UNIVERSITI PUTRA MALAYSIA

COMPARISON OF RESIDENT BIRD COMMUNITIES IN MANGROVE FOREST AND OIL PALM PLANTATIONS IN SELANGOR, MALAYSIA

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By

AAINAA SYAZWANI BT MOHAMAD AMIR HAMZAH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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April 2018

Chairman: Prof. Madya Hafidzi Mohd Noor, PhD.
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Oil palm plantations are constantly being trumpeted with the ability to accommodate the lower species richness and diversity of animals, including birds; while mangrove forest is a highly productive ecosystem and accommodates high diversity of flora and fauna communities. Most importantly, mangrove forest is the last refuge habitat for species that have lost its original habitat. Therefore, it is expected that proximity between oil palm plantations with natural forest (in this study are mangroves) will aid in the conservation of bird species in oil palm plantations, thus utilizing this semi-natural habitat as a biological conservation area. The aims of this study are to compare the diversity index of resident bird species in adjacent mangrove forest and oil palm plantations; as well as measuring the effectiveness of point count and acoustic sampling methods in estimating the diversity of birds and suggesting the most appropriate method use in both habitats. This study was conducted in Selangor, Malaysia from October 2012 to November 2013. 480 sampling points were established at a distance of at least 200m from each other. Audio recorder was also placed at each sampling point. Bird observation and recording of bird sound were performed simultaneously for 10 minutes at each point. The results registered 5686 individuals and 115 species of birds in these two habitats including 89 residents, 21 migrants, 4 feral and 1 vagrants. Among the 89 resident species, 8 species were threatened; 1 listed under EN and other 7 species were listed under NT. All threatened species were observed in mangrove while only 4 observed in oil palm plantation. Mangrove forests

recorded higher species richness and diversity index, as well as density when compared to the adjacent oil palm plantation. However, both habitats shared the same bird species with a relatively high percentage (74% similarities; 66 species) with omnivorous, insectivorous and carnivorous were the three most feeding guilds recorded in both habitats. There was no significant difference in the identification of bird species when using point counts and acoustic sampling at both study sites. However, if researcher has to choose one method to assess birds in oil palm plantation, point counts should be an option, while either point counts or acoustic sampling are appropriate for bird sampling in mangroves habitat. Although mangrove habitats accommodate high bird diversity index, oil palm plantation had also recorded a high number of generalist's species, some species of water birds and forest-dependent species as well as NT species. Therefore, it can be concluded that the proximity of natural forest to oil palm plantation is very important to aid in assist bird conservation in plantation. Choosing the appropriate sampling method based to the habitat type is also important for comprehensive sampling that can be used for conservation management of species in concerned habitat.

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

PERBANDINGAN KOMUNITI BURUNG RESIDEN DI HUTAN PAYA BAKAU DAN LADANG KELAPA SAWIT DI SELANGOR, MALAYSIA

Oleh

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Ladang kelapa sawit sentiasa dimomokkan dengan keupayaan untuk menampung kekayaan dan kepelbagaian spesies haiwan yang lebih rendah, termasuk burung; manakala hutan paya bakau merupakan ekosistem yang sangat produktif dan menampung kepelbagaian komuniti flora dan fauna yang tinggi. Paling penting, hutan paya bakau merupakan habitat perlindungan yang terakhir bagi spesies yang kehilangan habitat asalnya. Oleh itu, adalah diharapkan agar jarak dekat antara ladang kelapa sawit dengan hutan semulajadi (dalam kajian ini adalah paya bakau) dapat membantu dalam pemuliharaan spesies burung di ladang kelapa sawit, seterusnya menggunakan habitat separa semulajadi ini sebagai kawasan pemuliharaan biologi. Tujuan kajian ini adalah untuk membandingkan indeks kepelbagaian spesies burung residen di hutan paya bakau dan ladang kelapa sawit yang berhampiran; serta mengukur keberkesanan kaedah pengiraan titik dan persampelan akustik dalam menganggar kepelbagaian burung dan mencadangkan kaedah yang paling sesuai digunakan di kedua-dua habitat. Kajian ini telah dijalankan di Selangor, Malaysia dari Oktober 2012 hingga November 2013. 480 titik persampelan telah ditetapkan pada jarak sekurang-kurangnya 200m antara satu sam lain. Perakam audio juga diletakkan di setiap titik persampelan. Pemerhatian burung dan perakaman suara burung dilakukan secara serentak selama 10 minit pada setiap titik. Keputusan mencatatkan 5686 individu dan 115 spesies burung di kedua-dua habitat termasuk 89 residen, 21 burung hijrah, 4 “feral” dan 1”vagrant”. Antara 89

