BIRD COMMUNITIES AND FEEDING GUILDS FROM THREE LAND USE TYPES IN KERIAN RIVER BASIN, PERAK

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BIRD COMMUNITIES AND FEEDING GUILDS FROM THREE LAND USE TYPES IN KERIAN RIVER BASIN, PERAK

by

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ABBREVIATION

STUDY SITE

KRB	Kerian River Basin
SF	Secondary forest
OP	Oil palm plantation
PF	Paddy field

FEEDING GUILDS

Car	Carnivore
Ins	Insectivore
Fru	Frugivore
Nec	Nectarivore
Gra	Grainivore
Omn	Omnivore

HABITAT TYPE

GP	Gardens and parks (including wooded suburban areas)
OC	Open country (open grassy areas, scrub and tin mines)
IS	Inland freshwater swamps (mining pools, lakes and paddy fields)
MG	Mangroves
LF	Lowland rainforest (including secondary forest and forest edge)
LMF	Lower montane rainforest (including secondary forest and forest edge)

STATUS

R	Resident
M	Passage migrant/winter visitor
V	Vagrant
I	Introduced

INCIDENCE OF OCCURRENCE

C	Common
U	Uncommon
RA	Rare

PROTECTION BY LAW IN PENINSULAR MALAYSIA

TP	Totally protected (may not be hunted or reared in captivity)
GB	Game birds (may be hunted under license)
OPB	Other protected birds (may be reared in captivity under license)
NP	Not protected
NT	Near-threatened

MATERIALS AND METHODS

GIS	Geographical Information System
DEM	Digital Elevation Model
MCDA	Multi-Criteria Decision Analysis
AHP	Analytical Hierarchy Process
UPMGA	Unweighted pair-group method
F	Forest
R	River
E	Elevation
CI	Consistency Index
CR	Consistency Ratio
RI	Random Index

OTHER

MNS	Malaysia Nature Society
IBAs	Important Bird Areas
BBC	Bird Conservation Council
MPOC	Malaysian Palm Oil Council
MOA	Ministry of Agriculture
MADA	Muda Agricultural Development Authority
DOAP	Department of Agriculture Perak
IUCN	International Union for the Conservation of Nature
NRE	Ministry of Natural Resources and Environment
SPSS	Statistical Package for Social Science

KOMUNITI BURUNG DAN KUMPULAN PEMAKANAN DARI TIGA JENIS GUNA TANAH DI LEMBANGAN SUNGAI KERIAN, PERAK

ABSTRAK

Aktiviti pembukaan tanah telah menyebabkan kehilangan sejumlah besar spesies burung. Status burung di hutan sekunder (SF), ladang kelapa sawit (OP) dan sawah padi (PF) didokumentasikan dari Mac 2009-Februari 2010. Objektif kajian ini adalah untuk menentukan spesies burung yang terdapat di kawasan-kawasan kajian, menganalisa variasi kumpulan pemakanan di habitat yang berbeza dan mengenalpasti kawasan kesesuaian untuk spesies burung terancam yang terpilih. Kaedah *point-count* dan pemasangan jaring kabut (*mist-netting*) digunakan untuk bancian burung di SF dan OP, manakala hanya kaedah *point-count* digunakan di PF. Kumpulan pemakanan dikenalpasti untuk setiap burung yang direkodkan. Peta kawasan kesesuaian untuk Pycnonotidae yang terancam dikenalpasti untuk kegunaan pemuliharaan dengan menggunakan Sistem Maklumat Geografi (GIS) dan *Multi-Criteria Decision Analysis* (MCDA). Hasil menunjukkan sejumlah 183 spesies mewakili 49 famili direkodkan di kesemua tapak kajian. Hutan sekunder mencatatkan 106 spesies, diikuti oleh PF dengan 70 spesies dan OP dengan 58 spesies. Kelimpahan tertinggi famili burung yang diperhatikan di SF adalah Pycnonotidae (26.65%), Hemiprocnidae (19.77%) dan Muscicapidae (7.10%); di OP, Pycnonotidae (21.59%), Muscicapidae (19.12%) and Sturnidae (17.95%); di PF, Ardeidae (29.09%), Sturnidae (10.15%) dan Hirundinidae (7.86%). Hipotesis alternatif menyatakan kelimpahan spesies adalah berbeza dikesemua jenis habitat, $F(2,105) = 99.83$, $p < 0.05$. Lapan kumpulan pemakanan burung dikenalpasti di sawah padi diikuti tujuh kumpulan pemakanan di hutan sekunder dan kelapa sawit. Jika hutan ditukar kepada OP, kumpulan pemakanan yang berkemungkinan berubah adalah penurunan spesies insektivor, insektivor-frugivor, insektivor-nektarivor dan frugivor; dan peningkatan pada spesies karnivor, grainivor dan omnivor. Jika hutan ditukar kepada PF, kumpulan pemakanan yang berkemungkinan berubah adalah penurunan spesies insektivor, insektivor-frugivor dan frugivor; dan peningkatan spesies karnivor, insektivor-nektarivor, insektivor-grainivor, grainivor dan omnivore. Bandingan antara SF dan OP melalui *Mann-Whitney U-test* menunjukkan perbezaan signifikan hanya pada enam kumpulan pemakanan, termasuk insektivor, insektivor-frugivor, insektivor-nektarivor, frugivor, grainivor dan omnivor. Perbandingan antara OP dan PF menunjukkan kesemua kumpulan pemakanan adalah berbeza secara signifikan. Peta kawasan kesesuaian untuk Pycnonotidae yang hampir terancam menunjukkan bahagian hulu KRB yang didominasi kawasan hutan merupakan habitat yang paling sesuai untuk tujuan pemuliharaan. Analisis mendapati SF didiami oleh spesies burung hutan yang sensitif terhadap gangguan habitat dan tidak ditemui di OP. Vegetasi yang kompleks di hutan menyediakan lebih banyak nic, dan mempunyai diversiti tumbuhan dan serangga yang tinggi untuk menampung lebih banyak spesies burung. Berbeza dengan PF yang merupakan tanah lembab sementara, menampung pelbagai burung air dan spesies burung hijrah seperti *Bubulcus coromandus*, *Circus melanoleucos* dan *Vanellus cinereus*.

