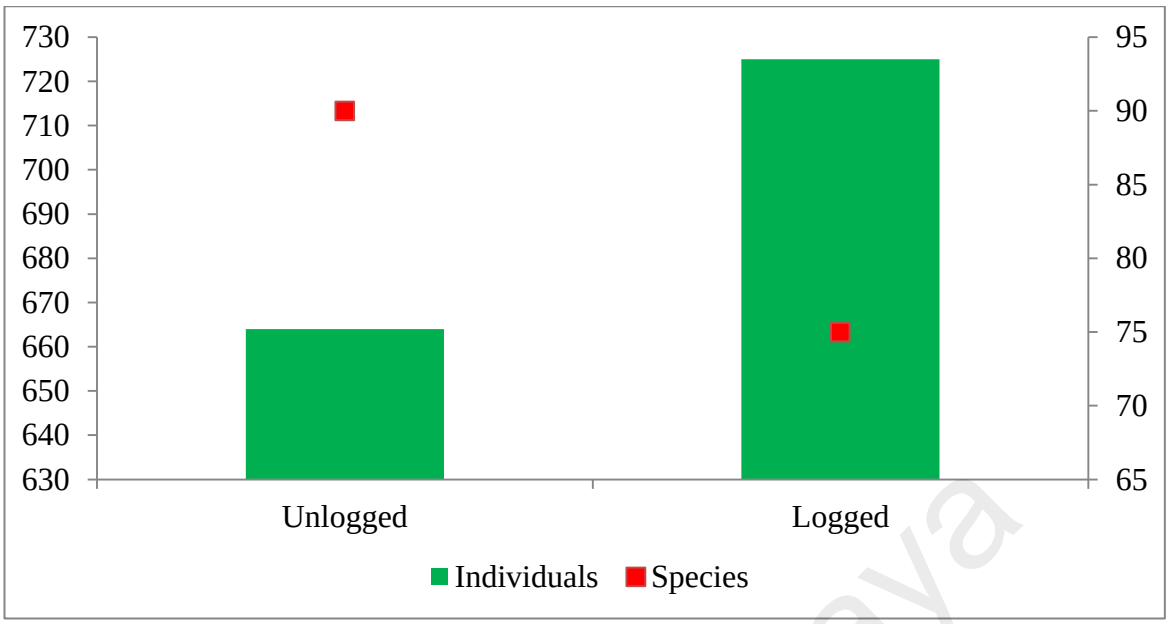


Figure 4.2-1: Total number of understorey birds individual and species recorded in unlogged and logged forests.

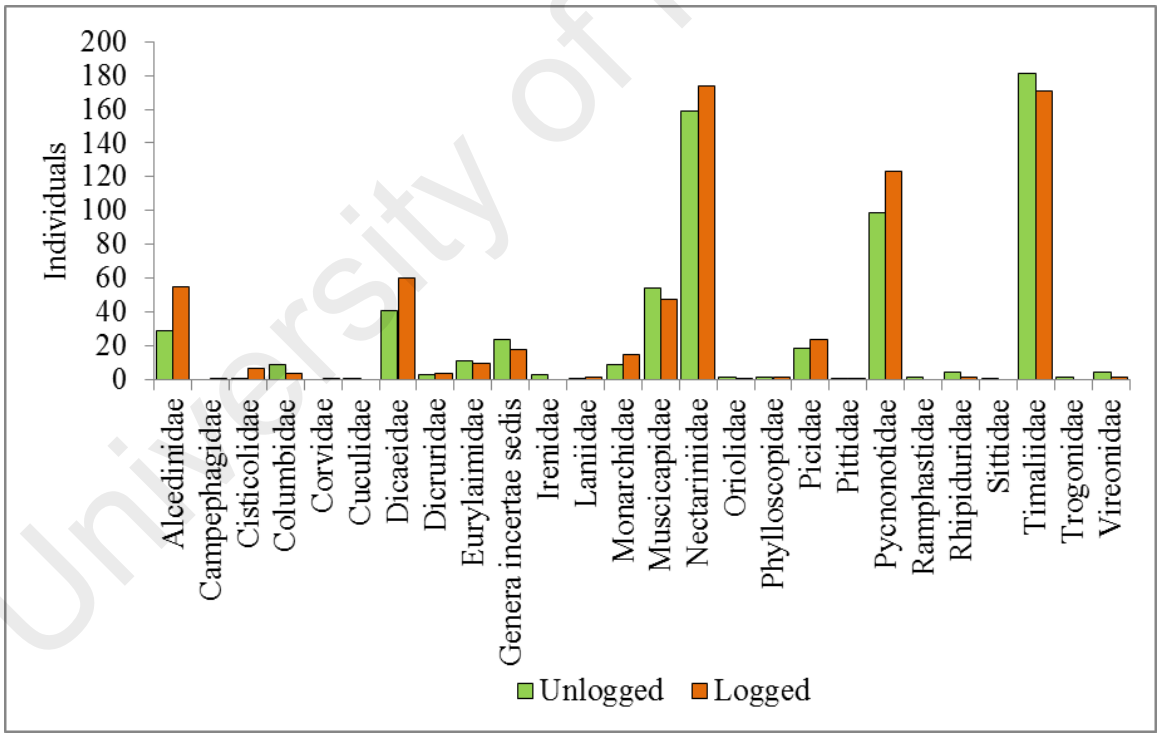


Figure 4.2-2: Number of understorey bird's individual representing each family recorded in unlogged and logged forests.

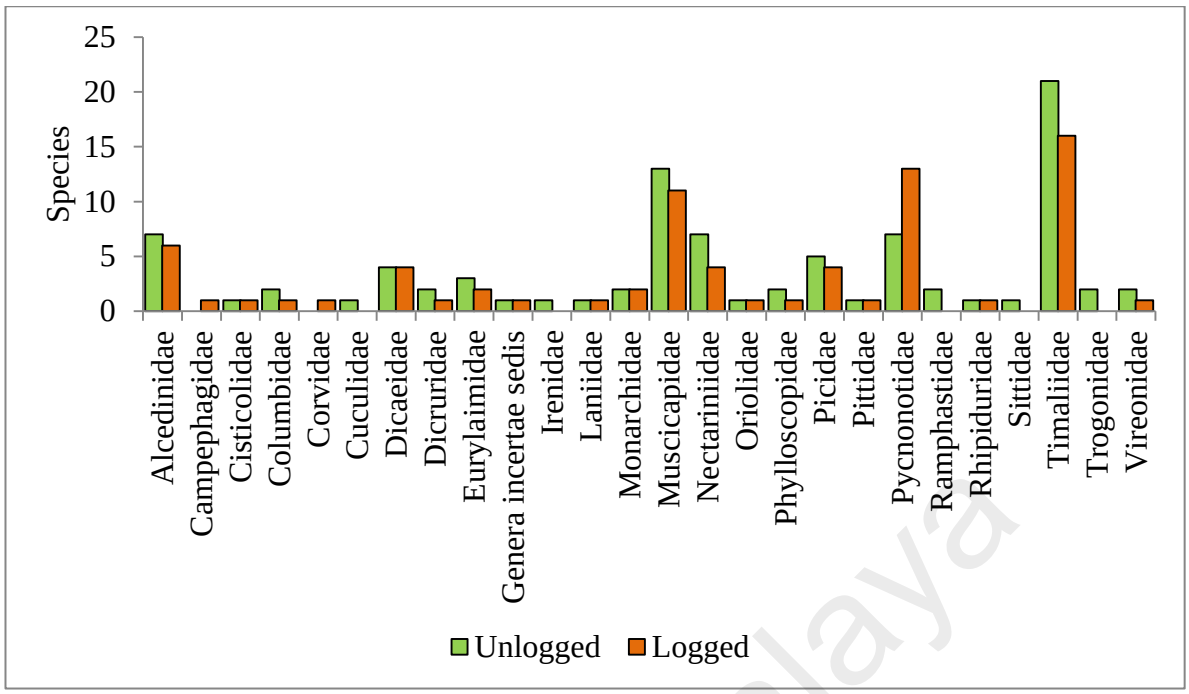


Figure 4.2-3: Number of understorey bird's species representing each family recorded in unlogged and logged forests.

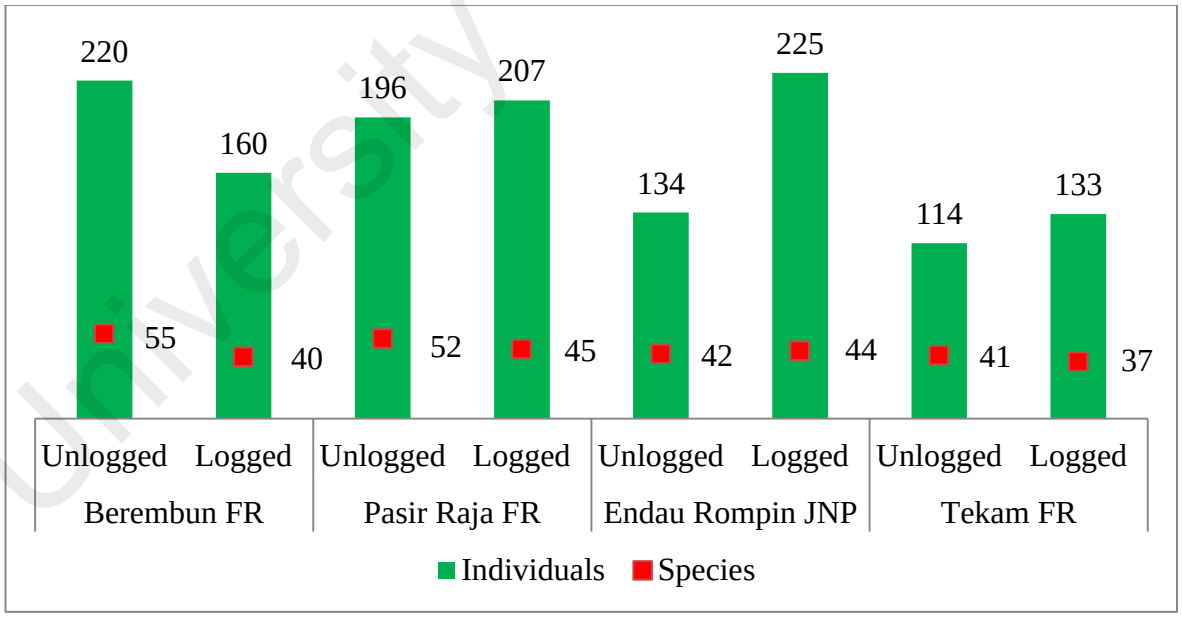


Figure 4.2-4: Number of individuals and species of understorey birds captured in both unlogged and logged forests of four forest reserves in Peninsular Malaysia.

Table 4.2-1: The values of understorey birds diversity inhabiting both unlogged and logged forests of four selected forest reserves in Peninsular Malaysia.

	Berembun FR		Pasir Raja FR		Endau-Rompin JNP		Tekam FR	
	Unlogged	**Logged**	**Unlogged**	**Logged**	**Unlogged**	**Logged**	**Unlogged**	**Logged**
No.of individuals	220	160	196	207	134	225	114	133
No.of families	21	15	16	14	12	16	14	10
No.of species	55	40	52	45	42	44	41	37
Richness values								
Margalef's index	10.01	7.49	9.66	8.25	8.37	7.94	8.45	7.36
Menhennick's index	3.71	3.08	3.71	3.13	3.63	2.93	3.84	3.21
Diversity value								
Shannon-Weiner (*H'*)	3.19	2.96	3.15	3.26	3.39	3.19	3.39	2.96
Simpson Index (*D*)	11.23	9.70	11.42	18.25	26.44	16.54	27.53	11.46
Evenness value								
***E1*(Pielou J)**	0.796	0.809	0.797	0.857	0.908	0.843	0.913	0.818

Table 4.2-2: Capture rate and standard deviation for each sampling sites.