spesies residen, 8 spesies adalah terancam; 1 disenaraikan di bawah EN dan 7 spesies lainnya disenaraikan di bawah NT. Kesemua spesies terancam telah ditemui di paya bakau manakala hanya 4 ditemui di ladang kelapa sawit. Hutan paya bakau telah merekodkan kekayaan spesies dan indeks kepelbagaian yang tinggi, begitu juga dengan kepadatan apabila dibandingkan dengan ladang kelapa sawit yang berhampiran. Walaubagaimanapun, kedua-dua habitat ini berkongsi spesies burung yang sama dengan peratusan yang agak tinggi (74% persamaan; 66 spesies) dengan omnivor, insektivor dan karnivor adalah tiga kesatuan makanan yang paling tinggi di kedua-dua habitat. Tidak terdapat perbezaan yang signifikan dalam mengenalpasti spesies burung apabila menggunakan kiraan titik dan persampelan akustik di kedua-dua kawasan kajian. Walaubagaimanapun, sekiranya penyelidik harus memilih satu kaedah untuk menilai burung di ladang kelapa sawit, kiraan titik haruslah menjadi pilihan, manakala kiraan titik atau persampelan akustik adalah sesuai untuk persampelan di habitat paya bakau. Walaupun habitat paya bakau menampung indeks kepelbagaian burung yang tinggi, ladang kelapa sawit juga telah mencatatkan bilangan spesies generalis yang tinggi, beberapa spesies burung air dan spesies hutan serta spesies NT. Oleh itu, dapat disimpulkan bahawa jarak dekat antara hutan semulajadi dengan ladang kelapa sawit adalah sangat penting dalam membantu pemuliharaan burung di ladang. Pemilihan kaedah persampelan yang sesuai mengikut jenis habitat juga adalah penting untuk persampelan yang komprehensif supaya dapat digunakan untuk pengurusan pemuliharaan spesies di habitat berkenaan.

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I certify that a Thesis Examination Committee has met on 4th April 2018 to conduct the final examination of Aainaa Syazwani bt Mohamad Amir Hamzah on her thesis entitled "Comparison of Resident Bird Communities in Mangrove Forest and Oil Palm Plantations in Selangor, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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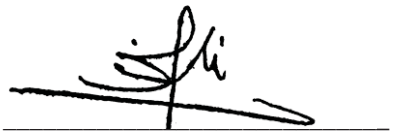

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ACE	Abundance-based Coverage Estimator
CBD	Convention on Biological Diversity
CD-ROM	Compact Disc, Read-Only-Memory
CO_2	Carbon dioxide
CR	Critically Endangered
D	Simpson's Index
EN	Endangered
FSC	Forest Stewardship Council
GB	gigabyte
GPS	Global Positioning System
H′	Shannon's Index
ha	hectare
HCV	High Conservation Value
ICE	Incidence-based Coverage Estimator
IsJ	Jaccard Similarity Index
IUCN	International Union for Conservation of Nature
J′	Pielou's Evenness Index
Kbps	Kilobits per second
kha	kilo hectare
KHz	Kilo Hertz
kt	kilotonnes
LC	Least Concern
m	meter
MMMean	Michaelis-Menten model based estimator
MP3	Moving Picture Experts Group Layer-3 Audio
MPEG	Moving Picture Experts Group
NEC	Nippon Electric Company
NGO	Non-governmental Organization
NRE	Natural Resources and Environment Ministry
NT	Near Threatened
PCM	Pulse Code Modulation
R_1	Margalef's Richness Index
RBA	Rapid Biodiversity Assessment
RSPO	Roundtable on Sustainable Palm Oil
ver.	Version
VU	Vulnerable
χ^2	Chi-square

CHAPTER 1

INTRODUCTION

Malaysia is blessed with a wide range of environments, e.g. forests, open areas, shrub lands, wetlands, lakes, rivers, ponds of aquaculture, woodlands, agricultural lands, rice fields, and areas of water treatment (Rajpar & Zakaria 2011) that are rich in avian diversity, including 532 residents, 167 migrants, 88 vagrants, and 52 endemic bird species (MNS 2015). In the early twentieth century, almost the entire region was covered with equatorial forest, while mangrove forest thrived along the west coast and sheltered estuaries on the east coast. What remains today is in large fragmentary measure; the only exceptions are 4343km^2 Taman Negara and the montane forests of the Titiwangsa Range. At the same time, creating open field by forest clearing has boded well for open field species and disuse of mining pools and rice paddies that provided secondary habitats for many species of waterfowl.