BIRD COMMUNITIES AND FEEDING GUILDS FROM THREE LAND USE TYPES IN KERIAN RIVER BASIN, PERAK

ABSTRACT

Land conversion activity has caused losses in a vast number of bird species. Bird status in secondary forest (SF), oil palm plantation (OP) and paddy fields (PF) were documented from March 2009-February 2010 at study sites in Kerian River Basin (KRB). The objectives of this study were to determine the current bird species present in the study areas, to analyze variation of feeding guilds in different habitat types and to identify suitability area for selected threatened bird species. Point count and mist-netting methods were used for bird census in SF and OP, while only point count method was used in PF. Feeding guilds were determined for each species recorded. Map of suitability areas for threatened Pycnonotidae were identified for conservation purposes using Geographical Information System (GIS) and Multi-Criteria Decision Analysis (MCDA). A total of 183 species representing 49 families were recorded at all study sites. Secondary forest scored 106 species, followed by PF with 70 species and OP with 58 species. The highest abundance of bird families observed in SF was Pycnonotidae (26.65%), Hemiprocnidae (19.77%) and Muscicapidae (7.10%); in OP, Pycnonotidae (21.59%), Muscicapidae (19.12%) and Sturnidae (17.95%); in PF, Ardeidae (29.09%), Sturnidae (10.15%) and Hirundinidae (7.86%). Alternative hypothesis established that the abundance of species is different across habitat types, $F(2,105) = 99.83$, $p < 0.05$. Eight feeding guilds were identified in paddy field and seven in both secondary forest and oil palm plantation. If forests were converted to OP feeding guild could possibly change with a decreased in insectivore, insectivore-frugivore, insectivore-nectarivore and frugivore species; and increased in carnivore, grainivore and omnivore species. If forests were converted to PF feeding guild could possibly change with a decreased in insectivore, insectivore-frugivore and frugivore species; and increased in carnivore, insectivore-nectarivore, insectivore-grainivore, grainivore and omnivore species. Comparison between SF and OP with Mann-Whitney *U*-test showed significant differences in six feeding guilds, including insectivore, insectivore-frugivore, insectivore-nectarivore, frugivore, grainivore and omnivore. Comparison between SF and PF showed significant differences in five feeding guilds, comprising of carnivore, insectivore-grainivore, frugivore, grainivore and omnivore. Comparison between OP and PF showed all feeding guilds to be significantly different. Suitability area map generated for near-threatened Pycnonotidae indicates upper part of KRB, characterized by forest, as the most suitable habitat for conservation. This analysis demonstrated SF was inhabited by forest dependent species sensitive to habitat disturbance, most absent in OP. Complex vegetation in forest offers more niches, with higher plant and insect diversity to support more bird species. In contrast, PF, a temporary wetland, support predominantly various waterbirds and migratory species such as *Bubulcus coromandus*, *Circus melanoleucos* and *Vanellus cinereus*.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Forest conversion is defined as a dramatic process where natural forest landscape is replaced by other land uses and affects their habitat and biodiversity (Shearman *et al.*, 2009). Forest conversion activity is the major driving force that has caused a tremendous rate of species extinction (Singh & Kushwaha, 2008). A review by Sodhi *et al*. (2004) stated that the current rate of habitat destruction in South-east Asia will result in the loss of 13-42% of mammals, birds, reptiles, amphibians, fish, butterflies and plants by 2100. Thus large numbers of flora and fauna in tropical rainforest including birds have been listed as threatened species due to the destruction of their habitat (Dybas, 2006).

Malaysia is a developing country that is actively converting natural forest areas to agricultural land and build-up areas (Sodhi *et al.*, 2004). Malaysia's land is very suitable for many agriculture crops such as oil palm plantation (*Elaeis guineensis*), rubber (*Hevea brasiliensis*) and rice (*Oryza sativa*). According to Sodhi *et al.* (2010a) oil palm plantation is the single largest agriculture crop in Malaysia because of the growing demands for food and biofuel. This leads to the establishment of giant companies such as Sime Darby Plantation Sdn. Bhd. and governing authority such as Malaysian Palm Oil Council with high profit margin annually.