Sites	Forest Types	Mean ± SD
Berembun FR	Unlogged	0.11 ± 0.03
	Logged	0.08 ± 0.02
Pasir Raja FR	Unlogged	0.10 ± 0.02
	Logged	0.10 ± 0.03
Endau- Rompin JNP	Unlogged	0.07 ± 0.08
	Logged	0.1 ± 0.014
Tekam FR	Unlogged	0.06 ± 0.022
	Logged	0.0625 ± 0.017

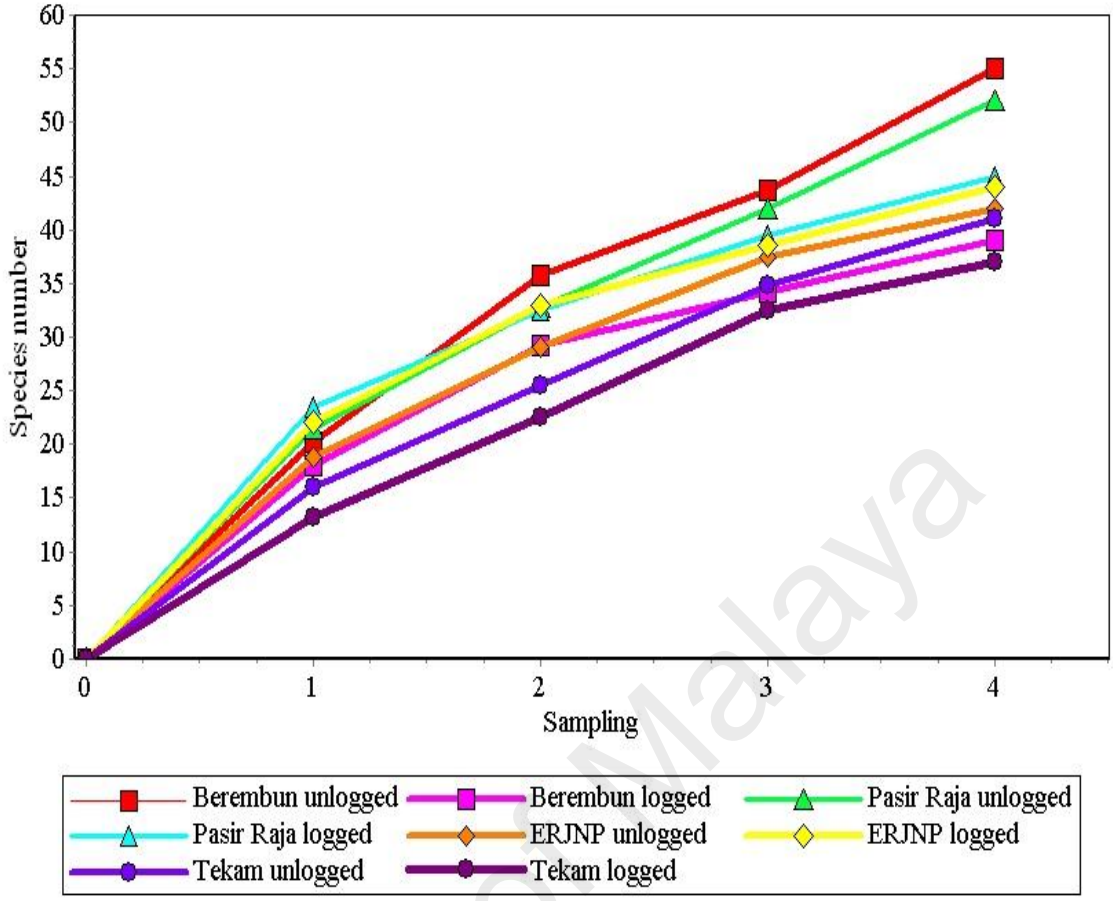


Figure 4.2-5: Species accumulation curves for understorey bird species inhabiting unlogged and logged forests at each study site.

Table 4.2-3: The value of species richness estimation of different habitats based on non-parametric tests (Chao2 refer to incidence-based estimator, ICE refers to incidence based coverage estimator and MMMeans refer to Michaelis-Menten model estimator).

Sites	No.of species	Estimators			% total richness estimated
		Chao 2	ICE	MMMeans	
Berembun FR (unlogged)	55	117.2	131.24	127.4	46.9
Berembun FR(logged)	39	52.88	62.39	65.95	73.75
Pasir Raja FR (unlogged)	52	188.9	154.01	103.28	27.53
Pasir Raja FR (logged)	45	69.2	72.15	69.81	65.029
Endau-Rompin JNP (unlogged)	42	56.28	66.25	69.09	74.63
Endau-Rompin JNP (logged)	44	55.27	61.61	66.73	79.18
Tekam FR (unlogged)	41	108.6	91.71	73.82	37.75
Tekam FR (logged)	37	63.88	73.29	71.79	57.9

4.2.2 Birds composition

4.2.2.1 Specialist species

There are 37 species belong to 19 families were recorded only in unlogged forests while 22 species belong to 13 families were recorded only in logged forests (Figure 4.2-3). Most of the families were represented by only a few species (less than five) and each species usually consist of less than 21 individuals. These species, recognized as specialist species, are dominated by species that belong to family Timaliidae (seven species), followed by families Nectariniidae, and Muscicapidae (four species each). Families Dicaeidae, Eurylamidae, Picidae, Pycnonotidae, Ramphastidae and Trogonidae were represented by two species each, while families Alcedinidae, Cistocolidae, Columbidae, Cuculidae, Dicruridae, Irenidae, Pittidae, Vireonidae and Sittidae were represented by only one species each.

In unlogged forests, all specialist species except Grey-throated Babbler *(Stachyris nigriceps*) and Ochracerous Bulbul (*Alophoixus ochraceus*) were recorded in low abundance (less than four individuals for each species). The former species was represented by 21 individuals while the latter species was represented by 11 individuals. Five specialist species were classified as Near-threatened according to IUCN classification. Scarlet-breasted Flowerpecker (*Dicaeum thoracicus*) is represented by three individuals while other four species, i.e. Streaked Bulbul (*Ixos malaccensis*), White-necked Babbler (*Stachyris leucotis*), Scarlet-rumped Trogon (*Harpectes duvaucelii*) and Red-throated Barbet (*Megalaima mystacophanus*) were represented by a single individual each.

In logged forests, all specialist species were also recorded in low abundance and was dominated by Rufous-tailed Tailorbird (*Orthotomus sericeus*) of family Cisticolidae (six individuals). Seven specialist species recorded in this area are classified a Near-threatened. Grey-bellied Bulbul (*Pycnonotus cyaniventris*) and

White-chested Babbler (*Trichatoma rostratum*) were represented by four and two individuals each, while the remaining five species are represented by only a single individual each. They are Finch's Bulbul (*Alophoixus finschii*), Buff-vented Bulbul (*Iole olivacea*), Garnet Pitta (*Pitta granatina*), Crested Jay (*Plathylopus galericulatus*) and Fiery minivet (*Pericrocutus igneus*).

A total of 35 species were recorded only in unlogged forest of Berembun FR. The species were dominated by Grey-throated Babbler *(Stachyris nigricep*s) with 17 individuals, Ochracerous Bulbul *(Alophoixus ochraceu*s) with 10 individuals and Mountain Fulvetta *(Alcippe peracensi*s) with eight individuals. Other species were recorded with less than five individuals. Family Timaliidae was represented by highest species number (eight species), followed by Nectariniidae (four species), Pycnonotidae (three species) and Muscicapidae (three species). The remaining families were represented by only two or single species each (Figure 4.2-6). Five Near-threatened species were recorded in this area. These are Buff-necked Woodpecker *(Meiglyptes tukki)* which was represented by five individuals while remaining four species, i.e. Rufous-collared Kingfisher (*Actenoides concretus*), Dark-throated Oriole (*Oriolus xanthonotus*), Streaked Bulbul *(Ixos malaccensis)* and Sooty-capped Babbler *(Malacopteron affine)* were represented by single individual each.

Eighteen species were recorded only in logged forest of Berembun FR. Family Pycnonotidae dominated this area with six species (Figure 4.2-6). The most common species were Black-crested Bulbul (*Pycnonotus flaviventris*) and Grey-bellied Bulbul (*Pycnonotus cyaniventris*) with four representatives. Two species recorded only in this area are Near-threatened species. These are Grey-bellied Bulbul and Fiery Minivet (*Pericrocutus igneus*).

There were 21 species that belong to 13 families were recorded only in unlogged forest of Pasir Raja FR (Figure 4.2-7). Family Timaliidae was represented by highest species number i.e. five. Their members include Grey-throated Babbler (*Stachyris nigriceps*), Sooty-caped Babbler (*Malacopteron affine*), Chesnut-winged Babbler (*Stachyris erythroptera*), White-necked Babbler (*Stachyris leucotis*) and Chesnut-backed Scimitar-babbler (*Pamatorhinus montanus*). All species were represented by less than five individuals each. Three Near-threatened species were recorded. These are Scarlet-breasted Flowerpecker (*Dicaeum thoracicus*), Red-throated Barbet (*Megalaima mystacophanus*) and White-necked Babbler (*Stachyris leucotis*).

In Pasir Raja FR, nine families which were represented by 14 species were recorded only in logged forest (Figure 4.2-7). Family Timaliidae and Pycnonotidae have highest species representative with three species each. Most representatives of family Timaliidae were contributed by Chesnut-rumped Babbler (*Stachyris maculata*) with five individuals. Three species which were recorded only in this forest reserve are classified as Near-threatened. These are Garnet Pitta (*Pitta granatina*), Finch Bulbul (*Alophoixus finschii*), and White-chested Babbler (*Trichastoma rostratum*).

A total of eight species were recorded only in unlogged forest of Endau-Rompin JNP. Member s of family Muscicapidae dominated this area with three species. These are Grey-headed canary Flycatcher (*Culicicapa ceylonensis*), Chesnut-naped Forktail (*Enicurus ruficapillus*), and Grey-chested Jungle-flycatcher (*Rhinomyias umbratilis*). Family Alcedinidae has two species representatives. These are Blue-banded Kingfisher (*Alcedo euryzona*) and Blue-eared Kingfisher (*Alcedo meninting*). All species were represented by less than two individuals. Three Near-threatened species were recorded. These are Blue-banded Kingfisher, Chesnut-naped Forktail (*Enicurus ruficapillus*) and Grey-chested Jungle flycatcher.

Seven families were recorded only in logged forest of Endau-Rompin JNP (Figure 4.2-8). Family Timalidae has highest species representatives with four species. These are Sooty-capped Babbler, Brown Fulvetta, White-chested Babbler, and Black-throated Babbler. All species were represented either by two or single bird. The only Near-threatened species recorded in this area is White-chested Babbler (*Trichastoma rostratum*).

Seventeen species were recorded only in unlogged forest of Tekam FR. Of this, six species belong to family Timaliidae, three species belong to Alcediniidae and two species are Muscicapidae. Other families such as Columbidae, Eurylamidae, Oriolidae, Picidae, Pittidae and Trogonidae were represented by only a single species each (Figure 4.2-9). All species were represented by less than five individuals. Chesnut-rumped Babbler (*Stachyris maculata*) and Ferruginous Babbler (*Trichostoma bicolor*), a member of family Timaliidae were well represented by six species each. This forest has more Near-threatened bird with eight species. These are Chesnut-rumped Babbler (four individuals), White-chested Babbler (*Trichastoma rostratum*) (three individuals) and Rufous-collared Kingfisher (*Actenoides concretus*) with two individuals. Other species were represented by a single individual each. The species include Rufous-chested Flycatcher (*Ficedula dumetoria*), Dark-throated Oriole, Sooty-capped Babbler (*Malacopteron affine*), Brown Fulvetta (*Alcippe brunneicauda*), and Scarlet-rumped Trogon (*Harpectes duvaucelii).*

A total of 13 species belong to seven families were captured only in logged forest of Tekam FR (Figure 4.2-9). Family Muscicapidae had higher species representatives with five while families Dicaeidae and Pycnonotidae were represented by two species only. Other families only have one species representative. These are Monarchidae, Alcediniidae, Picidae and Timaliidae. Three Near-threatened species were recorded in this forest. There are Chesnut-naped Forktail *(Enicurus ruficapillus)*,

Grey-chested Jungle-flycatcher (*Rhinomyias umbratilis*) and Buff-vented Bulbul (*Iole olivacea*). All species were represented by a single individual each.