Birds are group with functional diversity encompassing a wide range of dietary, foraging, and microhabitat niches and the performing of major functional roles, such as pollination, seed dispersal and predation (Tscharntke, Sekercioglu, Dietsch, Sodhi, Hoehn et al. 2008). The studies on bird assemblages have contributed significantly to the advancement of science in the field of community ecology (Wiens 1989). The diversity of the comparative avifauna is an excellent indicator of ecosystem stability since birds respond quickly to changes in their environment (Miller & Spoolman 2009). For example, the proportion of forest birds was particularly high in the structurally rich landscapes which contain large areas of natural forest (Peh, Sodhi, de Jong, Sekercioglu, Yap et al. 2006). Farmland birds are also generally used as indicators to understand the impact of changes in the intensification of agriculture on biodiversity (Herrando, Anton, Sarda-Palomera, Bota, Gregory et al. 2014; Morelli, Jerzak & Tryjanowski 2014). Therefore, the concept of "use of birds as indicators for the recognition of the land ecosystems that are rich of biological diversity" now has won wide global acceptance (Niemi & McDonald 2004; Schulze, Waltert, Kessler, Pitopang, Veddeler et al. 2004).

Species richness and the presence of rare species are two of the most commonly used criteria for the selection of conservation areas (Rodriguez-Ferraro & Blake 2008). Rare or unique species can support features or act as important contributors to the functional redundancy, and are likely to be particularly

important if the abundance of rare species increases in response to future environmental change (Jain, Flynn, Prager, Hart, Devan et al. 2014). Species evenness was more strongly related to the fragmentation than mature forest surface of at the landscape level. In addition, the community composition and relative abundance of the target species are important in selecting areas for conservation.

Birds play a vital role in the enrichment of the biodiversity of wetlands. Almost 10% of the world's bird species depends entirely in such systems (Wiliamson, Hudson, O'Connell, Davidson, Young et al. 2013), with around the same number again using the wetlands at some stage of their life cycle. This explains why the wetlands are renowned first and foremost as a haven for waterfowl by Ramsar International in 1971 (Davis 1994). Coastal zone provides an ideal habitat for many species of birds during the winter and migration seasons especially shorebirds. The most potentially important coastal areas for birds in Peninsular and East Malaysia are mangroves, mudflats, freshwater, marshes, nipa swamp forest, peat swamp forest, lakes, river systems, swamps cool and moist rice paddies (Rajpar & Zakaria 2010). The large coastal area in Malaysia offers ideal habitat for many bird species during the winter and migration season. On the basis of David, Aik, Chye, Kanda, Lim et al. (2006) in their investigations of birds at Malaysian coast in November 2004 until April 2005, it is estimated that 60,000-100,000 shorebirds using coastal wetlands of Malaysia during the winter (non-breeding) if all the coasts of Sabah and Sarawak are included. However, the shorebird numbers on the west coast of Peninsular Malaysia have reported declined dramatically. This applies in particular to the state of Perak and Selangor which has declined by 80% to 94% earlier and later by 50% over the last twenty years. Fairbairn and Dinsmore (2001) and Kushlan (2000) also reported that the density of birds is associated with environmental variables, such as vegetation cover, food, nursing safe and loafing sites.

Tropical forests are famous for being the most species-rich ecosystems on earth. The ecosystems host at least two-thirds of terrestrial biodiversity of the earth and provide significant local, regional, and global human benefits through the provision of economic goods and ecosystem services. Moreover, tropical lowland forest ecosystems contain some of the highest levels of endemism of species and biodiversity worldwide (Fitzherbert, Struebig, Morel, Danielsen, Bruhl et al. 2008). The forest structures have also been identified as a crucial factor for the presence of an animal community and the emergence of a specific bird species (Mattes, Moog, Werner, Fiala, Nais et al. 1998). In addition to the bird community, a great number of other plant and animal species as

well as species of high conservation concern are also directly depending on the specificity of forests.

