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Bird communities and feeding guilds from three land use types in Kerian River Basin, Perak

Nur Munira A., Nurul Salmi A. L., Shahrul Anuar, M. S. & Nur Juliani S.

School of Biological Sciences, Universiti Sains Malaysia, Penang 11800, Malaysia.

Corresponding Author: munirazman86@gmail.com

Abstract. The objectives of this study were to determine the current bird species present in the study areas and to analyze variation of feeding guilds in different habitat types. 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. 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%), Hemiprocridae (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. 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.

Keywords: Bird diversity, feeding guilds, secondary forest, oil palm plantation, paddy field

Introduction

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 (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). 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.

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; Lehmkühl *et al.*, 2007). Bird is an animal group that is always documented by many studies of habitat destruction (Naidoo, 2004; Waltert *et al.*, 2005; Ko *et al.*, 2009). As explained by Lawton *et al.* (1998) 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).

Materials and Methods

Study areas

Kerian River Basin (5.1580°N, 100.4554°E) is located in the northern states of Peninsular Malaysia and flows through three states; Pulau Pinang, Perak and Kedah. The major land uses are secondary forest, oil palm plantation, and rice fields. Secondary forest site was located near the riparian part of the upper stream of KRB. The nearest tributaries are Rambong River, Selama River and Si Puteh River. The study site covers 19.62 ha within 600 ha of secondary forest area. This forest was logged over 20 years ago (Ismail, *pers. comm.* 2010). Most plants comprised of trees from the family Dipterocarpaceae and stemless palm, Bertam (*Eugeissona tristis*). There is also an intact primary forest located adjacent to the secondary forest area. Several other habitat types such as rubber plantation and orchards are located 20 km from the study site. The villages' orchards are also located near the study site. The oil palm plantation was located near the middle stream of KRB 18 ha within 550 ha of oil palm plantation. The plantation was established 10 years ago and surrounded by roads, human settlements and many other oil palm plantations that are owned by private companies and individuals. Oil palm plantation and mixed vegetation occur on either side of the river banks, while secondary forest patches are found within 20 km radius of the area. The oil palm fruits were harvested every two weeks. Shrub and weeds make up most of the ground vegetation.

The paddy field was situated at the downstream section of KRB at Bandar Baharu district, Kedah. This study site was located 50 metres from the river bank and covered 19 ha with more than 10 paddy plots. The nearest village is Kampung Parit Teropong and most of the paddy fields are owned by the villagers. This paddy field were located close to mangrove and small forest patches with mixed vegetation.

Sample collection

Birds were surveyed at the secondary forest, oil palm plantation and paddy field by using standardized methods. All habitats were surveyed within a period of twelve months, starting from March 2009 to February 2010. Four consecutive days were spent in the field for every month's sampling period. The diversity and abundance count of birds were conducted through point count and mist netting methods (Waltert *et al.*, 2004). The point count sampling method is one of the most popular bird survey techniques (Zakaria *et al.*, 2009). Observations were carried out and species of birds were identified through their vocalization and direct observation from 0700 hr to 1100 hr and 1630 hr to 1830 hr. The wind condition during bird survey must be weak to avoid tree branch movement that might affect the accuracy of bird spotting (Chettri *et al.*, 2005). The observation was made using Omicron Estavia binocular 8x40. Playbacks of recorded bird songs were used to assist in bird surveys. A total of 15 sampling points were established in secondary forest, oil palm plantation and paddy field.

Data on bird feeding guilds and families are collected from various sources. Taxonomic data is compiled from Wells (1999 & 2007) and Robson (2008). Guild information mainly followed Wells (1999 & 2007); if unavailable, the species is assigned into dietary guilds based on field observations of foraging and dietary information from the literature. Definitions of bird feeding guilds are explained in Table 1. Mist-netting is important to confirm the bird species recorded during the point count observation and help to capture bird species that is difficult to be seen or rarely vocalize (Zakaria *et al.*, 2009). In secondary forest and oil palm plantation, 10 standard mist nets (9 m x 4 m with three pockets) were placed at different locations in every sampling visit. Nets were usually placed in potential flight corridors such as near to streams and logging roads (Meyers, 1993; Ralph *et al.*, 2004). Mist-netting was not done in paddy fields because in the first month of sampling session most nets were vandalised by local children and torn by macaques. Although netting effort could not be done, most birds in paddy field were successfully recorded through other approaches explained.