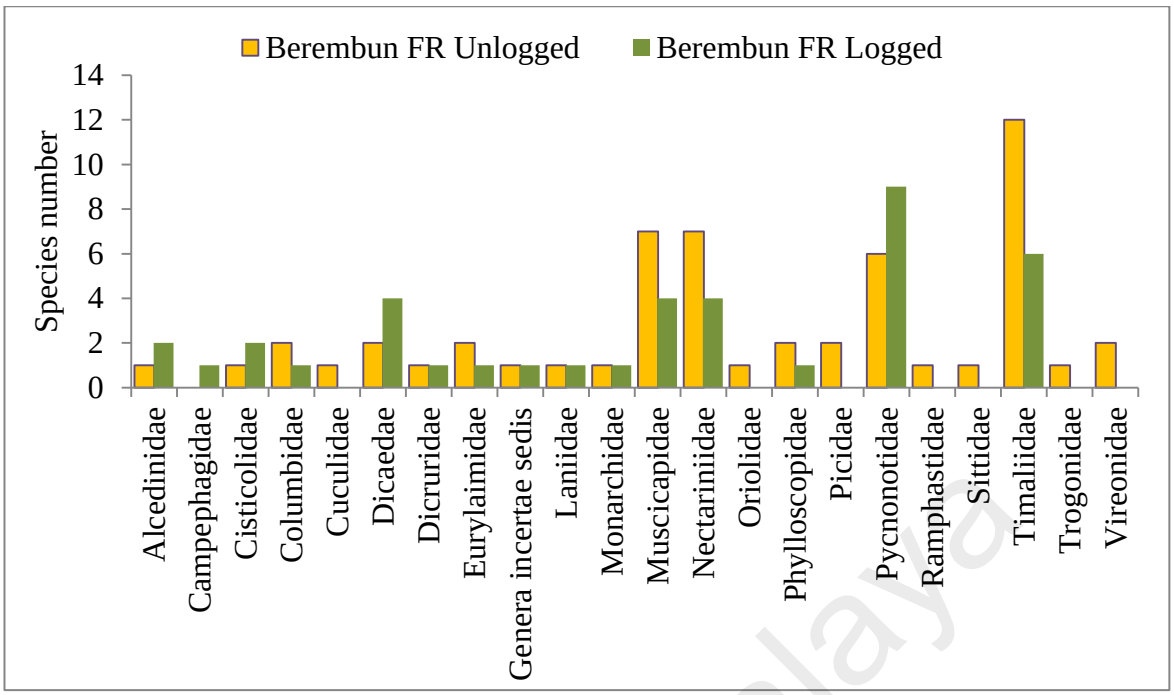


Figure 4.2-6: Proportion of bird's family by species number at Berembun FR.

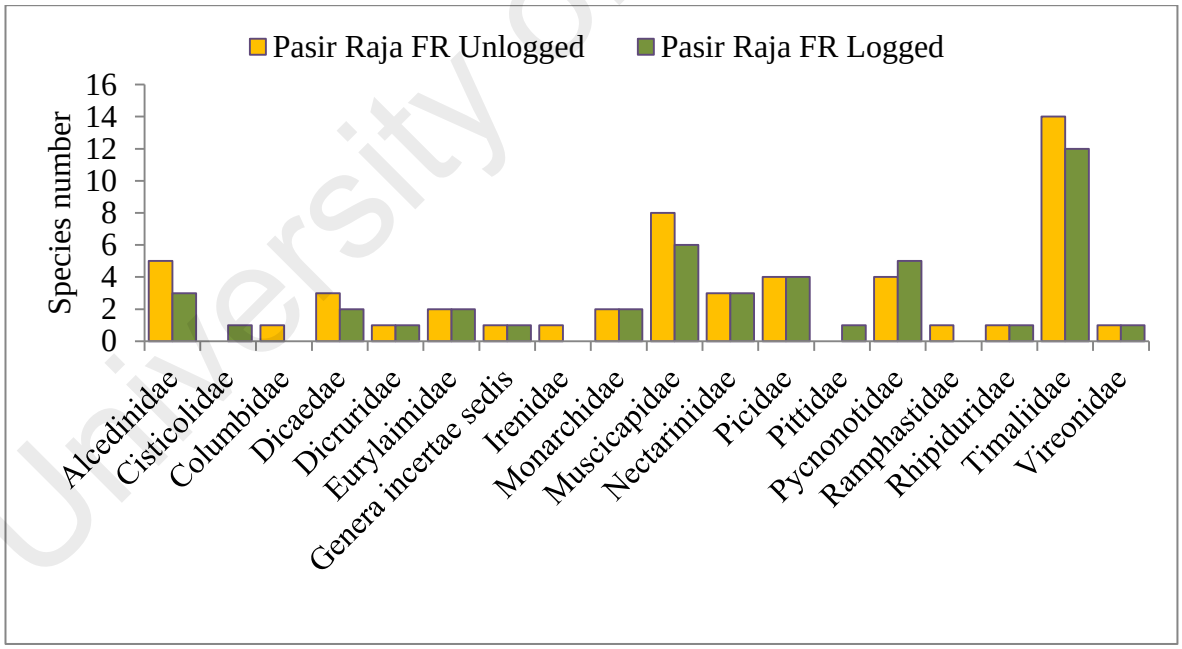


Figure 4.2-7: Proportion of bird's family by species number at Pasir Raja FR.

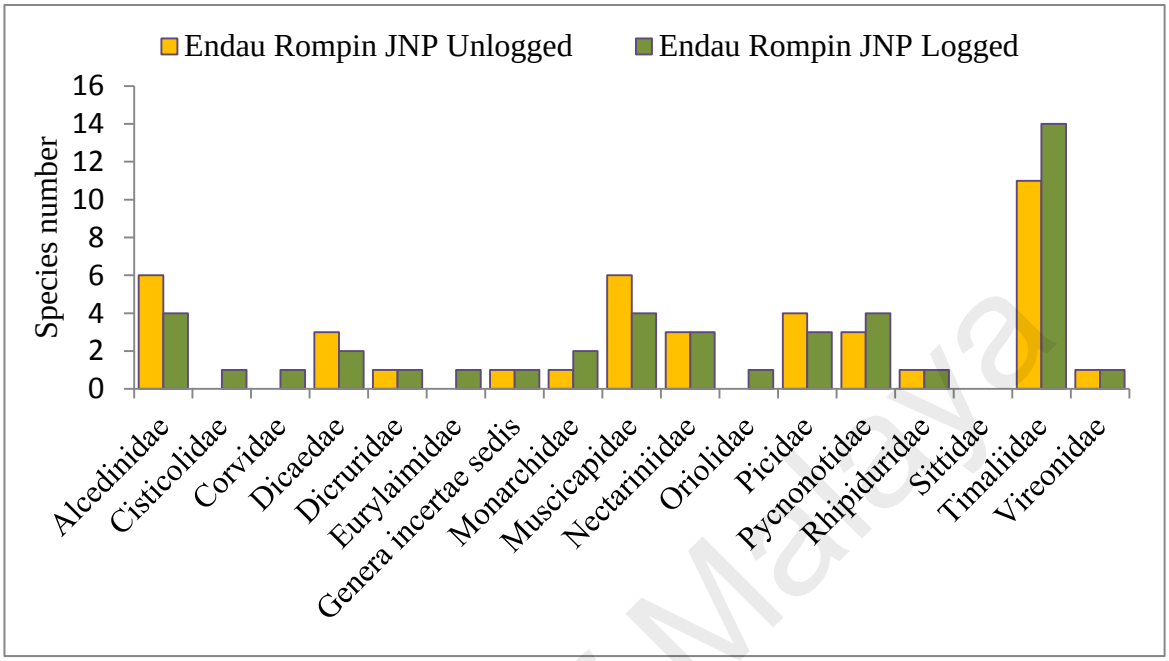


Figure 4.2-8: Proportion of bird's family by species number at Endau-Rompin JNP.

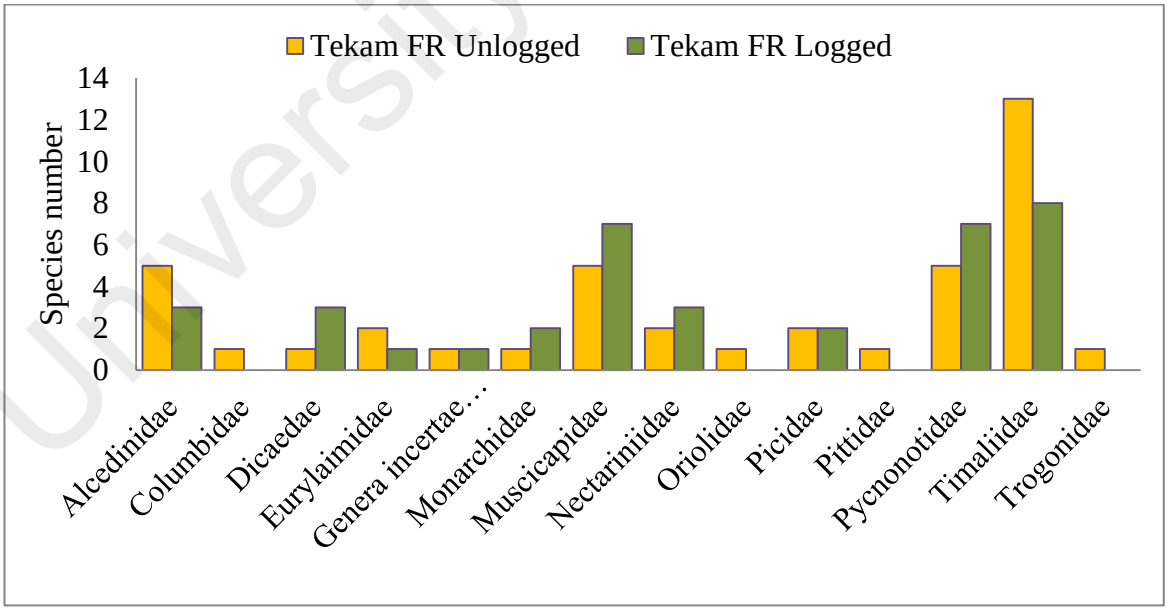


Figure 4.2-9: Proportion of bird's family by species number at Tekam FR.

4.2.3 Feeding Guilds

The results clearly shown that insectivorous birds were the most dominant group in unlogged and logged forests. The results indicated that more than 50% of all captured birds of all study sites consist of insectivorous.

Therefore, insectivorous/nectarivorous (IN) birds dominated unlogged forests. Insectivorous/nectarivorous guild was consisted of 159 individuals of seven species that belong to one family. Other common guild was foliage gleaning insectivorous (FGI) with 152 individuals that belong to 26 species and nine families. Other feeding guilds recorded include arboreal frugivorous (AF) which were represented by 135 individuals (15 species and six families). Terrestrial frugivorous (TF) was recorded as least abundant with nine individuals (two species and one family) (Figure 4.2-10).

Insectivorous/nectarivorous birds were dominated by family Nectariniidae. Of these, Little spiderhunter (*Arachnothera longirostra*) of family Nectariniidae was the most abundant species captured with 135 individuals (33.75 ± 24.76), followed by Purple-naped sunbird (*Hypogramma hypogrammicum)* with 13 individuals (3.25 ± 1.26). Foliage gleaning insectivorous (FGI) birds were mainly represented by members of family Timaliidae. This family consists of 137 individuals of 16 species. Scaly-crowned babbler (*Malacopteron cinereum)* was the highest species recorded with 36 individuals (9.0 ± 4.97), followed by Grey-headed Babbler (*Stachyris poliocephala*) with 21 individuals (5.25 ± 1.71) and Moustached Babbler (*Malacopteron magnirostre*) with 20 individuals (5.0 ± 1.41). The other families of FGI birds include Cistocolidae, Corvidae, Eurylaimidae, Dicruridae, Laniidae, Vireonidae (represented by one species only), Trogonidae, and Phylloscopidae (last two families were represented by two species each).

Insectivorous/nectarivorous birds dominated logged forests with 174 individuals that belong to four species with one family, followed by FGI with 163 individuals that belong to 21 species and nine families. AIF birds were represented 129 individuals with 15 species and four families. Terrestrial frugivorous were least recorded. Only four birds (belong to single species/family) were captured.

Insectivorous/nectarivorous birds were mainly represented by members of family Nectariniidae but were represented by only four species. Little spiderhunter was the most abundant species captured with 152 individuals (38.0 ± 6.48) followed by Purple-naped sunbird with 15 individuals (3.75 ± 1.71). Members of family Timaliidae dominated Foliage gleaning insectivorous birds. This family consists of 142 individuals which belong to 12 species. Moustached Babbler was the highest species captured with 36 individuals (9.0 ±1.41), followed by Grey-headed Babbler with 30 individuals (7.5 ± 3.87). Arboreal insectivorous/frugivorous birds were dominated by family Pycnonotidae with 119 individuals and 12 species. Family Pycnonotidae was mainly represented by Yellow-bellied Bulbul (*Alophoixus phaeocephalus)* with 52 individuals (13.0 ± 9.31). There is no significant differences between feeding guilds of birds from unlogged and logged forests (Mann-Whitney U test, p=0.071).