With the global population expected to increase by 40%, the daily calorie intake per capita increased by 11%, and a shift to heavier meat diet, it is estimated that production of food levels by 2050 would be 100% higher than in 2005 to 2007 (Tilman, Balzer, Hill & Befort 2011). Future pressure to convert natural habitats into farmland to meet these demands is likely to be concentrated in the tropics, where the greatest areas of land available, the highest standard of projected increase in population, the demands of foods and energy, and the most favourable climates for many crops and biofuels are found (Laurance, Sayer & Cassman 2014). The demand for agricultural commodities, including palm oil is likely to increase in line with a growing world population, which is probably the biggest threat to the world's birds (BirdLife International 2004).

To date, 50% of tropical forests were destroyed and degraded at alarming rate due to anthropogenic activities such as urbanization, the conversion into farmland, and logging activity (Fisher, Edwards, Giam & Wilcove 2011). This led to the significant changes in terms of species composition and relative abundance of different biological communities inhabiting them (Foster, Snaddon, Turner, Fayle, Cockerill et al. 2011). The clearance of natural forests to large scale of oil palm plantations through the tropics, in particular in the Southeast Asia, has led to the significant loss and the fragmentation of once large and continuous rainforest habitats (Koh & Wilcove 2009) and gives serious threats to the diversity of birds (BirdLife International 2004; Niesten 2004; Peh et al. 2006). These humans disturbances at the landscape scale, has structured population and assemblages of birds due to their highly specific habitat requirements (Brawn, Robinson & Thompson 2001). Approximately, 45 bird species in Malaysia are threatened due to habitat loss and degradation (World Bank Report 2011).

Mangroves are specialized ecosystems that developed along the sea coasts and river estuaries in the tropical and subtropical regions of the world, mainly in the intertidal zone (Adenan 2004). The ecosystem is also considered as the most productive and bio diverse that provide important functions as a buffer against erosion, storm surges and tsunamis in coastal areas (Saenger, Hegerl & Davie 1983). Mangrove habitats are home for many of the tropical world's biodiversity and to date approximately 50% of the world's mangrove forests have been lost as a consequence of the compensation and alteration of the coasts (Adenan 2004). With the degradation and destruction of mangroves

continue, there is a critical need for understanding the biodiversity of mangrove ecosystems (Vannucci 2002). Luiz, Krul and Moraes (2007) reported that mangrove ecosystems play an important role in the conservation not only residents species but also migratory and endangered birds.

Oil palm now extends to at least 10 million hectares worldwide and is the second largest global source of edible oils, after the soybean (*Glycine max).* The areas that is most suitable for palm oil is in tropical lowlands 10˚ either side of the equator. This crop has been greatly spreading in lowland Southeast Asia, which is a region of particularly high biodiversity and one supporting some of the most threatened forests in the world (Lambert & Collar 2002). The Southeast Asia dominates production, with Indonesia, Malaysia, and Thailand being the largest manufacturers in the world. In Malaysia, it is estimated that from 1990 to 2005, 55 to 59% of the extent of the Malaysian palm oil replaced old growth and secondary forests (Koh & Wilcove 2009). This poses a serious threat to the few remaining lowland forests in one of the most bio diverse in the world. The current high prices for oil palm combined with some aggressive and often subsidize is a national strategies to increase production (Clay 2004), means that the expansion of the crop is set to increase in the near future. Oil palm landscapes are some of the poorest habitats for biodiversity in tropical regions (Fitzherbert et al. 2008) and conversion of natural or logged forest to oil palm plantations leads to dramatic losses in biodiversity in the majority of the taxonomic groups (Foster et al. 2011). Typically, oil palms are monocultures characterized by reducing species richness and shifts in community toward disturbance of tolerant species (Azhar, Lindenmayer, Wood, Fischer, Manning et al. 2011) and a diminished functional diversity (Konopik, Linsenmair & Grafe 2014). Mitigation from the loss of biodiversity and soil degradation is one of the main challenges in the current decade (Tscharntke, Clough, Wanger, Jackson, Motzke et al. 2012). This loss of species is mainly caused by a loss of habitat heterogeneity. However, it has been become clear that, even in such impoverished landscapes, the abundance and species diversity can be significant variation dependents upon the vegetation management and the presence of the nearby forests (Azhar et al. 2011), suggesting that from the perspective of many species, inhospitable landscape monoculture can be softened to some degree. Therefore, agroforestry may be able to become more 'wildlife friendly' and does not necessarily result in a decline in agricultural production.