Agriculture industry is one of the major income sources for Malaysia. However, without sustainable practices in parts of the industry, it could pressure species and their habitats. Habitat destruction would cause several negative implications such as direct mortality of resident species, physiological stress and decreased reproduction, disruption of normal behaviour and activities, segmentation of interbreeding populations, changes in species interaction and alien species invasion (Feeley & Terborgh, 2008; Bernard *et al.*, 2009). For instance, forest bird species are absent in cultivated areas, however their abundance increased along the successional gradient from cultivation to old growth forest (Mallari *et al.*, 2011). This indicates bird community prefer to inhabit an area that has large tree density which provide good breeding areas and shelter (Minor & Urban, 2010).

Habitat changes also caused variation in bird species abundance. According to Maas *et al.* (2009) six years of habitat changes in Lore Lindu National Park, Central Sulawesi had given negative impacts on bird community structure. These include the widespread of common species and decreasing of sensitive birds. These differences might be caused by the high tolerance of common species within unfavourable environments such as limited food availability and exposure towards human activities. Besides, uncontrolled logging activities and plantation expansion that have caused habitat fragmentation also give negative effect on bird species (Brooks *et* al., 2002). For example, measures on genetic differentiation of endangered Golden-cheeked warbler (*Dendroica chrysoparia*) were negatively associated with habitat connectivity (Lindsay *et al.*, 2008). The variation occurred due to limited dispersal capability that is caused by fragmentation.

Therefore, the importance of this study is to determine the current bird status and to predict the possibilities that might occur if forest is converted into agriculture areas. The study sites are located within the Kerian River Basin (KRB) boundary, north Peninsular Malaysia. Most forested areas comprised of secondary forest and several areas of primary forest. The main agricultures within KRB boundary include oil palm plantation and paddy fields. Old growth secondary forest (more than 20 years) in this study is represents forested areas, while oil palm plantation and paddy fields represent agriculture areas. Selections of these three habitats are explained in the following paragraphs.

According to Guariguata & Ostertag (2001) the occurrence of tropical secondary forest is believed to have increased in these recent years due to agriculture development process. Similar situation is found to occur in Peninsular Malaysia, where secondary forest and tropical plantations have been identified as the major land use types (Styring & Ickes, 2001; Peh *et al*., 2006). Secondary forest is usually formed subsequently after massive logging activities that have occurred for more than 20-30 years (Brown & Lugo, 1990). Secondary forest is characterized by the low composition of timber trees, fast growth rates of vegetation and the production of various seeds that are widely dispersed (Brown & Lugo, 1990).

Secondary forest or second-growth vegetation serves as an important habitat for many bird species (Blake & Loiselle, 1991). According Borges & Stouffer (1999) secondary forest with greater vegetation complexity commonly has more similar microclimate to the primary forest and this allow forest birds to inhabit the habitat. Observation by Kwok & Corlett (2000) had shown that forest dependent

bird species was frequently recorded in secondary forest because of the vegetation complexity and the richness in flowering trees. Forest dependent bird species is very sensitive toward habitat changes and identified as totally protected bird. Since there were a lot of secondary forest areas that have been identified in the upper stream of Kerian River Basin, it is vital to conduct a study to determine the bird status of the area for future conservation and monitoring purposes.

According to Ministry of Agriculture (MOA) (2010), the most popular plantation area in Malaysia is *Elaeis guineensis* or oil palm with 4.88 million hectares. This African oil palm had been chosen for their unique tolerance in extreme site conditions. Currently, Malaysia and Indonesia are the two South-east Asian countries that have become primary producers of world's oil palm with 17,400,000 and 19,700,000 metric tons, respectively (Koh & Wilcove, 2008). Bird families that dominate this area are generalist that feed on wide range of food sources and very adaptable to unfavourable environment, such as Pycnonotidae, Corvidae and Cuculidae (Aratrakorn *et al*., 2006). Further investigation on bird community in oil palm plantation is needed to confirm if oil palm plantation in Kerian River Basin is a threat or has conservation value for birds.

Malaysian traditional crop, *Oryza sativa* or rice has become secondary and it covers approximately 510,474 ha of the land in Peninsular Malaysia (MOA, 2010). The interest on paddy fields as unique wetland landscapes for many waterbirds and land bird species have increased recently among ornithologists and conservationist in countries such as Korea, Japan, India, Indonesia and Americas (Acosta *et al*., 2010; Amano *et al*., 2010; Fujioka *et al*., 2010; Sundar & Subramanya, 2010). Waterbirds

such as egrets, storks, snipes, sandpipers, lapwing and herons were found to dominate in all areas of the paddy fields worldwide (Sundar, 2006; Takahashi & Ohkawara, 2007; Kelly *et al*., 2008). Several of these bird groups normally exist in large flocks. Landbirds such as raptors (Katoh *et al*., 2009), sparrows, cisticolas, doves, munias and weavers (Shah *et al*., 2008) have also been reported to occur in paddy fields. Thus, with the presence of such dynamic bird groups, paddy field has become an important habitat to study.