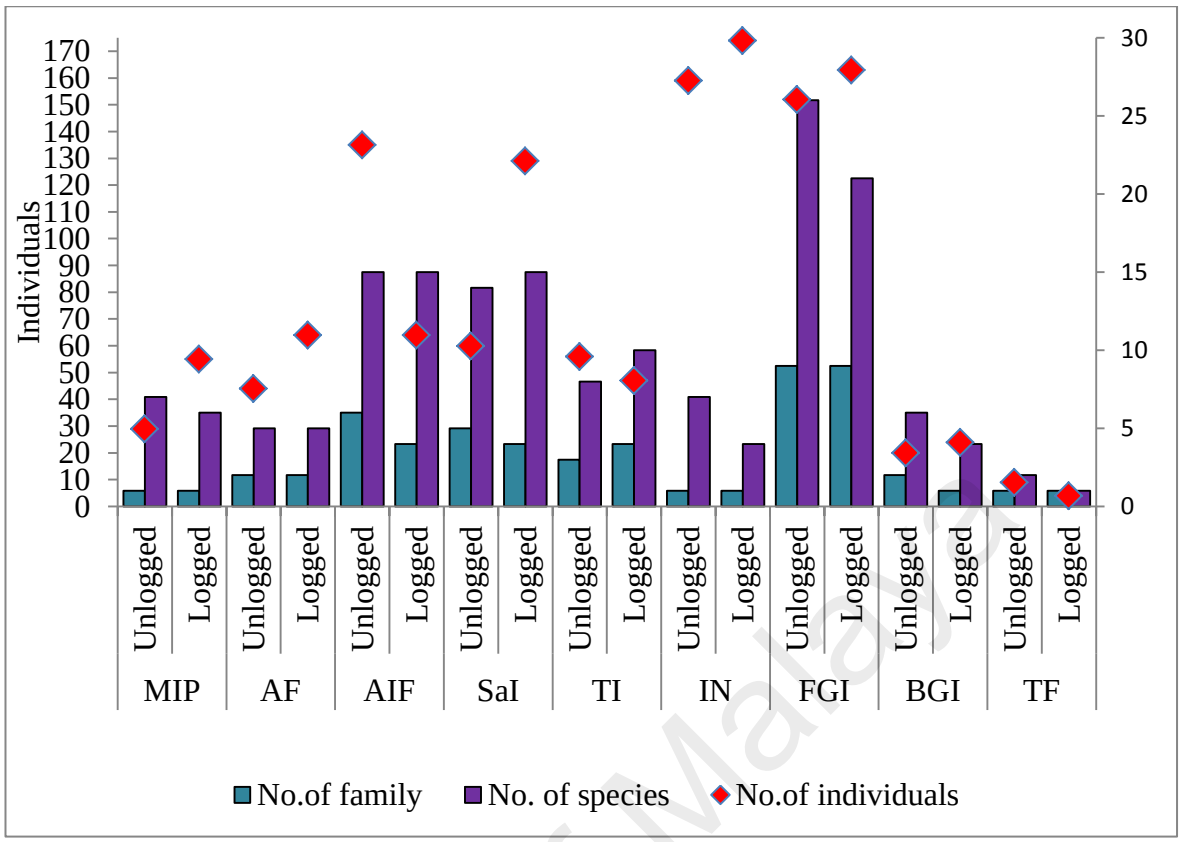


Figure 4.2-10: The composition of bird feeding guilds inhabiting unlogged and logged forests.

Table 4.2-4: Number of species and individuals (in parenthesis) according to feeding guilds.

Feeding Guilds	Berembun FR		Pasir Raja FR		Endau-Rompin JNP		Tekam FR	
	Unlogged	Logged	Unlogged	Logged	Unlogged	Logged	Unlogged	Logged
MIP	1 (1)	2 (4)	5 (10)	3 (7)	6 (9)	4 (34)	5 (9)	3 (10)
FGI	15(40)	10 (29)	14 (45)	13 (57)	9 (34)	15 (60)	13 (33)	5 (17)
TF	2 (7)	1 (4)	1 (1)	0	0	0	1 (1)	0
AF	2 (12)	5 (16)	4 (16)	2 (16)	3 (11)	2 (17)	1 (5)	3 (15)
SaI	8 (8)	3 (3)	9 (24)	8 (21)	7 (20)	6 (14)	4 (8)	5 (9)
AIF	13 (61)	11 (41)	7 (28)	6 (29)	4 (20)	6 (36)	7 (26)	8 (27)
TI	5 (13)	4 (12)	5 (14)	6 (25)	6 (18)	5 (14)	6 (11)	8 (14)
IN	7 (71)	4 (55)	3 (54)	3 (42)	3 (17)	3 (42)	2 (17)	3 (35)
BGI	3 (7)	0	4 (4)	4 (10)	4 (5)	3 (8)	2 (4)	2 (6)

4.3 Comparison of Bird Diversity between Three Regenerated Forests

4.3.1 Overall

A total of 592 birds belong to 71 species and 23 families were captured. Of these, 160 birds were caught in early regenerated forest (1-15 years), 207 birds in intermediate regenerated forest (16-30 years) and 225 birds in old growth forest (>31 years). More species were captured in old growth forest (44 species), followed by early regenerated forests (40 species) and intermediate regenerated forest (39 species) (Figure 4.3-1). Species variation among forests is not significantly different (χ^2=0.829, d.f.=2, p=0.661).

Highest bird diversity was observed in early regenerated forest (Shannon-Weiner index=3.263) but lowest in intermediate regenerated forest (Shannon-Weiner index=2.96). In term of species richness, early regenerated forest recorded highest species (Margalef's index=8.25), while lowest value was recorded in intermediate regenerated forest (Margalef's index =7.49). Meanwhile, distribution of individuals among the species was highest in early regenerated forest compared to intermediate regenerated forest or old growth forest (Table 4.3-1).

Of recorded species, most are residents (62 species or 88.6%), six are migrants (8.57%), and only a single species has both resident and migrant populations (1.43%). In term of protection status, 98.5% are categorized as totally protected while the remaining (1.43%) are protected species. Two species, Oriental White-eye (*Zosterops palpebrosus*) and Emerald Dove (*Chalcopaps indica*) are protected. Eighteen species are classified as Near-threatened while two species are classified as vulnerable (Appendix B). These latter species are Brown-chested Jungle–flycatcher (*Rhinomyas brunneata*) and Blue-banded Kingfisher (*Alcedo euyzona*).

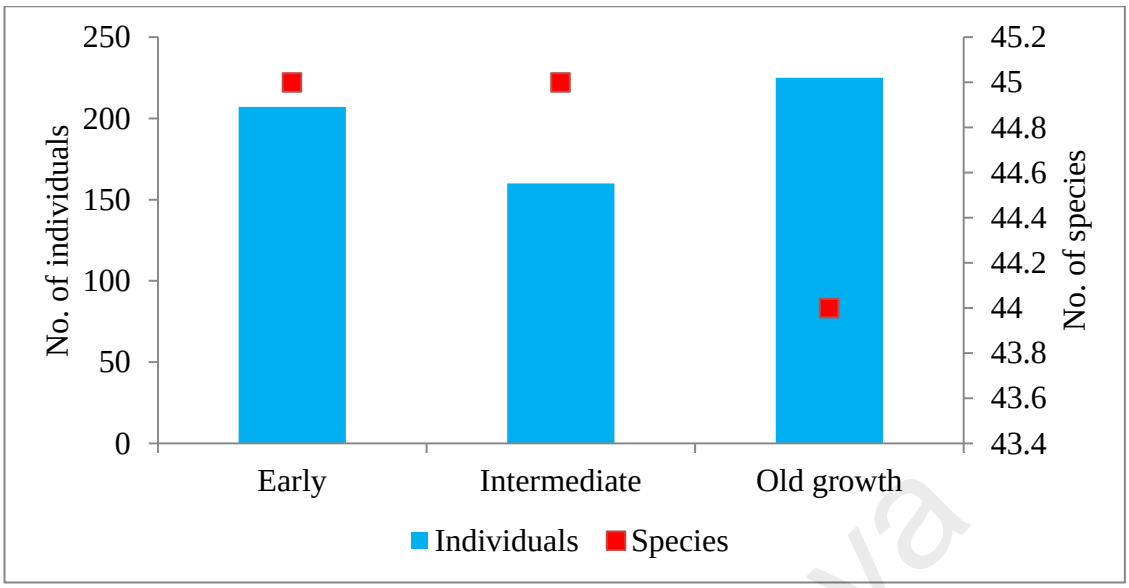


Figure 4.3-1: Number of species and individuals of understorey birds inhabiting three different stages of regenerating forests.

Table 4.3-1: Diversity values for understorey birds inhabiting three different stages of regenerating stages.

	Early	Intermediate	Old growth
No.of individuals	207	160	225
No.of families	14	15	16
No.of species	45	39	44
Richness			
Margalef's index	8.25	7.49	7.94
Menhennick's index	3.13	3.08	2.93
Diversity			
Shannon-Weiner (H')	3.26	2.96	3.19
Simpson's index (D)	18.25	9.70	16.54
Evenness			
Pielou J	0.86	0.81	0.84

4.3.2 Species composition

Results indicated that old growth forest recorded highest abundance of birds with 225 individuals (38%), followed by intermediate regenerated forest with 207 individuals (35%) and early regenerated forest with 160 individuals (27%) (Figure 4.3-2). A total of 21 families were recorded. These families are represented by 45 species (35%) in early regenerated forest, 39 species (31%) in intermediate regenerated forest, and 44 species (34%) in old growth forest (Figure 4.3-3). Most families recorded in this study can be found in regenerated forests. Timaliidae, Pycnonotidae and Muscicapidae were most dominated families in regenerated forest. However, some families were recorded only in selected regenerating forests. Families Corvidae and Oriolidae for instance were recorded only in old growth forest. On contrary, families Camphaphegidae, Columbidae, Laniidae and Phylloscopidae were captured in intermediate regenerated forest while family Pittidae was found only in early regenerated forest (Figure 4.3-4).

Overall, highest species dominated regenerating forests were represented by family Timaliidae with 16 species, followed by family Pycnonotidae (12 species) and family Muscicapidae (nine species). In early regenerated forest, family Timaliidae recorded highest species captured (12 species), followed by family Muscicapidae (six species) and family Pycnonotidae (five species). Grey-headed Babbler (*Stachyris poliocephala*) of family Timaliidae was the most abundant species captured with 13 individuals, followed by Short-tailed Babbler (*Malacocincla malaccensis*) and Moustached Babbler (*Malacopteron magnirostre*) (10 individuals each). Family Muscicapidae were dominated by White-rumped Shama (*Copsychus malabaricus*) with seven individuals while family Pycnonotidae were dominated by Yellow-bellied Bulbul (*Alophoixus phaeocephalus*) (14 individuals). More species of family Pycnonotidae were recorded in intermediate regenerated forest with nine species followed by family

Timaliidae (six species). Of this, Grey-cheeked Bulbul was the most abundant species with ten individuals. Family Timaliidae was dominated by Moustached Babbler with nine individuals. This family was recorded highest in old growth forest (14 species) followed by families Muscicapidae, Pycnonotidae and Alcedinidae. These latter families were represented by four species each. Within family Timaliidae, Chesnut-rumped Babbler and Scaly-crowned Babbler were the most abundant species. Each species were represented by 13 and 11 individuals respectively. The most abundant species for family Pycnonotidae was Yellow-bellied Bulbul (22 individuals) while Rufous-backed Kingfisher representing family Alcediniidae with 17 individuals.

Little spiderhunter was the most abundant bird in all sampling sites. This species represent 16.9% of understory bird in early regenerated forest, 29.38% in intermediate forest and 16.89% in old growth forest. The second most abundant species was Yellow-breasted Flowerpecker (*Dicaeum maculates*). This species represents 7.25% birds in early regenerated forest, 5% in intermediate regenerated forest and 7.11% in old growth forest.

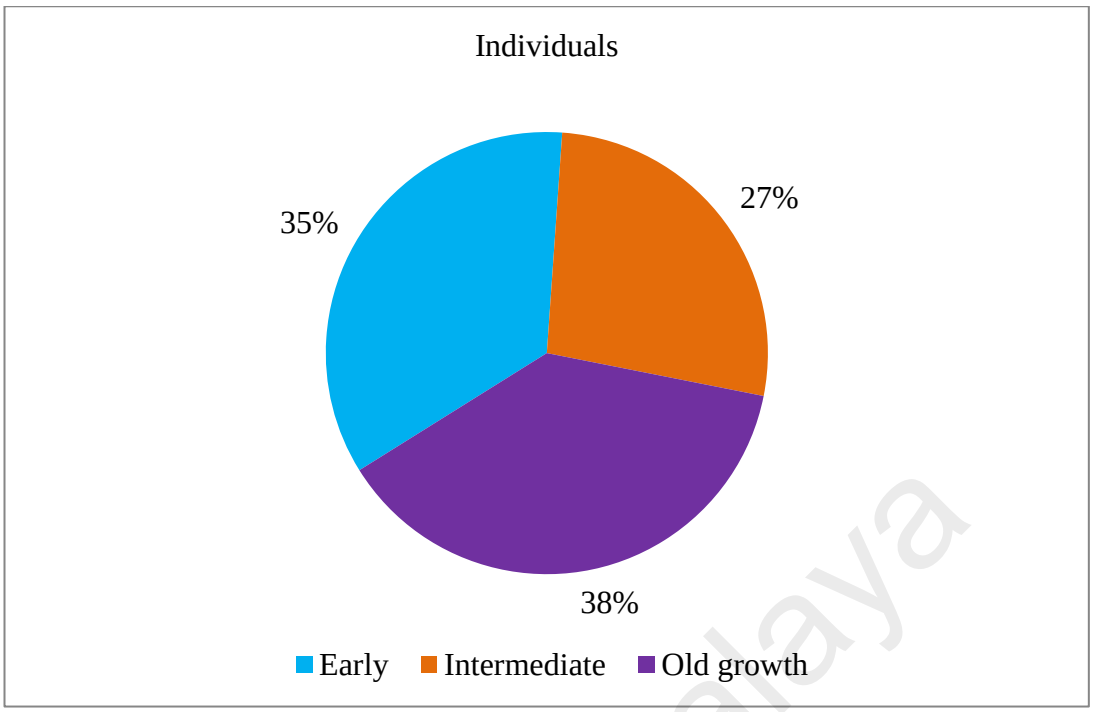


Figure 4.3-2: Percentage of understorey bird's individuals inhabiting different type of regenerating forests.