The intensification of agriculture requires an approach of land-sparing and widely promoted to prevent further loss of natural habitats (Phalan, Onial, Balmford & Green 2011). This approach maximizes the profitability of existing

farms, so that global food demands can be met using a minimum amount of agricultural land, which reduces the need to convert most diverse natural habitats (Phalan et al. 2011). It is vital to determine what habitat characteristics of complexity can be maintained without compromising productivity. However, it may have negative effects on biodiversity and their associated ecosystem services in agricultural landscapes (Steffan-Dewenter, Kessler, Barkmann, Bos, Buchori et al. 2007) because the heterogeneity of agricultural habitats has decreased (Stoate, Baldi, Beja, Boatman, Herzon et al. 2009). Intensification usually involves removal of the species of plants that compete with crops for light, water, and nutrients, in addition to decline the diversity of plants directly, reduce the species richness and abundance of animals by removing the food sources and reduction of habitat complexity, and the use of pesticides, which further reduce the animal populations (Tscharntke, Klein, Kruess, Steffan-Dewenter & Thies 2005). Besides reducing the capacity of many species to persist in agricultural landscapes, intensification also limits the ability of species to disperse via the agricultural matrix, compounding the effects of the habitat fragmentation (Kupfer, Malanson & Franklin 2006). For example, birds are expected to be sensitive to the loss of heterogeneity of cultivated lands and most preferring the uncultivated land uses, because many species utilize non-cultivable crop habitats for nesting and foraging (Moorcroft, Wilson & Bradbury 2006).

Loss of habitat, biological invasions, the direct exploitation of species and climate change threaten species in each taxonomic group (Brook, Sodhi & Bradshaw 2008). Species loss can negatively affect the functions and services of key ecosystems such as the recycling of nutrients or predation of pests (Tscharntke et al. 2012). A detailed understanding of habitat-wildlife associations is fundamental to inform the way we manage habitat for animals (Jacobsen 2012), and restore habitats (Lindenmayer, Wood, McBurney, Michael, Crane et al. 2010), and underpins the theory and conservation practice (Zeng, Xu, Wang & Zhou 2013). Reduce the loss of habitat is more effective than trying to increase the populations of birds in their foraging areas and then restore the habitat. The maintenance of forest patches in oil palm plantation, in particular those that have a high conservation value (HCV), has been promoted by the Roundtable on Sustainable Palm Oil (RSPO) certification program as a means for mitigating the loss of biodiversity within and around oil palm plantations (Yaap, Struebig, Paoli & Koh 2010). In the majority of the habitats, it is expected that habitat heterogeneity increase with the size of the patch with larger patches contain a greater diversity of microhabitats (Connor & McCoy 1979). Vertebrates species that are able to fly, like birds and bats, are known to benefit from a certain extent by the presence of forest fragments, in particular the larger ones (>300 ha) within the converted matrix habitats (Struebig,

Kingston, Zubaid, Mohd-Adnan & Rossiter 2008). For example, it was suggested that the value of agricultural plantations for the conservation of birds might be increased while maintaining patches of forest within or nearby plantations (Azhar et al. 2011); even if the results have not always been consistent (Edwards, Larsen, Docherty, Ansell, Hsu et al. 2010). Although its overall effectiveness has not been demonstrated, this type of strategies are generally perceived as useful practices for the improvement of biodiversity and forming part of a 'wildlife friendly' management system in oil palm plantations (RSPO 2013).