In this study, bird has been chosen as indicator to predict the possibilities that occur if forested area is converted into agriculture area. It is the best indicator for habitat loss and food availability (Lim & Sodhi, 2004; Lehmkuhl *et al*., 2007). Bird is an animal group that is always documented by many studies of habitat destruction (Schmiegelow *et al*., 1997; Brooks *et al*., 1999a; Naidoo, 2004; Waltert *et al*., 2005; Ko *et al.*, 2009). As explained by Lawton *et al*. (1998) and Louette *et al*. (1995) birds frequently served as the indicator or 'flagship taxa' in biodiversity inventories because birds are widespread and present in most habitat types. Birds are easy to observe or detect compared to the other fauna due to their loud vocalization, most of them have bright colour patterns and they are abundant in many habitat types.

In Malaysia, excellent information on birds is well-known including ecology and food preference (Strange & Jeyarajasingam, 1999; Wells, 1999; Wells 2007; Robson, 2008). This study focused on the changes of bird communities and their feeding guilds distribution across three habitat types namely secondary forest (SF), oil palm plantation (OP) and paddy field (PF). All these habitats have different

characteristics and landscape which sustain different food sources and thus attract different bird feeding guilds. Feeding guild is a useful tool for examining changes in bird communities because variations in feeding guilds are largely determined by the habitat structure and food availability (Arriaga-Weiss *et al.*, 2008).

It is important to avoid any activity that can cause negative effects such as ecosystem degradation and biodiversity loss. Hence, the concept of sustainable development must be followed by all the developers. Sustainable development is defined as an approach to meet human needs, while at the same time preserving the environment (Bezák & Halada, 2010). The examples of sustainable management that can be implemented such as protecting the young timber trees during logging, promoting the regeneration of endangered plant species and maintainance of buffering zones surrounding the protected areas, that later will reduce the harvesting pressures (Burton *et al*., 2006). The importance of sustainable concept has become increasingly recognized in recent years. By identifying the most ecological valuable areas, planning and management practices can be applied in order to maintain the area's value (Smith & Theberge, 1987).

The identification of threatened bird in all habitats is very useful for conservation purposes. Sustainable practices and conservation works are important steps to protect threatened species (Brooks *et al.*, 2002; Bezák & Halada, 2010). These steps begin with the identification of the most suitable area for threatened birds. Geographical Information System (GIS) was used to map the distribution of threatened animals, to identify habitat suitability of animals and the least-damaging areas for infrastructure (Joerin *et al*., 2001; Store & Kangas, 2001; Clevenger *et al*.,

2002). In this study, the integration of field data, GIS tool and Multi-Criteria Decision Analysis (MCDA) are used to analyse spatial data and to generate map of suitability area for selected threatened bird species. The identification of suitability areas for threatened bird is reliable for the agriculture management and bird's conservation effort in order to achieve a sustainable development in Kerian River Basin.

1.2 Rationale

Recent studies on birds in Malaysia revealed that, inadequate information exist on bird diversity and feeding guilds in different habitat types that has been conducted (especially in northern Peninsular Malaysia). Most of bird studies focus on forested areas in southern Peninsular Malaysia (Peh *et al*., 2005; Zakaria *et al*., 2005; Peh *et al*., 2006; Sodhi *et al*., 2007). Thus, it is a necessity and relevant to conduct a bird study in northern Peninsular Malaysia. Past study by Nájera & Simonetti (2010) investigated the bird community structure in oil palm plantation, and they suggested that for future research it is important to examine the bird habitat use within the agriculture area, as it can aid in formulating the management actions that will provide the greatest benefits for bird communities. Before any management actions can be employed, it is necessary to discover the areas of bird distribution within the agriculture areas.

Bird feeding guild is another important aspect to discover in this study. As explained by Poulin *et al*. (1994) any actions that affect the environmental resources will similarly affect the members of the guilds using those resources. These include

logging activities and exploitation of valuable trees and land conversion. This means, through feeding guild information, quality of particular habitat, in terms of food and carrying capacity could be evaluated (Foster, 1977). Besides, availability of food sources such as arthropods, small vertebrates, fruits and nectar is varied between habitat types and thus support different groups of birds to exist (Szaro, 1986). In this study, bird feeding guilds is able to give additional knowledge for better understanding of birds in different habitat types of Kerian River Basin.

These days integration of GIS application and ecological study is still lacking in Malaysia. In developed country such as Australia, GIS play an important role in coastal and marine conservation, research and management (Zharikov *et al*., 2005). In more advanced countries GIS has become a powerful tool used by natural resource managers and decision makers in managing wildlife (Lauver *et al*., 2002). By using GIS, field data including large varieties of spatial data and aspatial (attribute) data can be analyzed (Salem, 2003). Several advantages of GIS application in ecological studies are development of biodiversity databases, biodiversity monitoring and aiding in identifying the areas that are in need of conservation (Salem, 2003). In this study, GIS and field data are used to map the suitability area for selected threatened bird species in Kerian River Basin. This is also an important contribution of this study, i.e., to identify valuable areas for conservation purpose.

1.3 Objectives

The objectives of the study can be summarised as follows:

1. To determine the current species present in the study areas. Species are recorded through point count method and mist-netting.

2. To analyse variation of bird feeding guilds in different habitat types. Bird feeding guilds information is based on literatures and field observation.