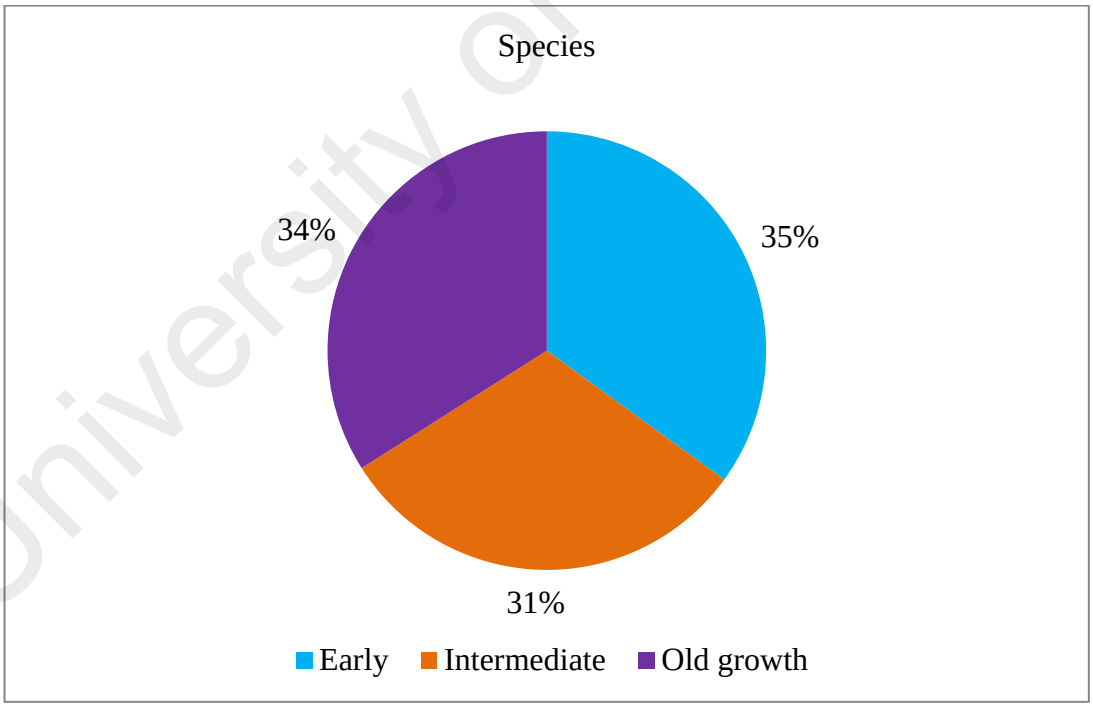
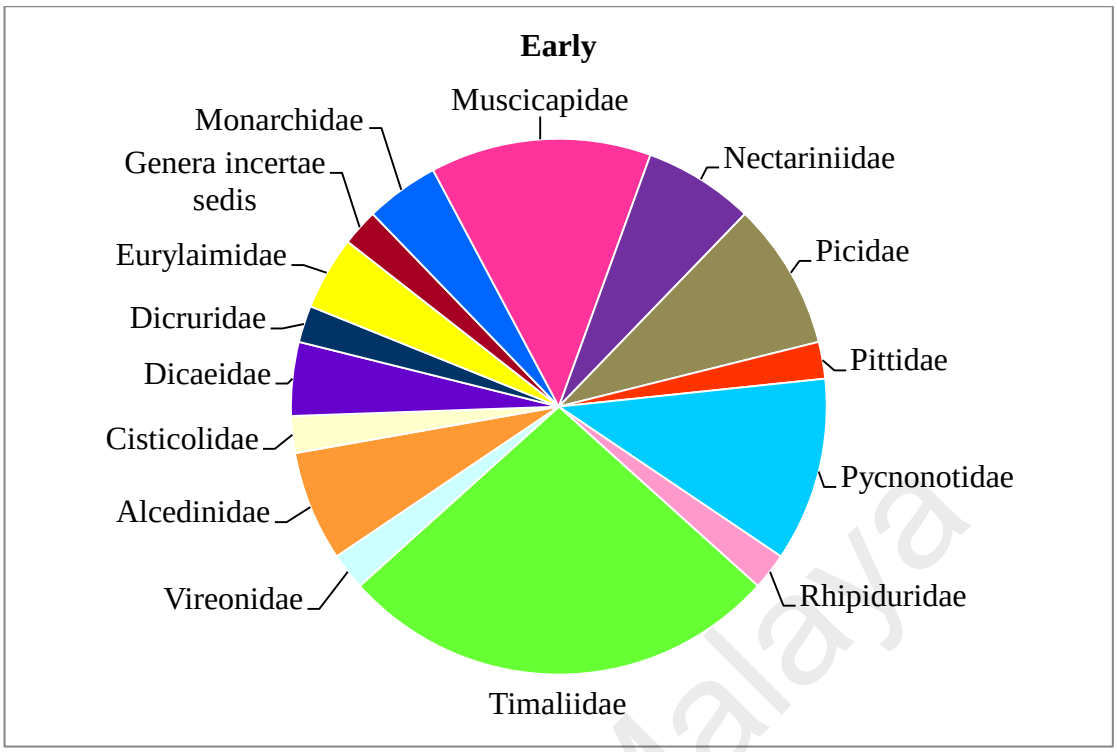
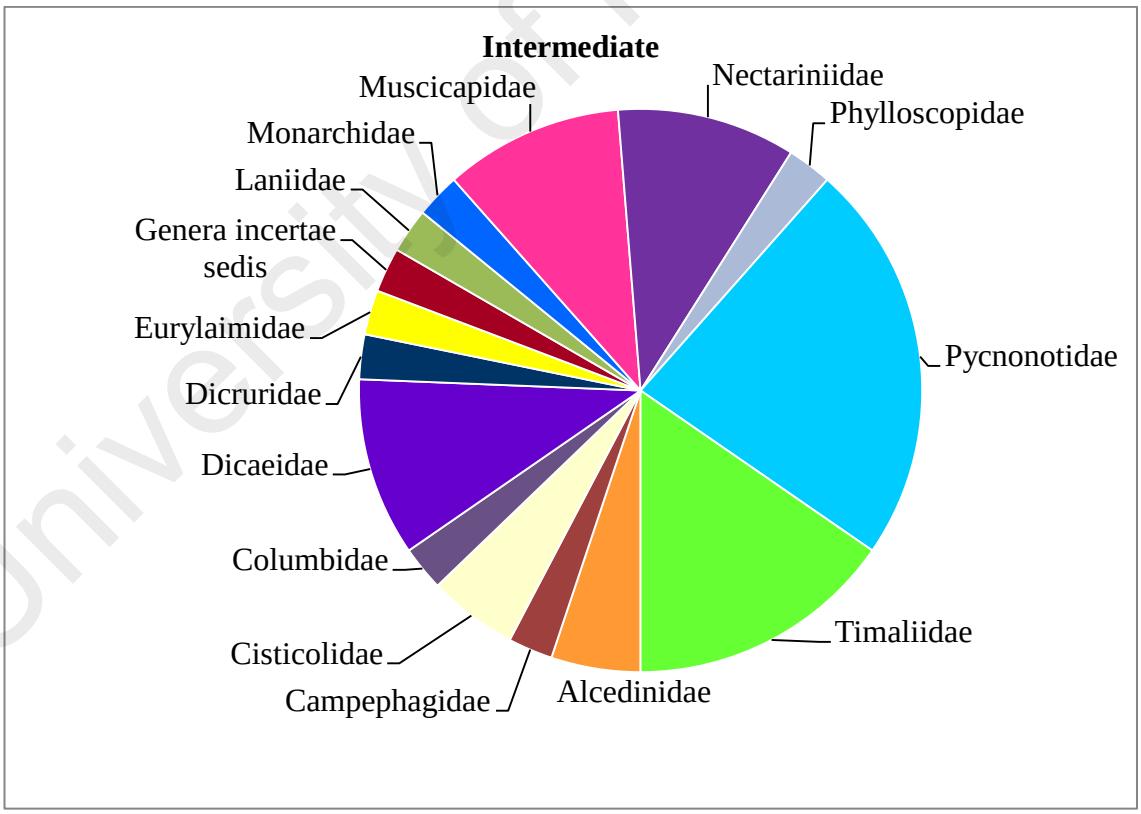


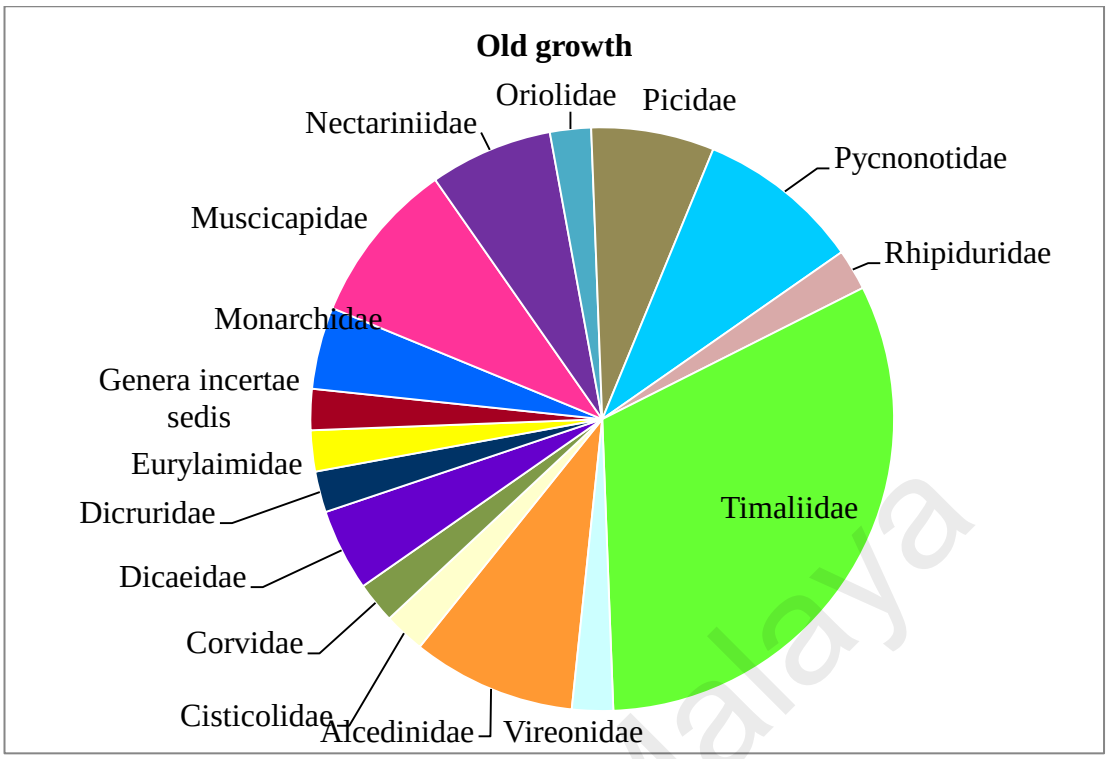
Figure 4.3-3: Percentage of understorey bird's species inhabiting different type of regenerating forests.



a) Early regenerated forest



b) Intermediate regenerated forest



c) Old growth forest

Figure 4.3-4: Composition of understorey birds recorded from three types of regenerating forests.