Table 1. Definitions of bird feeding guilds (Lim & Sodhi, 2004; Sigel *et al.* 2010)

Feeding guilds	Definitions
Carnivore	Birds that feed mainly non-insect animals (e.g. fish, lizard)
Insectivore	Birds that feed predominantly on insects and small arthropods
Frugivore	Birds that feed predominantly on fruits
Nectarivore	Birds that feed floral nectar
Granivore	Birds that feed on grains/seeds from the ground or off plants
Omnivore	Birds that ate various combination of food sources, e.g. House Crow (<i>Corvus splendens</i>), primarily human refuse and fruits
Insectivore-frugivore	Birds that ate a combination of two food sources, such as insects and fruits
Insectivore-nectarivore	Birds that ate combination of two food sources, such as insects and floral nectar
Insectivore-granivore	Birds that ate a combination of two food sources, such as insects and grains

Data analysis

Species accumulation curve and Species diversity

Species accumulative curve indicates the number of new recorded species obtained at each time the sampling was conducted. The main purpose of species accumulative curve analysis is for determining the sampling effort sufficiency (Kreb, 1999). Species diversity is an important measurement in various biological diversity works and ecological monitoring (Tews *et al.*, 2004). The species diversity index used in this study is Shannon-Wiener Function.

Statistical analysis

Statistical analysis is used to account for the differences in sampling (i.e. number of individuals) among habitat types (Lee *et al.*, 2005). In this study, statistical significant differences of the mean number of individual among the habitats are tested using One-way ANOVA (parametric test) and Kruskal-Wallis and Mann-Whitney *U*-test (non-parametric test). All datasets were analyzed using Statistical Package for Social Science (SPSS version 11.5).

Results and Discussion

Bird diversity in three different habitat types

From all habitat types evaluated in every month of the sampling session, bird species has recorded an increment from March 2009 to February 2010 (Figure 1). Secondary forest was noted as the habitat that showed the highest species accumulation, followed by paddy field and oil palm plantation. The highest increment of the bird accumulation in secondary forest was recorded in May 2009, with 19 species. As for the oil palm plantation and paddy field, the highest number of species recorded in April 2009 was 11 and nine species, respectively. At the end of one year sampling period (from January 2010 and December 2010), there was zero accumulation in oil palm plantation and paddy field. This revealed that while secondary forest requires further sampling, most of the bird species in oil palm plantation and paddy field have been censused.

The total of bird species recorded in secondary forest, oil palm plantation and paddy field during observations (from March 2009 to February 2010) was 182 species from 48 families. Bird species were divided into resident, migrant, resident and migrant, introduced and vagrant with the scores of 74.34%, 14.75%, 9.29%, 1.09% and 0.55%, respectively. Null hypothesis states that abundance of species is not different across habitat types while alternative hypothesis is vice versa. Statistical analysis showed the null hypothesis is rejected while the alternative hypothesis is accepted with the abundance of species is different across habitat types, $F(2, 105) = 99.83, p < 0.05$. In secondary forest (SF), a total of 106 bird species belonging to 33 families were recorded. The highest abundance of bird species observed in SF was Pycnonotidae (26.65%), followed by Hemiprocnidae (19.77%), Muscicapidae (7.10%) and Aegithinidae (6.01%). Pycnonotidae was exemplified by 13 species of bulbuls that fed on small berries, insects, small invertebrates and small lizards.

The Hemiprocnidae; Whiskered Treeswift (*Hemiprocne comata*) and Grey-rumped Treeswift (*Hemiprocne longipennis*) were usually seen either individually or in a large flock perched on branches of tall trees. Whiskered Treeswift (*Hemiprocne comata*) was often seen perched at the tip of a branch and return to the same branch every time. Muscicapidae and Aegithinidae were usually spotted flying in the middle of forest storey. The largest bird family recorded from the study was Pycnonotidae (13 species) followed by Picidae (eight species), Cuculidae (eight species), Nectariniidae (seven species), Timalidae (six species), Muscicapidae (six species) and Dicaeidae (six species).