3. To identify suitability area for selected threatened bird species by using GIS application in order to identify valuable areas for conservation. Suitability area is shown in a map through the integration of Geographic Information System (GIS) tools and Multi-Criteria Decision Analysis (MCDA).

CHAPTER 2

LITERATURE REVIEW

2.1 Bird diversity and community in different habitats

From muddy mangroves to mountain ranges, Malaysia encompasses of various tropical habitats teeming with hundreds of resident bird species. The country's location on the East Asian Australasian flyway also makes it as a host to more than 120 migratory birds (Wells 1999 & 2007). Half of Malaysia's land mass is covered by natural and man-made habitats. Natural tropical habitats such as montane forest, lowland rainforest and wetlands are easily accessible by more than 600 bird species (Robson, 2008). Meanwhile man-made habitat, mainly agriculture areas, also supports bird species. The areas include rubber plantations, oil palm plantations and paddy fields. This multi-habitat selection which includes both natural and man-made habitats has become one of the major factors in making Malaysia as an excellent home and stop over areas for resident and migratory birds.

Each habitat type has distinct characteristics which make them differ from each other. Examples of characteristics that distinguish the habitats are vegetation structure, abiotic factors and wildlife community that habitat bears. Different habitat also receives different frequency of human activities. These characteristics eventually describe the pattern and temporal changes of bird species that occurred (Greenberg & Center, 2008). Food availability in a habitat is also an important determinant for birds to exist (Clearly *et al.*, 2007). A habitat that serves variety of foods such as insects, fruits, nectar, invertebrate and large prey such as rodent and

snake, will continually sustain various types of bird species ranging from the small sized to larger sized.

Natural habitat is different from man-made habitat in many aspects and thus supports different bird communities. For example, montane forest which is low in temperature and receives high precipitation makes this habitat to be continuously moist (Brunjinzeel & Veneklaas, 1998). In addition, higher altitude makes the montane forest to be shrouded in mist for at least part of each day. Vegetation structure becomes less complex as the plant growth is restricted by the cool upland ambient and reduction in sunlight intensity. Common vegetation includes tree ferns and epiphytic plants such as moss, lichen, and orchids (Freiberg & Freiberg, 2000). Thus, because of this unique environment, it harbours unique bird community which does not exist at lower altitudes.

Lowland rainforest is another type of natural habitat. A study of floristic structure in Pasoh Forest Reserved by Kochummen *et al.* (1990) stated that plant diversity was very high with 530 trees per hectare representing about 210 species. Thus, with complex vegetation structure, more niches are available for many bird species. According to Lee *et al*. (2007) the rarefaction analyses and species estimator had confirmed eight protected areas of forests (in Sulawesi, Indonesia) that consistently showed high number of endemic forest bird species. The key families in lowland rainforest are woodpeckers, barbets, hornbills, bulbuls, flowerpeckers, trogons, babblers, cuckoos and spiderhunters (Strange & Jeyarajasingam, 1999).

Malaysia is a tropical country that is lined with long coastal areas, that offers a variety of wetland habitat types (both natural and man-made). Near to the coastline, wetlands such as mudflats and mangrove forest are dominated by birds that have high adaptability toward muddy environment and hot temperatures. Long-legged waterbirds such as herons, egrets and bitterns utilize mudflats and deeper waters to search for foods (Bennett & Reynolds, 1993). Study on the ecology of Selangor mangrove forest birds by Noske (1995) stated that shallow waters and exposed mudflats become an ideal habitat for shoreline birds such as plovers and sandpipers. Wetlands have become one of the important migratory stops for birds that fly all the way from Siberia and China by providing them with food and shelter (Lomoljo *et al.*, 2010).

Further inland, habitats such as marsh swamp, freshwater lake and paddy fields can be found. These habitats also become ideal habitats for specialist wetland birds. A study by Zakaria *et al*. (2009) in Paya Indah Wetland Reserve, Selangor, has found a total of 13,872 birds from 100 species and 38 families; where Ardeidae was the dominant family with nine species recorded. According to them, Paya Indah Wetland Reserve is important in providing food resources, shelter, nesting and roosting areas for various birds. Paddy field is also another important wetland area for many bird species. As reported by MOA (2010), four states in northern part of Peninsular Malaysia; Kedah, Perak, Perlis, and Pulau Pinang have appeared as the top producers of rice in this country. Kedah, also called the '*negeri jelapang padi*', which means 'Rice bowl', encompasses the largest area of paddy fields (210, 644 ha), while Pulau Pinang comprises the smallest areas (25, 630 ha) (MOA, 2010).

Paddy is cultivated in flooded fields. The uniqueness of this wetland is that it consists of stagnant water, high plant productivity, and other habitat qualities which can support diverse group of animal populations (Zedler & Kercher, 2005). Paddy field is characterized by the presence of temporary and seasonal standing water body (Bambaradeniya *et al*., 2004), and subjected to several agriculture practices such as harvesting, ploughing and transplanting of seedlings (Maeda, 2001). These situations will completely influence the temporal distribution of land birds and waterbirds (Maeda, 2001). Paddy field plantations provide high chances for the bird species especially waterbirds to dominate the areas.