Table 4.3-2: The most abundant species captured from different regenerating forests.

a) Early regenerated forest

Species name		Individuals	Percentage (%)
Little Spiderhunter	*Arachnothera longirostra*	35	16.9
Yellow-breasted Flowerpecker	*Dicaeum maculatus*	15	7.25
Yellow-bellied Bulbul	*Alophoixus phaeocephalus*	14	6.76
Grey-headed Babbler	*Stachyris poliocephala*	13	6.28
Short-tailed Babbler	*Malacocincla malaccensis*	10	4.83
Moustached Babbler	*Malacopteron magnirostre*	10	4.83

b) Intermediate regenerated forest

Species name		Individuals	Percentage (%)
Little Spiderhunter	*Arachnothera longirostra*	47	29.38
Grey-cheeked Bulbul	*Alophoixus bres*	10	6.25
Hairy-backed Bulbul	*Tricholestes criniger*	9	5.63
Moustached Babbler	*Malacopteron magnirostre*	9	5.63
Yellow-breasted Flowerpecker	*Dicaeum maculatus*	8	5

c) Old growth forest

Species name		Individuals	Percentage (%)
Little Spiderhunter	*Arachnothera longirostra*	38	16.89
Yellow-bellied Bulbul	*Alophoixus phaeocephalus*	22	9.78
Rufous-backed Kingfisher	*Ceyx rufidorsa*	17	7.56
Yellow-breasted Flowerpecker	*Dicaeum maculatus*	16	7.11
Chesnut-rumped Babbler	*Stachyris maculata*	13	5.78
Scaly-crowned Babbler	*Malacopteron cinereum*	11	4.89
Moustached Babbler	*Malacopteron magnirostre*	10	4.44

4.3.3 Representation of specialist species in various stages of regenerating forests

Only few bird's families were recorded in various forests experiencing different stages of regeneration. For example, Garnet Pitta (*Pitta granatina*) that represents family Pittidae was found only in early regenerating forest. Four species that belong to various families were captured only in intermediate regenerating forest. These include Fiery Minivet (*Pericrocutus igneus*) of family Campephagidae, Tiger Shrike (*Lanius tigrinus*) of family Laniidae, Emerald Dove (*Chalcophaps indica*) of family Columbidae and Eastern-crowned Babbler (*Phylloscopus coronatus*) of family Phyloscopidae. Two species were only found in old growth forest. These are Crested Jay (*Platylophus galericulatus*) of family Corvidae and Dark-throated Oriole (*Oriolus xanthonotus*) of family Oriolidae (Figure 4.3-5).

Eight species, classified under different families were found only in early regenerated forest. These are Blue-banded Kingfisher (*Alcedo euryzona*) of family Alcedinidae, Black and Red Broadbill (*Cymbirhynchus macrorhynchos*) of family Eurylaimidae and Crimson-winged Woodpecker (*Picus punic*eus) of family Picidae. Other bird's family such as Pycnonotidae were represented by two species (i.e Black-headed Bulbul (*Pycnonotus atriceps*) and Finch's bulbul (*Alophoixus finschii*) while family Muscicapidae was represented by three species (i.e. Grey-headed canary Flycatcher (*Culicicapa ceylonensis*), Grey-chested Jungle-flycatcher (*Rhinomyias umbratilis*) and Blue-throated Flycatcher (*Cyornis rubeculoides*) (Appendix C).

Ten species were found only in intermediate regenerated forests. Family Pycnonotidae recorded highest species representatives with five species (Figure 4.3-5). These are Grey-bellied Bulbul (*Pycnonotus cyaniventris*), Stripe-throated Bulbul (*Pycnonotus finlaysoni*), Ashy Bulbul (*Hemixos flavala*), Red-eyed Bulbul *(Pycnonothus brunneus*), and Black-crested Bulbul (*Pycnonotus flaviventris*). Family Timaliidae were represented by two species, i.e.Oriental white-eye (*Zosterops*

palpebrosus) and Pin striped-tipped Babbler (*Macronus gularis*). The other species recorded in this forest were Common Tailorbird (*Orthotomus sutorius*) of family Cisticolidae, Plain Flowerpecker (*Dicaeum minullum*) of family Dicaeidae and Pale Blue-flycatcher (*Cyornis unicolor*) of family Muscicapidae.

Three species were recorded only in old growth forest. These are Rufous-collared Kingfisher (*Ceyx rufidorsa*), and Banded Kingfisher (*Lacedo pulchella*) of family Alcedinidae and Sooty-capped Babbler (*Malacopteron affine*) of family Timaliidae. All these species were represented by than ten individuals in all stages of regenerating forest (Appendix C).

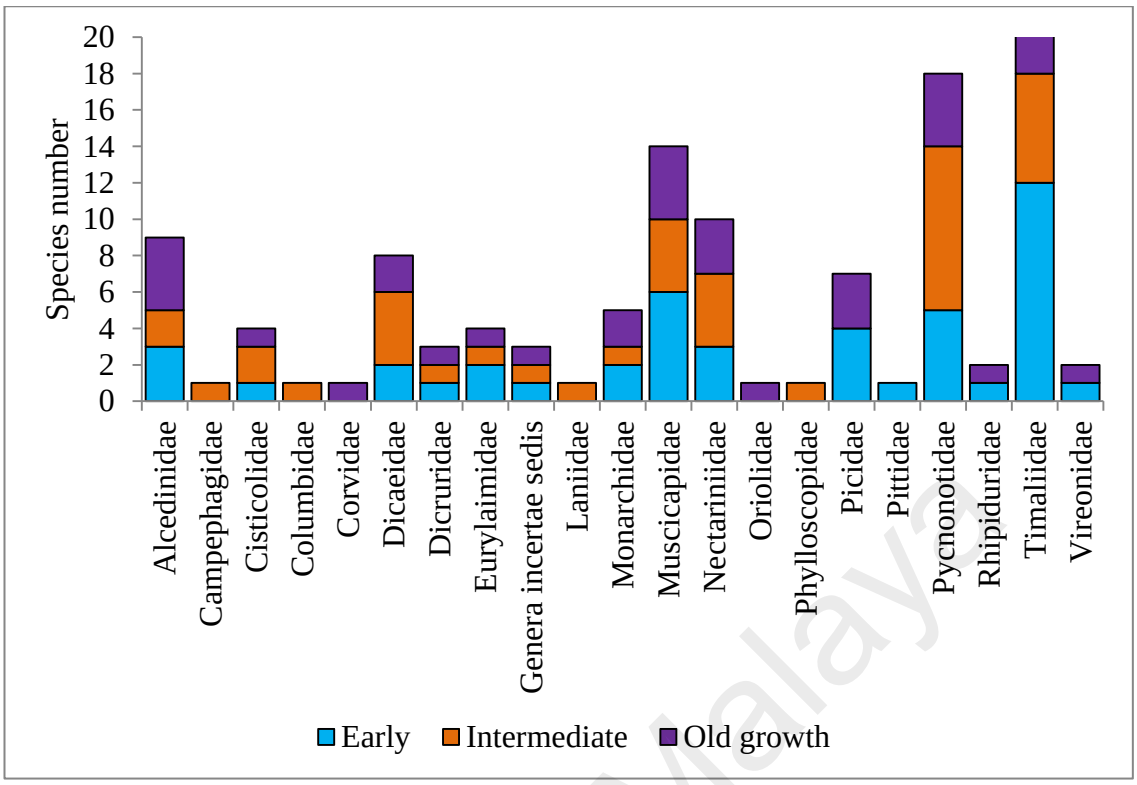


Figure: 4.3-5: Distribution of bird families in three stages of regenerating forests.

4.3.4 Feeding guilds composition

4.3.4.1 Overall

Overall, three stages of regenerating forest were dominated by insectivorous birds with 249 individuals which belong to 14 families and 42 species, followed by insectivorous/nectarivorous birds with 139 individuals and four species. Whereas, insectivorous/frugivorous birds were represented by 101 individuals with six species, frugivorous birds were represented 53 individuals with six species and miscellaneous birds were represented by 45 individuals of five species (Figure 4.3-6).

Results also showed that foliage gleaning insectivorous (47.33 ± 15.89), insectivorous/nectarivorous (46.33 ± 7.51) and arboreal insectivorous/nectarivorous (33.67 ± 4.04) have higher representatives. The lowest number of representatives was terrestrial frugivorous (1.33 ± 2.31).

More insectivorous birds were captured in early regenerated forest than intermediate regenerated forest and old growth forest. These are foliage gleaning insectivorous (27.54%), sallying insectivorous (10.14%), terrestrial insectivorous (12.08), insectivorous nectarivorous (20.29%) and bark gleaning insectivorous (20.29%). In contrast, more miscellaneous (15.38%) and arboreal insectivorous-frugivorous (16.29%) were captured in old growth forest compared to early regenerated forest and intermediate regenerated forest. Most bird species utilize different stages of regenerating forest. Terrestrial frugivorous but not bark gleaning insectivorous was present in intermediate regenerated forest (Table 4.3-3). The feeding guilds composition are not significantly varies with habitat type (χ^2=0.212, d.f. = 2, p>0.05). However different group varies with type of feeding guilds (χ^2=20.33, d.f. = 8, p<0.05).

4.3.4.2 Early regenerated forest

Foliage gleaning insectivorous (FGI) and insectivorous/nectarivorous (IN) were the highest individuals birds captured in early regenerating forest. Foliage gleaning insectivorous birds were represented by family Timaliidae (nine species), Vireonidae (one species), Eurylaimidae (one species), Dicruridae (one species) and Cistocolidae (one species). Family Timaliidae were dominated by Grey-headed Babbler (*Stachyris poliocephala*) with 13 individuals (3.25 ± 1.71), Moustached Babbler (*Malacopteron magnirostre*) and Short-tailed Babbler (*Malacocincla malaccensis*) with 10 individuals (2.5 ± 3.0). IN birds were dominated by family Nectariniidae with three species. Little spiderhunter (*Arachnothera longirostra*) were the most abundant species of family Nectariniidae with 35 individuals (8.75 ± 3.59). Only terrestrial frugivorous (TF) were not represented by any species in this type of forest.

4.3.4.3 Intermediate regenerated forest

Insectivorous/nectarivorous (IN) and arboreal insectivorous/frugivorous (AIF) were represented by highest number of individuals in intermediate regenerating forest. However, IN birds were only represented by family Nectariniidae with four species. Little spiderhunter was the most common species of family Nectariniidae with 47 individuals (11.75 ± 6.75). AIF birds were represented by family Pycnonotidae (nine species), while family Timaliidae and Eurylaimidae have single representative each. Family Pycnonotidae was dominated by Grey-cheeked Bulbul (*Alophoixus bres)* with 10 individuals (2.5 ± 1.73), Hairy-backed Bulbul (*Tricholestes criniger)* with nine individuals (2.25 ± 0.96) and Spectacled Bulbul (*Pycnonothus erythropthalmus)* with six individuals (1.5 ± 1.73). Family Timaliidae was represented by Oriental White-eye (*Zosterops palpebrosus*) (0.25 ± 0.5) and family Eurylaimidae was represented by Green Broadbill (*Calyptomena viridis*) (0.25 ± 0.5). There is no representative for Bark gleaning insectivorous (BGI) in this type of forest.

4.3.5.4 Old growth forest

Old growth forest was dominated by foliage gleaning insectivorous (FGI) and insectivorous/nectarivorous (IN) birds. FGI birds were represented by family Timaliidae (consists of 14 species), but other families such as Vireonidae, Dicruridae, and Cistocilidae only have single species representative each. Members of family Timaliidae such as Chesnut-rumped Babbler (*Stachyris maculata*) and Scaly-crowned Babbler (*Malacopteron cinereum*) were represented by 13 individuals (3.25 ± 5.85) and 11 individuals (2.75 ± 0.96) respectively. IN birds were dominated by family Nectariniidae with three species. Little spiderhunter of family Nectariniidae were recorded highest number of individuals with 38 individuals (9.50 ± 6.66). Only terrestrial frugivorous (TF) were not recorded in this type of forest.

Table 4.3-3: Number of individuals (N), species (S) and percentage of birds assigned into different feeding guilds.