The effect of habitat heterogeneity on species diversity is a fundamental concept in community ecology often invoked to explain the absence of an effect of the species in the area (MacArthur & Wilson 1967). The relative abundance of a species is often associated with the vegetation community, food resources, and habitat structural complexity (Rajpar & Zakaria 2011). In accordance with the habitat heterogeneity hypothesis (MacArthur & MacArthur 1961), the resources and recesses increase with increasing the spatial heterogeneity (Bazzaz 1975). Habitat structure is one of the main factors influencing the avian survival rate, reproductive success, the breeding time, species dispersal and habitat selection (Rajpar & Zakaria 2011). Taking into account the key importance of heterogeneous habitat to maintain biodiversity in agricultural landscapes (Roschewitz, Thies & Tscharntke 2005), increasing the proportion of these semi-natural elements in agricultural landscapes can expect to benefit birds, especially species specialists with more demanding habitat requirements (Chiron, Filippi-Codaccioni, Jiguet & Devictor 2010). Several species of birds that both forage and nest in the fields are associated mainly to crop heterogeneities due to the preferences for specific types of vegetation or using several types of crops at different moments during the year (Hiron, Berg & Part 2012). Although creating or leaving aside the uncultivated habitat may not be economically viable, it has been suggested that the increased heterogeneity of crops in agricultural landscapes can mitigate negative effects of agriculture on biodiversity without causing a dramatic reduction in the production (Fahrig, Baudry, Brotons, Burel, Crist et al. 2011).

Accordingly, species of birds developed a broad spectrum of adaptations and ecological responses to different and specific constraints of habitat (Wiens 1989). Studies comparing groups of disparate ecosystems have revealed that structurally complex ecosystems will have more biodiversity, with strong relationships of species richness-habitat heterogeneity (Acevedo & Aide 2008). Many studies have shown that more structural complexity habitats support a greater diversity of birds (Honkanen, Robergr, Rajaarkka, & Monkkonen 2009).

Therefore, by increasing spatial habitat heterogeneity in agricultural landscapes has been suggested as a potential method to stop or reverse decreased farmland biodiversity (Roschewitz et al. 2005). Several studies have compared the richness of bird species in the mangroves to other types of forests in relation to habitat complexity (Acevedo & Aide 2008), based on the premise that as mangroves are structurally simple and have large areas with low plant species richness, with the prediction that bird species diversity is driven less by area effects rather than the effects of habitat heterogeneity.

Problem Statement

Mangroves are the most productive ecosystems in the world and support a genetically diverse community of terrestrial and aquatic flora and fauna. This habitat also provides innumerable direct and indirect benefits to human besides provide the last refuge for species that have lost their original habitat. At the same time, the expansion of plantations is a major form of landscape transformation worldwide including Malaysia. Oil palm plantations are believed to maintain lower bird species and less variety of species than other type of forest. However, this does not mean that oil palm landscapes are totally unsuitable for bird biodiversity and therefore not taken into consideration by conservation biologists. Hence, management practices should be put in place to preserve biodiversity while maintaining the same levels of production and profit. Considering that now most of the major forests in the region have been logged, a new conservation limit has emerged – an urgent need to use semi-natural and productive matrices for biological conservation. By assessing the diversity of birds in adjacent oil palm plantation and mangrove forests, it is hoped that the proximity to these habitats will affect the bird communities in oil palm plantation and become a region of high conservation value.

Hypothesis

The main hypothesis was that the diversity and densities of birds would be higher in the mangrove habitat and lower in the oil palm plantations since mangroves are very important habitats for a wide variety of water birds, as well as for terrestrial birds and their importance depends on the size, vegetation diversity, water quality, food resources and topography; while oil palm plantations are crops that have been planted in the form of intensive monocultures and not commercially suitable for mixing with low intensity agroforestry systems. The secondary hypothesis was that acoustic sampling

would produce a greater sampling of species richness compared to the point count method since acoustic sampling could increase the probability of detection and early detection of birds.

Objectives

Therefore, it is extremely important to study the avian species richness and diversity in different types of habitat that are adjacent to each other in order to understand the conduciveness of habitat on avian community for future direction and conservation activities. In this study, I examine the bird communities in two adjacent ecosystems; mangrove forests and oil palm plantations in Selangor, Malaysia. The general objective was to compare the results of resident bird communities between mangrove forests and oil palm plantations that are adjacent to each other with simultaneously conducted point counts and acoustic sampling.

The specific goals were to:

1. Distinguish the diversity index of resident bird species between mangrove forests and oil palm plantations that are adjacent.
2. Measure the effectiveness of acoustic sampling and point count method as tools in estimating diversity, species composition, and abundances of the bird community.

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