Malaysia's land mass, covered with oil palm plantation, is also inhabited by birds. As reported by Malaysian Palm Oil Council (MPOC), oil palm is extensively planted in Malaysia since this country is the second largest oil palm producer in the world (MPOC, 2010). Rubber plantation is also commonly found in Malaysian landscape. However, Aratrakorn *et al.* (2006) suggested in his finding, birds existed in oil palm and rubber plantations in southern Thailand, were species that have wide ranges of habitats and foods, adaptable to human environment and low conservation status. According to Koh and Wilcove (2008), oil palm plantation managed to sustain common bird species because these species have the capability to adapt to this monoculture that is characterized by its less complex vegetation structure, low food availability and frequently received human activities. Since there are differences in bird diversity and distribution in natural habitats and man-made habitats, further investigation is needed in order to gain information on the bird status and to identify their threats due to the uncontrollable obsession of human activities.

2.2 Environmental changes and its effect on birds

Nowadays, there are many factors that have been identified to cause global environmental changes. A study by Tilman *et al*. (2001) stated that the predominant factor to this phenomenon would be agriculture expansion activities. It was predicted that within the next 50 years, a total of 10^9 hectares of natural ecosystem will be converted into agriculture (Tilman *et al*., 2001). As reported by Rao and Puttanna (2000) and Sharpley *et al.* (2003), the amount of pesticide used is positively correlated with the number of agriculture activity, as pesticide brings benefits to crop yields. However, the drawbacks from the excessive usage would cause intensification in nitrogen and phosphorus eutrophication of terrestrial, freshwater and near-shore marine ecosystem. This eutrophication and habitat loss lead to the emergence of tremendous problems, for instance, ecosystem degradation, loss of ecosystem services and species extinction (Tilman *et al.*, 2001).

Study on bird community changes affected from habitat loss in many developing countries is increasing over time (Yorke, 1984; Waltert *et al*., 2005; Zakaria & Francis 2001). According to Sigel *et al*. (2010), habitat loss and fragmentation have reduced the density of tropical bird communities at an immense rate. Many implications seem to appear when forested areas are converted into monoculture plantation. The main problem is the lost of tree diversity which can lead to several disastrous side-effects, such as scarcity of food sources, global warming due to the absence of trees and canopy layer that decreased the uptake of CO_2 and shading area, respectively, decrease in microhabitat for different bird

species to occupy and loss of insects and arthropods which frequently live on trees. All these problems are able to suppress bird population.

Past studies has shown that habitat modification might cause either positive or negative effect on wildlife population. In bird population study, research conducted by Greenberg & Center (1998) suggests that bird diversity had gradually improved in coffee plantations. In contrast, there are studies that reported on the negative correlation of habitat loss with the pattern of species richness (Shochat *et al*., 2010; Sigel *et al*., 2010). For instance, a study on the effects of human access and landscape structure on forest bird richness found that habitat modification did affect the bird community structure. Modification affects toward endemic forest species negatively although beneficial for the survival of open-land birds (Aubad *et al.*, 2010).

In Malaysia, the emergence of agriculture industries is rapidly increased annually to fulfil human demands. Forests, dominantly located in lowland areas, are highly subjected for conversion to agriculture areas and the remaining forest left are mountainous regions with low agriculture value or in isolated protected areas (Kawanishi & Sunquist, 2004). With good support under the government agricultural scheme, agricultural activities have become one of the most important industries that contribute to Malaysia's economy. As reported by Malaysian Palm Oil Council (MPOC), Malaysia is one of the world's largest palm oil exporters and currently accounts for 39% of world palm oil production and 44 % of world exports (MPOC, 2010). The expanding of oil palm plantation areas will result in attenuation

of forest cover which in turn becomes a threat causing habitat loss for wildlife communities (Sodhi *et al*., 2010b).

Few studies on bird population of the oil palm plantation have been done that focused on the effect of oil palm expansion (Fitzherbert *et al*., 2008) and conservation efforts to reduce extinctions on bird species (Peh *et al*., 2005). As reported by Peh *et al*. (2005), Koh & Wilcove (2008) and Fitzherbert *et al*. (2008), oil palm plantation sustains a small number of bird species as compared to forest and other tree crops. They concluded that the only way to avoid the critical loss of biodiversity was to stop the conversion of forest areas and strictly use existing cropland and degraded habitats for oil palm plantation. Related study by Aratrakorn *et al*. (2006) had tried to evaluate the changes in bird communities following conversion of lowland forest to oil palm plantation in southern Thailand. They have confirmed that the forest birds including woodpeckers, barbets, broadbills, leafbirds and babblers were poorly represented in the plantations.

Other than oil palm, Malaysia is also dominated by paddy field cultivation. Rice is the staple food for Malaysians and many other developing countries (Bambaradeniya *et al*., 2004). Malaysia's traditional landscape is covered by paddy fields with a total area of 673,745 ha (MOA, 2010). Between 2005 and 2010, there were only a small number of researches related to the biodiversity of paddy field being conducted. This was also stated by Guadagnin *et al*. (2005), mentioning the lack of ecological study on waterbird assemblages in fragmented wetlands and its documentation. Example of studies that have been carried out within this interval period were breeding behavior and reproductive success of Grey-headed lapwing in

paddy field in central Japan (Takahashi & Ohkawara, 2007), the effects of landscape on waterbird densities in California paddy fields (Elphick, 2008) and the study of paddy field as breeding habitat for threatened bird species (Sundar, 2009).