Feeding guilds	Early			Intermediate			Old growth		
	S	**N**	**%**	**S**	**N**	**%**	**S**	**N**	**%**
Miscelleneous (MIP)	3	7	3.38	2	4	2.52	4	34	15.38
Foliage gleaning Insectivorous (FGI)	13	57	27.54	10	29	18.24	15	56	25.34
Terrestrial frugivores (TF)	0	0	0	1	4	2.5	0	0	0
Arboreal frugivores (AF)	2	16	7.73	5	16	10.06	2	17	7.69
Sallying insectivores (SaI)	8	21	10.14	3	3	1.89	6	14	6.33
Arboreal insectivorous frugivores (AIF)	6	29	14	10	36	22.64	6	36	16.29
Terrestrial insectivorous (TI)	6	25	12.08	4	12	7.55	5	14	6.33
Insectivores nectarivores (IN)	3	42	20.29	4	55	34.59	3	42	19
Bark gleaning insectivorous (BGI)	4	10	4.83	0	0	0	3	8	3.62

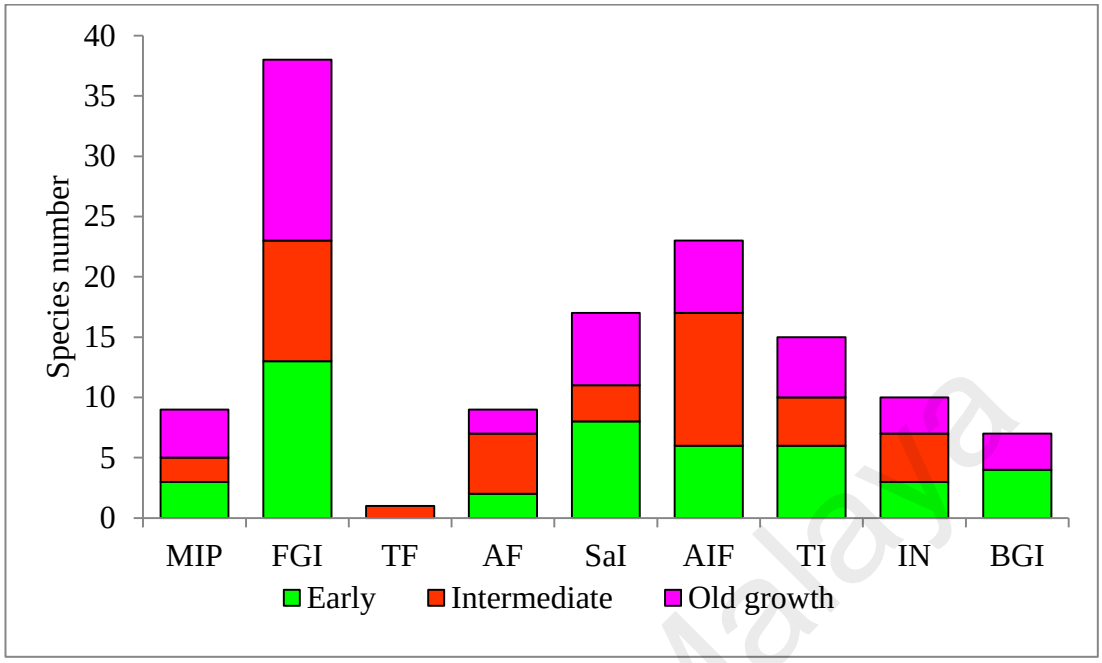


Figure 4.3-6: Composition of bird species of different feeding guilds captured in three types of regenerating forest.

CHAPTER 5

DISCUSSION

5.1 Understorey Birds Assemblages of Selected Forest Reserves in Peninsular Malaysia

Currently there are 696 species of birds have been recorded in Peninsular Malaysia (BirdLife-International, 2013). Of these, 45 species were categorized as globally threatened (BirdLife-International, 2013). A total of 240 species of birds recorded in Peninsular Malaysia are grouped as sea-bird, upperstorey and nocturnal birds. These species were excluded from analysis since the sampling methodologies used in this study would not be able to record these species.

Results indicated that families Timaliidae, Muscicapidae and Pycnonotidae are the most abundance and diverse species recorded during sampling. Forest birds belong to families Timaliidae and Muscicapidae frequently dominated forest understorey (Johns, 1986). While members of families Pycnonotidae and Nectarinidae appeared to be most abundance in secondary growth forest (Zakaria et al., 2005) since these species appeared to be always benefited from logging activities.

Little Spiderhunter (*Arachnothera longirostra*) was the most abundance species that was captured in all study sites. This species had broad range of distribution and commonly used lowland forest but also had extended its territory into montane forest. It was commonly found in secondary forest and frequenting forest fringe or wooded areas of primary forest (Ramli et al., 2009). The growth of wild banana and ginger along the logging road and forest edge had attracted this species.

Distribution of bird was influenced by habitat vegetation structure (Peh et al., 2005). Endau-Rompin JNP has highest species diversity than other forest reserves because it had experience longer regeneration process (more than 31 years). This had

allowed its vegetation to recover to their original structure and composition. In addition, this forest was gazette as national park, which prevent further logging activities or other disturbance. As a result, vulnerable species such as Brown-chested Jungle-flycatcher (*Rhinomyias brunneata*) and near threatened species such as Crested Jay (*Platylophus galericulatus*) were recorded in this forest. Occurrence of these species showed that old growth forest has the ability in providing suitable habitat for forest birds.

There are 70 species of understorey bird that are classified as Near-threatened in Peninsular Malaysia (MNS-Bird, 2010). Current study had recorded 26 species of Near-threatened birds (Table 4.1-3) and two vulnerable species (i.e. Brown-chested Jungle-flycatcher and Blue-banded Kingfisher). The presence of red listed species provides strong evidence that the study sites possess valuable habitat and sufficient resources.

Results of this study are heavily influenced by method used. In this study, only mist netting was chosen because the study intends to record understorey bird diversity. Mist netting was proven as a suitable technique in surveying understorey birds (Seaman and Schulze, 2010). In dense tropical forest, birds that are inconspicuous, cryptic and vocally inactive can be captured by mist nets but were easily missed by counting methods (Ramli et al., 2004; Seaman and Schulze, 2010). However, major factors such nets location, sampling time, number of days where nets were operated, netting hours and weather will affect capture success (Ramli et al., 2004; Derlindati and Caziani, 2005; Barlow et al., 2006).

Number of bird species captured by mist netting technique was influenced by netting hours and study duration. Long netting hours will potentially recorded more species while shorter netting hours resulting in less captured. This had been proven by sampling methodologies in Pasir Raja FR (i.e. 4200 hours) resulting in capturing of 403 individuals that belong to 66 species. While less netting hours were conducted in Endau- Rompin JNP, (i.e. 3,520 hours) had recorded only 359 individuals, belong to 52

species. However, sampling also showed that shorter netting hours still have the ability to capture appropriate samples. Presence study showed that minimal netting effort (3,000 hours) in Tekam FR had successfully recorded (54 species) compared to Endau-Rompin JNP.

Migrants birds start to arrive in Peninsular Malaysia as early as July and August but in very large numbers from September to November (Jeyarajasingam and Pearson, 1999). During migration season, stopover site is a location where habitat requirements for a species are generally met, and variations in stopover habitat determine how well a particular stopover site provides everything a species needs to rest and refuel (Roger and Tankersley, 2004). Available habitat during migration is probably limited by extent of particular cover types, by the spatial distribution and environmental condition of suitable stopovers and by sheer number of migrants using the available stopover sites (Moore and Simons, 1992).

Small numbers of migratory species were captured in this study. The occurrence of migrant's species indicated that the study sites were suitable for stopover sites for some species. Black-backed Kingfisher and Siberian blue Robin were commonly found during this period. Both species were passage migrant (Robson, 2008). Siberian blue Bobin were recorded at all study sites. At Pasoh forest reserve, more individuals of this species were recorded in mature forest compared to regenerated forest (Wells, 2007). Recent study recorded similar result. These species were recorded higher in Endau-Rompin JNP (old growth forest) compared to Berembun and Tekam FR. Study showed that Siberian blue Robin prefer mature than regenerating forests as their stopover site (Wells, 2007).

5.2 Understorey Birds Assemblages in Unlogged and Logged Forests

Understorey bird communities significantly differ in composition between unlogged and logged areas of selected forest reserve. Approximately 53.37% of species in unlogged forests were more abundance than logged forest. Current assessment showed that primary avifauna at Berembun FR, Pasir Raja FR and Tekam FR differed slightly in species richness and community structure between unlogged and logged forests. Fewer primary forest bird species were detected in unlogged forest at Endau-Rompin JNP. However some studies found that richness of bird communities in unlogged and logged forest was similar, although important changes in species abundance and composition did occur (Wong, 1986; Lambert, 1992; Johns, 1996). Many primary forest species that were initially affected by logging are capable of recolonizing logged forest over time (Peh et al., 2005). This study proved that some species were found only in unlogged forest while other were recorded only in logged forest. Previous study by Styring and Ickes (2001) found that relative abundance of certain species such as woodpecker differed significantly. Orange-backed Woodpecker (*Reinwardipicus validus*) for instance was recorded in unlogged forest only.

Vegetation structure and tree composition differ between unlogged and logged forests (Thiollay, 1997). Major difference between unlogged and logged forests is the frequency of canopy opening (gaps). Primary forest contains less gaps. These gaps were only created in primary forest due to tree fall, but subsequent regeneration and succession may be inhibited for extended periods by liana growth (Schnitzer and Boners 2002). However, gaps are more frequent in selectively logged forest. Their number can vary substantially depending upon topographical conditions. This means logged forest is not necessarily resource-poor, and indeed a greater frequency of gaps could mean that logged forests contain a higher abundance of resources essential for some of the species than primary forest (Johns, 1996). This may explain results indicated contrasting bird

community composition between logged and primary forests, but no apparent differences in overall species richness (Cleary et al., 2005). Johns (1996) found that higher species richness in disturbed forest was due to increase number of common edges species. Results indicated that secondary and forest edge species such as member of families Pycnonotidae, Dicaeidae and Nectariniidae were abundantly recorded in logged forest mainly due to the rapid spread of small fruit and shrub in the logged forests. Secondary and forest edge species were increased in number while primary forest species (such as babbler of Timaliidae) decreases when condition shifted from primary to logged forests (Zakaria et al., 2005).

Most logged forests covered in the recent study are not fully recovered to their original structure and composition. Many previous studies throughout Peninsular Malaysia also show similar results (Wong, 1985; Wong, 1986; Peh et al., 2005). All these studies showed that species richness was lower in old growth forest than unlogged forest. On the other hand, logged forest of Endau-Rompin JNP (that have been left for regeneration for more than 31 years) have recorded more bird's species and individual than nearby unlogged forest. This clearly implies that complete regeneration of logged forest require longer time (Huth and Ditzer, 2001; Peh et al., 2005). Therefore, logging cycle which is less than 35 years in Peninsular Malaysia might impede the recovery of some forest species (Peh et al., 2005).

Logged forest can play importance role in conservation of primary forest species. Species that were absent from early logged forest including members of family Pittidae (Johns, 1986) were recorded in logged forest in recent study. Forest birds such Garnet Pitta (*Pitta granatina*), Grey-chested Jungle-flycatcher (*Rhinomyas umbratilis*) and Grey-headed Flycatcher (*Culicapa ceylonensis*) were recorded in logged forest. However, number of individuals was less in logged forest compared to unlogged forest. Previous study indicated that secondary forest can play important role in conserving

biodiversity when the primary forests are located nearby (Ramli et al., 2009). Same conclusion was also derived by Peh et al. (2006) which stated that relatively high forest species richness was presence in degraded habitat that positively associated with nearby forest primary forest.

Distribution of primary forest birds among vegetation strata in logged forest was different than the pristine forest due to the lack of emergent trees (Peh et al., 2005). Birds species responds to forest disturbance can be dictated by their direct physiological sensitivity to associates changes in microclimate (Thiollay, 1992). Birds that forage exclusively in the lower understorey can be physiologically and behaviorally specialized for lower light conditions (Stratford and Robinson, 2005). Increased canopy-discontinuity that fragments these low habitats may thereby reduce the availability of suitable foraging condition for light sensitive species (Felton et al., 2008). For example understory group such as babblers (Timaliidae) are known to become heat-stressed very easily outside their preferred environment. This is in contrast with species such as Drongo, Malkoha and Leafbird that will occupy foraging volume normally exploited by understorey birds (Johns, 1986).

Certain groups of forest species such as understorey insectivorous (flycatcher), terrestrial insectivorous, large canopy frugivorous and bark forager (woodpecker) are disproportionately affected both by logging and forest fragmentation (Lambert, 1992; Styring and Ickes, 2001; Lambert and Collar, 2002; Cleary et al., 2007). In logged forests, bird communities tend to recover after several decades (Wong, 1986; Yap et al., 2007) but sensitive species such as woodpeckers may took longer time (Styring and Ickes, 2001).

The abundance of insectivorous birds was decreased in exploited areas (Thiollay, 1992) due to changes in arthropods abundance (Burke et al., 2004) and certain invertebrates (Ford et al., 2001) which could be caused by microclimatic

changes at forest edges (Sekercioglu et al., 2002). This study showed that the abundances of insectivorous birds have decreased in logged forest. However, species in this guild intensively exploit resources of logging gaps (Zurita and Zuleta, 2009). This apparent contradictory result shows that mechanism producing patterns of species abundance may differ at different scales and reflects the interaction between microhabitat use within an area and changes in abundance between different areas (Wunderle, 2006). In the forest, insectivorous birds are generally more specialized than other bird guild (Mansor and Sah, 2012). For this reason, they are more sensitive to subtle change (Canaday, 1997). As a result, insectivorous birds have developed numerous specialized niches and forage in certain narrowly defined microhabitats (Sekercioglu, 2002).