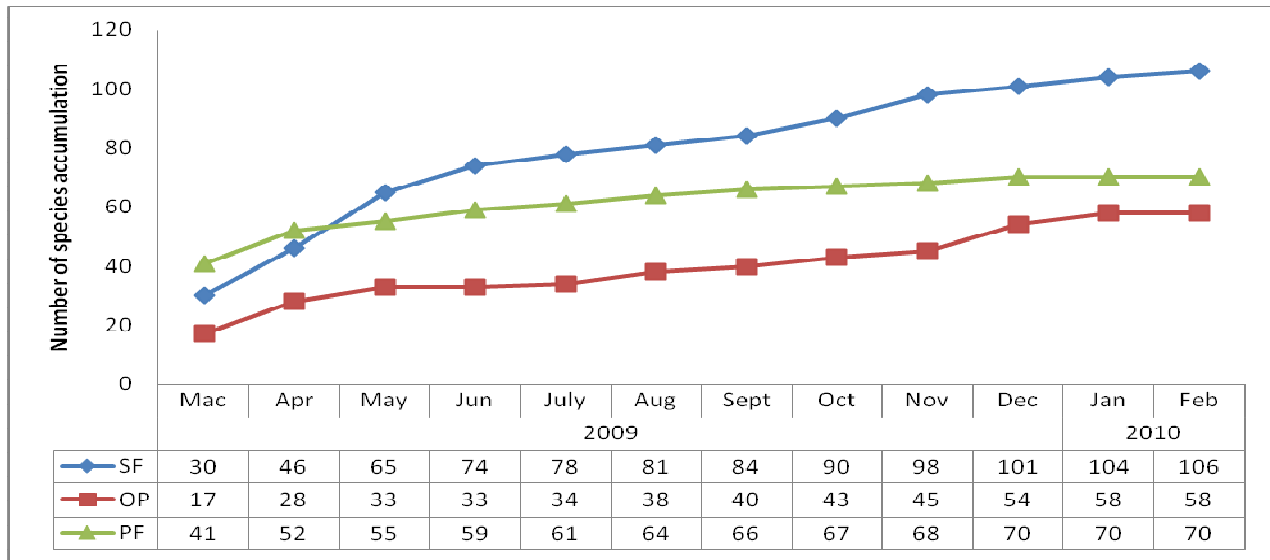


Figure 1. Species accumulative curves; secondary forest (SF), oil palm plantation (OP) and paddy field (PF).

Throughout the sampling session in three different habitat types, 66 out of 106 (62.26%) bird species can only be found in the secondary forest such as Blue-winged Leafbird (*Chloropsis cochinchinensis*) and Grey-bellied Bulbul (*Pycnonotus cyaniventris*). These birds were categorized as forests dependent which exclusively inhabit forested areas. Secondary forest is very significant in accommodating high diversity of bird species because this area is located near Bintang Hijau Range (intact primary forest) and riparian areas which create suitable habitats for forest birds. Being in the vicinity of riparian corridor, the area composed of mixed patches of different vegetation types, nutrients, moisture, light, soil and rocks. These provide different types of habitat that are inhabited by both land bird and waterbirds. Thus riparian corridors served as transportation highways for bird communities.

In oil palm plantation, a total of 58 species from 30 families were recorded within 12 months of sampling period. It was recorded that 85.71% of total bird species present in the oil palm plantation overlap with the bird species found in either secondary forest or paddy field. The four highest abundant bird families observed was Pycnonotidae (21.59%), followed by Muscicapidae (19.12%), Sturnidae (17.95%) and Halcyonidae (9.49%). Pycnonotidae was highly represented by Yellow-vented Bulbul (*Pycnonotus goiavier*) with 32 observations, and was usually seen within shrub areas hunting for insects. Meanwhile Oriental Magpie Robin (*Copsychus saularis*) from Muscicapidae family had 27 observations and was the second commonest bird species found. They were frequently observed near shrub areas, puddles and mixed vegetation. This bird species was easily detected through their repeated song between individuals and locally known as 'Murai Kampung'. Bird species found abundant in the plantation are all common in non-forest habitats. This difference is presumably the result of the simple, more open structure and single-species dominance in oil palm plantation. The homogenous, uniform age and physiognomy of the oil palm trees result in far less structural complexity than in the diverse and uneven-aged of secondary forest. The oil palm plantation

is relatively sparse and the understorey poorly developed. This means fewer opportunities for camouflage or cover-up, which is particularly important for breeding birds and forest dependent species. Moreover, this environment could be responsible for the much lower abundance of invertebrates on understorey plants in oil palm plantation (Aratrakorn *et al.*, 2006). The lower food abundance is probably another important factor in the lower bird species in the plantation. The lack of fruit probably explains the lesser importance of both the resident and winter visitor insectivore-frugivore in the plantation.

A total of 70 bird species from 31 families was recorded in paddy field during the survey period. The highest abundance of bird group observed was Ardeidae (29.09%), followed by Sturnidae (10.15%), Hirundinidae (7.86%) and Passeridae (7.53%). Ardeidae such as Purple Heron (*Ardea purpurea*), Little Heron (*Butorides striata*), Eastern Cattle Egret (*Bulbulcus coromandus*) and Intermediate Egret (*Mesophoyx intermedia*) mainly feed on various aquatic animals, such as small fishes, invertebrates, amphibians, small mammals and crustaceans. Sturnidae; starling, mynas and sparrow were closely associated with fruiting trees, houses and open areas respectively. These species were commonly seen in a large flock up to 20 to 25 individuals.