These studies have highlighted the importance of paddy field cultivation areas that served as breeding habitat for waterbirds. Paddy fields can also uphold the most diverse and abundant amount of breeding waterbirds in the world as shown in Southwestern Louisiana (Pierluissi *et al*., 2010). This has proved that paddy field ecosystem exhibits a good habitat potential to support diverse bird groups. Based on this information, more studies should be carried out in order to know the current situation of bird diversity in Malaysia's paddy fields.

2.3 Bird feeding guilds: characteristics and variations

The use of bird guilds as an indicator of habitat changes is commonly practised worldwide. Guild is defined as "a group of species that exploit the same class of environmental resources in the same way" (Simberloff & Dayan, 1991). Guilds represent a functional group between a group of species and ecosystem (Iongh & Weerd, 2006). In this study, feeding guild has been chosen as the functional group in the observation of the bird communities' changes with habitat change. Bird feeding guilds are differentiated based on the differences in their diet pattern; carnivores (raptors), frugivores (fruit-eaters), insectivores (insect eaters), nectarivores (nectar feeders), granivores (seed eaters) and omnivores (general feeders). These feeding guilds will respond differently towards human disturbances and habitat changes.

Bird feeding guilds are different between habitats across tropical regions (Karr, 1980). A study by Poulin *et al.* (1994) in north-eastern Venezuela revealed that five parameters have been identified to influence the variation in feeding guilds, which include (1) the number of species that exists in the habitat, (2) proportion of transient individuals (migratory species), (3) seasonal variation (e.g. fruiting season), (4) bird's body size and (5) total biomass of the habitat. Their study also confirmed these five factors were also related to diet characteristics in terms of the food type consumed and diet variations, at the species level. Besides, Johnson & Sherry (2001) and Renton (2001) suggested that differences in food availability among habitats lead to distinct differences in the diet of bird species and also variation in temporal and spatial bird distribution.

As added by Pearman (2002), (6) forest cover and (7) vegetation structures are the components that determined the variation in feeding guilds composition. For instance, in Amazonian forest, nectarivores, shrub-layer frugivores, and ant-following birds are captured in areas with relatively low primary forest cover, meanwhile shrub-layer insectivores, shrub-layer omnivores, and birds probing dead foliage for large insects tend to be captured in areas of relatively high primary forest cover (Pearman, 2002). In addition, Chettri *et al.* (2005) have proven that different feeding guilds have showed preferences for diverse habitats. This suggests that the diversity of feeding guilds is directly related to the habitat conditions. Table 2.1 showed example of feeding guilds with different habitat preferences.

Table 2.1 Feeding guilds with different habitat preferences (Chettri *et al.* 2005)

Feeding guilds	Habitat preferences
Insectivore	High closed canopy and dense vegetation, these provide high tree density and basal area.
Frugivore	Abundant under open canopy conditions due to high visibility of fruits
Carnivore	Prefered to habitat with vertical complexities which this situation promote suitable area for nesting birds and small mammals as prey for them
Nectarivore	Prefered to habitat that receive moderate disturbance with more flowering plants under open conditions
Granivore	Prefer more disturbed and open habitats due to large seed banks
Omnivore	Prefer open canopy habitat and also habitat with distinct stratification which sustain high food sources

Changes in feeding guilds are also influenced by habitat destruction that is mostly induced by human activities. More studies on this issue are further reviewed in the following subtopic.

2.3.1 Effect of habitat changes on feeding guilds

Many past literatures have tried to relate bird feeding guilds with habitat changes to demonstrate the impact on bird community. According to Sodhi *et al*. (2008), forest structure and food abundance could change the breeding cycle of some bird groups. In addition, Zakaria *et al*. (2009) reported the information on bird feeding guilds could help in determining the population trends. There are several reviews on bird feeding guilds from 1990's to 2010 that have discussed in detail about the effects of disturbance or loss of tropical rainforest on birds (Canaday, 1996; Aratrakorn, *et al*., 2006; Gray *et al*., 2006; Sodhi *et al*., 2008), respond of frugivores bird to fruit harvesting activity (Moegenburg & Levey, 2003), food habits of raptor (LourenÇo & Sergio, 2006), investigation on frugivores bird in facilitating germination of invasive plants (LaFleur *et al*., 2009), and feeding guilds composition in wetland reserve (Zakaria *et al*., 2009). From these reviews, they have come out with one concrete conclusion stating that the bird feeding guilds respond differently according to the different habitats where they lived.

A study by Miller *et al*. (2003) found that the riparian areas in western North America should be conserved because urbanization of the area could affect the birds that forage for insects or seeds. This study was conducted due to concerns on the increase of human settlement in lowland riparian areas of Colorado (USA). In contrast, according to Levey (1988) and González Varo (2010), habitat fragmentation did not have any influence on the abundance and composition of frugivore assemblage. This situation occurred because frugivore species (1) can move easily across habitat fragmentation, (2) tolerate at least temporally in disturb

habitat and (3) feed on several fruits species (generalist frugivore) (Harris & Pimm, 2004). Besides, bird communities in riparian areas were reported to be an important indicator for stream health. Parameters such as birds' physical measurements, longevity, feeding and breeding strategies have been used to classify stream condition (Larsen *et al*., 2010). A combination of information between a simple count data of bird communities and riparian areas could also be used as indicator for stream condition that is surrounded by agriculture plantations. More changes in bird feeding guilds due to the alteration of ecosystems are shown in Table 2.2.