Johns 1986 found that less insectivorous birds (notably terrestrial, foliage gleaning and sallying species) were found in logged forests. This is because terrestrial insectivorous is adversely affected by forest disturbance (Johns, 1996; Newmark, 2006). The relative abundances of terrestrial insectivorous was approximately twice as high in primary forest (Newmark, 2006). Terrestrial insectivorous of babblers (e.g. Black-capped Babbler and Large-wren Babbler were rarely observed in logged forest at Tekam FR and no species of family Pittidae was recorded (Johns, 1986). On contrary, this study had recorded Garnet Pitta (family Pittidae) in logged forest. Other terrestrial birds such as Siberian blue Robin, White-rumped Shama, Black-capped Babbler, and Short-tailed Babbler were also found in both forests but the number of individuals is slightly lower in logged forest.

Previous study also shown that foliage gleaning insectivorous such babbler, flycatcher and faintail are common in primary forest but were never recorded in logged forests. Surprisingly this study had recorded members of family Timaliidae and Rhipiduridae (i.e. flycatcher and faintail) in unlogged and logged forests. However the

number of Spotted faintail was more frequently observed in unlogged than logged forests. Wong (1985) stated that babblers are extremely abundant in primary forest. Similarly, this study only recorded members of family Timaliidae such as White-necked Babbler (*Stachyris leucotis*) and Grey-throated Babbler (*Stachyris nigiceps*) in unlogged area. They are mostly gleaning insectivorous and may find less food in regenerating vegetation (Johns, 1986). Drying of litter and hardening of soil in logged forest have severely reduced the availability of soil arthropods and had marked effects upon little gleaning birds (Johns, 1986; Johns, 1996).

5.3 Comparison of Bird Diversity Inhabits Three Different Regenerated Forests

The rate of forest regeneration and recovery of animal diversity after logging is highly dependent on ecological requirements of species involved such as food resources and environmental condition. Variation in food availability may explain why unsuitable forest management is producing negative impacts on birds' abundance.

Diversity and richness patterns of understorey birds recorded from three regenerating forests were different. Result showed that more individuals and species were recorded in old growth forest. This is because habitat structure of old growth forest is closely resemble to primary forest (Cleary et al., 2005). It was reported that older regenerated forests have high levels of similarity with its neighbouring primary forest (Barlow et al., 2007). Comparative studies between primary forest and naturally regenerated area generally positive assessment and reported equivalent or higher species richness than secondary forest (Gil-Tena et al., 2009). Forest maturation will increase amount and availability of quality habitat. This process increase populations size of bird that inhabiting matured forest (Gil-Tena et al., 2009).

Bird's assemblages are influenced by forest structure. Some bird species only occupied certain forest structure. This study showed that Near-threatened species

require specific habitat for their survival. For example, Rufous-collared Kingfisher was found only in old growth forest. Previous study shown that this species usually occupies mature regenerated forest (Wells, 1999).

Forest structure was influenced by the creation of forest gaps. The gaps were created by tree removal process during logging activity or tree felling by natural disturbances such as strong wind. Forest gaps represent important habitat patch for tropical forest birds (Wunderle et al., 2005). In addition, canopy openness will increase light penetration and modify microclimatic condition. Colonization of various vegetation in these areas was contributed by fleshy fruits and flowers that were produced by pioneer species (Feisinger et al., 1998; Wunderle et al., 2005). Fleshy fruiting trees are more abundance after logging resulting from increasing sun exposure to forest floor (Owiunji and Plumptre, 1998). Edge species such as Red-eyed Bulbul and Little Spiderhunter can tolerate high temperature and light intensity during feeding which allow them to better occupy disturbed and regenerating forests.

Major changes in bird community composition occurred few months after timber been harvested. Bird diversity decreased one year after logging process but returned to levels similar to unlogged forest 5 to 10 years later (Thiollay, 1992; Mason, 1996). Forest takes long time to recover to structurally resemble primary forest, which needed by many specialized bird species. The impoverishment of the understorey bird community was worse immediately after logging. This study showed that higher number of individuals and species were recorded in early stages of regenerating forest (1-15 years) but was reduced in intermediate regenerating forest (16-30 years), and increased in old growth forest (>31 years). Recently logged forest exhibit an avifauna characteristics of both primary and older logged forests (Johns, 1989).

Some families were successfully survived in different forest structure after logging. These families are associated with disturb forest caused by logging. For

example, members of family Timaliidae (babbler), Pycnonotidae (bulbul), Muscicapidae (flycatcher) and Nectariniidae (spiderhunter) are abundance in logged forest. Opportunistic species such as bulbuls and spiderhunters prefer secondary forest than primary forest (Wong, 1986). These colonizing species have special adaptation to survive in logged forest. For instance, they switch their diet from insect to fruits depending on forest disturbance and quantity of food resources.

Current study only recorded one member of family Pittidae (i.e. Garnet Pitta) in early regenerated forest. On contrary, previous study stated that members of family Pittidae was never been recorded in logged forest such as Tekam FR even after 12 years of logging (Johns, 1989). Time since logging may also influence the observed response of animal species and communities. However the responses may be quite variable a few years after logging and more stable many years after selective logging (Azevedo-Ramos et al., 2006).

In Peninsular Malaysia, a planned of 30 years cutting cycle has been devised for sustainable logging. However, the result of this plan was not very successful because old growth forests are not fully regenerated. The forests obviously have lower and denser tree diversity than primary forest. Therefore, not all forest birds were detected in this type of forest.

Variation in vegetation structure or forest composition influences the abundance of resources used by birds (Zurita and Zuleta, 2009). In Asia and Neotropics, frugivorous and insectivorous abundances are generally affected by forest disturbance, while the abundances of granivorous bird are typically increases in modified habitats. However, the effects on other feeding guilds are not consistent (Gray et al., 2007). Certain birds group such as understory insectivorous, large canopy frugivorous and bark forager are disproportionately affected by logging and forest fragmentation (Lambert, 1992; Styring and Ickes, 2001; Cleary et al., 2007).

High proportion of bird species that were usually recorded in unlogged forest have now been recorded in regenerated forest but with less abundance. The formation gap created during logging, recreation of cool and humid microclimate are typical characteristic of unlogged forest. This allow reestablishment of many understory birds such as babbler of the genus *Stachyris* (Johns, 1989). For example, Chesnut-rumped Babbler (*Stachyris maculata*) was found in regenerated forest and Grey-headed Babbler (*Stachyris poliocephala*) was recorded in early regenerating forest. Although, bird communities in logged forest tend to recover after several decades (Wong, 1986; Yap et al., 2007), sensitive species such as woodpeckers may require longer recovery time (Styring and Ickes, 2001).

Insectivorous-nectarivorous birds are feeding on flowers. Open habitat of recently logged forest contains higher densities of flowering plant. This study showed that insectivorous-nectarivorous birds were common in all level of regenerating forests. Flowering plants were mostly visited by sunbird (genera *Anthreptes* and *Hypogramma*), while many spiderhunter visited bananas and ginger (Johns, 1986).

Loss of large trees during logging process obviously reduces availability of foraging strata for foliage and bark gleaning insectivores. However, contrary to bark gleaning insectivorous especially members of family Picidae, foliage gleaning insectivore may recover their population in regenerating forest. Recent study found that family Picidae was recorded only in early regenerating forest but totally absent in intermediate and old growth forest. Previous study showed that the abundance of bark gleaning insectivores was reduced even after 12 years of logging (Johns, 1986).

5.4 Potential indicators

This study discovered that some bird species have a potential to become indicator species. Birds are often used as a biological model because they are good ecological indicators and can be easily observed (Clergeau et al., 2001). In addition, birds are sensitive to environment health and sustainability (Birdlife 2003). Previous studies indicated that bird's composition varies in term of topography, vegetation structure, microclimate, food availability, degree of disturbances and history of logging (Mohamed Zakaria, 2002; Peh, 2005).

This indicated that the number of Scaly-crowned Babbler, Grey-throated Babbler and Grey-chested Jungle-flycatcher have decreased in logged forest than unlogged forest (Appendix C). Scaly-crowned Babbler was vulnerable to habitat changes due to their physiologicall ill-adapted to microclimate changes and food scarcity (Zakaria, 2001). This species frequent the lower and middle canopies and glean invertebrate from foliage; as it known as folige gleaning insectivorous (FGI). Grey-throated Babbler was totally dissapeared in logged forest which indicated that the forest reserves were not providing adequate food resources and suitable microclimate in attracting this sensitive species.

On the other hand, some species such as Brown Fulvetta, Chesnut-rumped Babbler and Grey-headed Babbler (Appendix C) had considerably increased their number in logged forests but the abundance is different depending on level of forest regeneration. These species are suitable indicator for measuring regenerating stages of the forest. Rufous-collared Kingfisher, Black-backed Kingfisher, Banded Kingfisher and Rufous-backed Kingfisher (all belong to family Alcedinidae) were found more abundance in old growth forest compared to early and intermediate regenerated forests. These species can act as indicator of mature forest.

Some forest babblers such as Short-tailed Babbler, Grey-headed Babbler and Moustached Babbler were found in all stages of regenerating forests. These species have successfully recolonized the regenerated forest due to the presence of undisturbed forest patches and regeneration of the forest canopy and sparse ground cover. It shows that these species were able to survive in this forest despite been logged due to their sensitivity to habitat disturbance (Zakaria et al., 2005). However, further studies with the specific methodology for indicator study should be apply for the best result.

CHAPTER 6

CONCLUSION

Community structure and species composition of understorey bird were influenced by vegetation structure of particular habitat, microclimate, food availability and logging history (Peh et al., 2005). This study focused on understorey bird assemblages in four selected forest reserves located throughout Peninsular Malaysia. Results showed that members of family Timaliidae, Muscicapidae and Pycnonotidae are the most abundance and diverse in the study areas. Little Spiderhunter *(Arachnothera longirostra*) of family Nectariniidae was the most abundance species recorded in the forest reserves. Occurrence of migratory species such as Siberian blue Robin, Black-backed Kingfisher and Tiger Shrike indicated the forest reserves in Peninsular Malaysia can play important role as stopover site for migrant birds.

Previous study indicated that secondary forest can play important role in conserving biodiversity when the primary forests are located nearby (Ramli et al., 2009). Logged forest if left untouched for certain period of time can play importance role in conservation primary forest species. Changes in forest structure lead to change in species composition. In Peninsular Malaysia, production forest is manage by selective management system with 30 years of cutting cycle (Rahim et al., 2009). This logging activity had reduced fauna diversity which can be and reflected by the degree of habitat disturbance (Mansor and Sah, 2012). First logging rotation will cause some bird population to decline (Johns, 1986) while second rotation will strongly affects species composition (Edwards et al., 2010). This clearly shows that disturbed forest requires longer time to recover or resemble the primary forest structure. Further disturbance on regenerating forest will impede recovery of some primary forest species.

This study proved that old growth forests are able to provide ecological requirement such as variability of food resources for understorey birds. More individuals and species were recorded in old growth forest compared to intermediate and early regenerated forests. This is because old growth forests is closely resembled to primary forest and have highly community similarity with neighbouring primary forest. Forest maturation also increases the quality of available habitat. Therefore, management of logging practices in Malaysia should consider second rotation in term of conservation of biodiversity.

Long-term study is needed to gather more information and assess the effects of logging on understorey bird community. Other sampling methods such as direct observation and point count can be used to collect diverse information about bird assemblages, level of habitat disturbance and level of forest recovery. Results of this study provide early ideas about the effect of logging and forest management practices on understorey bird species inhabiting forest reserves in Malaysia. Birds have potential to be one of the biodiversity indicators for sustainable forestry.

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Hassan, N., & Ramli, R. (2012). Effects of longging activity of understory bird diversity inhabiting different forest reserves. Paper presented at the Zoological and Ecological Research in Progress, University of Malaya.

Hassan, N., & Ramli, R. (2010). Diversity of Understory Birds of Two Selected Logged Forest in Peninsular Malaysia Paper presented at the Biological Science Graduate Congress 2010, University of Malaya, Kuala Lumpur.

Hassan, N., & Ramli, R. (2010). Animal Diversity in Protected Area: A Case Study On Understory Birds Of Johor National Park – Endau Rompin. Paper presented at the First National Conference on Natural Resources, Kota Bharu, Kelantan.

Hassan, N., & Ramli, R. (2010). Diversity of Understory Birds In Selected Primary And Logged Forests In Peninsular Malaysia. Paper presented at the The 2010 International Meeting of the Association for Tropical Biology and Conservation, Sanur–Denpasar, Bali, Indonesia.