Thirty seven (53%) bird species comprised of 20 families were solely found in paddy field. Out of the 37 bird species, the three highest were Ardeidae (eight species), Scolopacidae (four species) and Estrildidae (three species). The Ardeidae includes heron, egret and bittern, while Scolopacidae consists of sandpiper and snipe. Both families were agricultural wetland species where most of the time they forage in the paddy field areas. This temporary wetland habitat continuously support many waterbirds and land birds and differ from with other habitat types. Farming activities, paddy growing seasons and paddy field landscapes were the main factors that influence bird foraging activities and occurrence (Kelly *et al.*, 2008; Ibáñez *et al.*, 2010; King *et al.*, 2010). Throughout the study period, observation indicates that farming activities and paddy growing seasons regularly influenced bird occurrence in the paddy plots of Bandar Baharu, Kedah. Observations showed different bird groups use paddy field in different planting processes.

In the three habitat types, the highest Shannon-Wiener index was recorded in December 2009 (3.479), May 2009 (2.649) and January 2010 (3.321), respectively. In contrast, the lowest index was recorded in October 2009 (2.704), Jun 2009 (1.863) and February 2010 (2.154), respectively. The Kruskal-Wallis test has showed that the Shannon-Wiener diversity index was significantly different across the three different habitat types, χ^2 (2, N = 36) = 20.425, $p < 0.05$. Bird existence was much influenced on their adaptation towards surrounding environments. It has been demonstrated several times that bird species diversity is correlated with the vegetation complexity in a habitat (Yorke 1984; Waltert *et al.* 2004; Sodhi *et al.* 2008).

Bird feeding guilds in three habitat types

Secondary forest was dominated by insectivorous species (33.73%), followed by insectivore-frugivore (24.21%) and frugivorous species (19.70%). These three highest feeding guilds were mostly represented by Apodidae, Picidae, Pycnonotidae, Timaliidae, and Muscicapidae. Granivorous species (0.54%) was the rarest feeding guilds recorded in secondary forest. Insectivore-granivore was absent in the secondary forest. According to Chettri *et al.* (2005) a habitat with dense vegetation, i.e, higher tree density and basal areas, influence the high existence of insects. Insects favor moist condition and dense foliage (Erwin, 2002). Therefore with the presence of high food source, insectivore birds were recorded in high percentage in secondary forest.

In the oil palm plantation, the highest feeding guild was carnivore (35.89%) followed by omnivore (33.42%) and frugivore (11.83%). Carnivorous species was represented mostly by Crested Serpent-eagle (*Spilornis cheela*), Collared Scops Owl (*Otus lettia*) and Buffy Fish Owl (*Ketupa ketupu*) while omnivore and frugivore were represented by Pycnonotidae and Sturnidae, respectively. Insectivore-nectarivore (0.91%) was the rarest feeding guilds in oil palm plantation. Insectivore-granivore was absent in oil palm plantation. Existence of carnivorous species in oil palm plantation was mainly influenced by availability of their food sources. Preys such as shrews, snakes, and rats were among food sources available in oil palm plantations.

In paddy fields, carnivorous species (42.27%) was dominant, followed by omnivore (18.44%) and granivore (12.13%). Most of the carnivorous species were represented by Ardeidae and Acciptrinae, while omnivore and granivore comprised of species such as mynas and munias, respectively. Insectivore-nectarivore (0.59%) which was represented by Brown-throated Sunbird (*Anthreptes malaccensis*) and Olive-backed Sunbird (*Cinnyris jugularis*) were identified as the rarest feeding guild in paddy fields. Paddy fields sustain many food sources that attract large number of carnivorous species. Observation showed animals such as small invertebrates, fish, snakes and rodents were among predominant diet for them. As explained by Stafford *et al.* (2010), most waterbirds diet in paddy fields consists of benthic and surface-dwelling invertebrates and aquatic vertebrates.

Conclusions

Variation in bird diversity and feeding guilds in different habitat types were predominantly influenced by vegetation structure and food availability. Secondary forest comprised of forest dependent birds and half of these bird species (61 species) were similar to the list of bird found in Malaysia's primary forest as showed in study by Peh *et al.* (2005). Based on feeding guild analysis, insectivore, insectivore-frugivore and frugivore species that are largely dependent on a variety of fruiting trees, dominate in secondary forest. This study has demonstrated that, if forested areas are to be converted into oil palm plantation, almost all forest dependent species could disappear. Bird species which dominated in oil palm habitat is highly adaptable towards human disturbance and tolerate extreme environment. If forested areas were to be converted into paddy field, bird composition would be dramatically changed where this habitat is highly adaptable to waterbirds but not for forest dependent species. This temporary wetland is influenced by paddy growing season where in different seasons, different bird groups are attracted to utilize the area. This habitat also harbour a variety of feeding guilds compared to secondary forest and oil palm plantation.

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