Table 2.2 Studies that assess the impact of human disturbance on bird feeding guilds together with information on the method used.

Source	Country	Census type and effort	Treatment	Impact on birds	Vegetation parameters
Lambert 1992	Malaysia	M, TC	L/U	Negative on species richness.	d, h
Danielsen & Heegaard 1995	Indonesia (Sumatra)	TC: 2000 m	F/L/A	Negative on specialized insectivores.	-
Johns 1996	Malaysian (Borneo)	M:100 hours TC: 500 m	L/U	Negative on terrestrial insectivore and insectivore-frugivore. Insectivore-frugivores generalist and large frugivore survived in logged forest.	sd, dbh,
Canaday 1996	Ecuador	M: 10 SR	L/A	Negative on insectivores.	-
Parody *et al*. 2001	USA (Michigan)	History of ornithological surveys	50 years of landscape change	Ground-omnivores species increased in sizes over time. Number of aerial and hovering insectivores species declined.	-
Pearman 2002	Ecuador	M: 5060 hours	F/L/A	Nectarivores relatively low in primary forest. Insectivores & omnivores relatively high in primary forest cover	dbh, d, bta

Table 2.2 Continued

Source	Country	Census type and effort	Treatment	Impact on birds	Vegetation parameters
Luck & Daily 2003	Costa Rica	SR	A	Frugivores differed significantly among agriculture. Large frugivores were common visitors to trees in high intensity agriculture sites. Small frugivores declined with distance from large rain forest.	fr
Laurance 2004	Brazil	M: mark-recapture, 1000 hours	F/G/E	Total bird capture and captured insectivores increased with distance from edge while capture of frugivores and nectarivores did not vary significantly.	ch, cf, lt, dps
Lim & Sodhi 2004	Singapore	TC: 29	A/HL	Negative on insectivores and carnivores. Frugivores were favored by low-density housing. Omnivores did not prefer more urbanized sites. Positive on granivores in high public housing	-
Peh *et al*. 2005	Malaysia (Johor)	PC: 40, 200 m apart	F/L/Mx	Arboreal frugivores & omnivores, and insectivores showed persistence in Mx.	fr, fl, cf, dbh, lt, bta, d

Table 2.2 Continued

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Source	Country	Census type and effort	Treatment	Impact on birds	Vegetation parameters
Harvey *et al*. 2006	Nicaragua	PC: 100 m apart	F/U	High abundance and species richness of birds associated with high tree cover was largely explained by the presence of many frugivores and insectivores species	dbh, cf, h
Felton *et al*. 2008	Bolivia	PC: 360	L/U	Negative on species richness, insectivore and frugivore	dbh, d, cf
Sigel *et al*. 2010	Costa Rica	History of ornithological surveys	L	Negative on insectivores and ground/understorey nesters	-
Sodhi *et al*. 2010a	Southeast Asia (review paper)	-	L/U	Negative on species richness and abundance/density of forest-dependent	-

Explanation of the abbreviations: **Census types**; M: Mist netting, PC: point counts, SR: spot recordings (auditive or visual), TC: transect counts. **Treatments and effort**; F: forest, G: gaps, L: logged forest, U: unlogged forest, Mx: Mix rural habitat, A: agriculture, E: forest edge, HL: Human landscapes, T: Total effort of all plots. **Vegetation parameters**; bta: basal tree area, ch: canopy height, cf: cover of foliage in one or more strata, d: density of vegetation, dbh: diameter at breast height, dps: distance from sampling point, fl: flower production, fr: fruit production, ft: forest type, h: height, sd: stem density, lt: leaf litter depth

Past studies had shown that bird feeding guilds could be a strong indicator on the effect of human disturbance on birds since this functional group had been used worldwide. Bird feeding guilds are frequently assessed because of the considerable information existing in past literatures that makes these functional groups easier to study. Many studies had compared and analyzed their observation between logged and unlogged forest, forested areas and agricultural areas, or forested areas and human landscapes and overall had shown important results for future reference and conservation. None of these studies had tried to identify the changes in bird feeding guilds if forested areas are converted into agriculture plantation and man-made wetland areas. Here we see the gap and attempt to assess the impact of human disturbance in these types of areas. In addition, past studies in Malaysia had only covered east Malaysia and southern Peninsular Malaysia, while the northern area still lacks examination.

2.4 Bird studies in Malaysia

Malaysia is a small tropical country located on the equatorial line. This country is rich with the existence of various birds' species. More than 746 bird species exist in Peninsular Malaysia and also Sabah and Sarawak in Borneo (MacKinnon, 1993; Wells, 1999 & 2007). Most of the recent bird studies that have been conducted in Malaysia mainly focused on affected forest habitats caused by activities such as logging and habitat conversion. Very few studies have been found to focus on other habitat types such as agricultural plantation and wetland areas in Malaysia as scope of the present study. However, the study of birds in this country is constantly growing.