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SPECIES COMPOSITION OF BIRDS IN OIL PALM AREAS, NORTHERN SARAWAK, BORNEO, MALAYSIA

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ABSTRACT

Birds play an important role in the ecosystem. However, the species composition of birds in oil palm areas and their roles in balancing the ecosystem are still minimally understood. Hence, this study was carried out to investigate them. A study on bird species composition using the point count method in oil palm areas was conducted at three oil palm estates located in Northern Sarawak, Malaysia. A total of 72 bird species belonging to 30 families including one vulnerable and six near-threatened species have been recorded from 123 points. Bird species richness was the highest in Sebungan and Sabaju Estates and the lowest in Taniku Estate. Twenty-six out of 72 species of birds were common to these three different oil palm estates. Seven species consisting of Oriental Magpie Robin, Long-tailed Parakeet, Yellow-vented Bulbul, Greater Coucal, White-breasted Waterhen, Spotted Dove, and Malaysian Pied Fantail were the dominant species recorded in all estates. Ardeidae, Cuculidae, Nectariidae and Cisticolidae were the most diverse bird families in oil palm areas. Knowledge of bird species composition in oil palm areas could provide a better understanding of their importance towards bioindicator species to the ecosystem and the conservation actions to be taken.

Keywords: bioindicator, bird, dominant species, oil palm, species composition.

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INTRODUCTION

Agriculture development has impacts on biological diversity (Karp *et al.*, 2012), especially for birds that suffer significant global declines due to agricultural progress (Azhar *et al.*, 2011). Managing the agricultural area to reduce negative impacts on bird populations requires a better understanding of the species that inhabit certain agricultural area. Apparently, their implications towards agricultural production, primarily through ecosystem functions which are supposed to benefit humans in terms of pollination, biological pest control, disposal of waste, and cycling of nutrients and birds, have negative impacts on agricultural production (Sekercioglu, 2006; Triplett *et al.*, 2012; Wenny *et al.*, 2011; Whelan *et al.*, 2008). Conservation-production interactions have complex implications in agricultural areas. Therefore, changing management strategies may support the diversity of bird species for the benefit of growers and bird conservation (Luck *et al.*, 2015).

As reported, 26.1% of the land in Malaysia was devoted to agricultural production in 2018 (The World Bank, 2022). In 2021, 5.74 million hectares of land in Malaysia has been developed for oil palm agricultural production (Malaysian Palm Oil Board, 2022). The Malaysian palm oil industry remains committed to producing sustainable palm oil by ensuring a balance between oil palm development, as well as preserving and conserving biodiversity. In order to develop more sustainable oil palm agriculture practices, Malaysia has implemented the Malaysian Sustainable Palm Oil Certification (MSPO) schemes to sustain the production of the Malaysian palm oil supply chain for global market consumption.

Birds are known as bioindicators and act as ecosystem functioning and balancing agents (Kiros *et al.*, 2018; Lim and Mojiol, 2019; Sekercioglu *et al.*, 2016). They are the key groups in earth's

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biodiversity components (Hasmat *et al.*, 2020) which play important roles as agents of nutrient cycles, pollinators, seed dispersal and control population of their prey (Sekercioglu *et al.*, 2016). There are several factors that influence the composition and distribution of birds in an area such as habitat complexity, foraging site Brickle, nest-site selection or breeding site and shelter (Bradbury *et al.*, 2000; Soderstrom and Part *et al.*, 2000). Bird assessment is an important tool for biodiversity identification so that subsequent conservation actions can be taken (Amit *et al.*, 2015). Therefore, this study was instituted to assess and understand the bird species composition in oil palm areas located in Bintulu and Miri, Sarawak.

MATERIAL AND METHODS

Study Sites

This study was conducted in three oil palm estates comprising Taniku oil palm estate (TANE) with 5026 ha in Miri, Sarawak, Malaysia (4°23′44.64″N, 114°06′58.05″E), Tinbarap oil palm estate (TINE) with 13 396 ha in Miri, Sarawak, Malaysia (4°04′11.68″N, 114°15′08.37″E), and Sebungan and Sabaju oil palm estates (SSE) with 9683 ha in Bintulu, Sarawak, Malaysia (3°11′47.99″N, 113°28′11.17″E). The study sites are shown in *Figure 1*, located in Northern Sarawak, Malaysia. These estates have been in operation for approximately 4-21 years and are mostly of peat land area. SSE and TINE have a large-scale peat swamp forest patch (TINE: >200 ha, SSE: >300 ha) in their estates for conservation purposes and some parts of their estates are surrounded by forest. TANE has a small forest patch and is mostly surrounded by other oil palm estates. The summary of the sampling estates is in *Table 1*.

Data Collection

The bird sampling was conducted using the point count method. A total of 123 points (TINE: 56 points, SSE: 44 points, TANE: 23 points) were established and randomly sampled in this study. The sampling was conducted one time for each point. Each point was at least 500 m apart from the other. The sampling was done for 15 min for each point. The detected species and the number of individuals through sighting and sound were recorded. The sound of birds was recorded using an Olympus LS-P4 for further identification. The sampling was conducted in the morning between 06:30 and 10:30.

Data Analysis

Relative abundance was used to determine the percentage of each bird species in each area by dividing the number of species. The relative

Figure 1. Location of three oil palm estates in Northern Sarawak, Malaysia.

TABLE 1. SUMMARY OF THE ESTATES

Estates	Size of the estate (ha)	Number of sampling points	Forest patches within oil palm landscape (ha)	Range of palm age (years old)
TANE	5 026	23	-	10-21
TINE	13 396	56	>200	10-13
SSE	9 683	44	>300	4-13

abundance was calculated from the percentage ratio of individual numbers of a species, divided by the total individual numbers recorded in that area. Species diversity was used to determine the diversity of bird species in each area. Species diversity (*H'*) was calculated using the Shannon-Weiner index (Magurran, 1988). Species richness was calculated using Margalef's Richness Index (R_1) to determine the richness of the birds' species in each area. Species evenness was calculated using Pielou's Evenness Index (E') to determine the evenness of the species distribution of the bird in each area.

RESULTS AND DISCUSSION

Bird Species and Their Conservation Status in Oil Palm Areas

This study recorded 2621 birds belonged to 72 species and 30 families found from three oil palm estates (*Table 2*), representing 10.7% of the total species of birds (673 species) reported in Borneo Island (Phillipps and Phillipps, 2014). Data analysis as presented in *Table 3* showed that the species distribution was more evenly distributed (Pielou's Evenness Index). Shannon-Weiner Diversity Index indicated bird species have the highest diversity in TANE than SSE and TINE even though both estates showed the richest bird species (Margalef's Richness Index). The high richness of bird species in SSE and TINE is attributed to the presence of forest patches within their oil palm estates and the adjacent forest areas. This finding is similar to the previous studies by Amir *et al.* (2015) and Yaap *et al.* (2010) which mentioned that the retention of forests promotes the biodiversity patches within or around oil palm estates.

Several species listed as threatened under international status, and protected under local conservation status, have been recorded in this study. Under the IUCN Red List of Threatened Species, one Vulnerable (Long-tailed Parakeet) and six near-threatened species (Green Imperial Pigeon, Fluffy-backed tit-babbler, Chestnut-winged Babbler, Black-throated Babbler, Black Hornbill and Green Iora) were recorded in this study. Some noteworthy bird species that are protected under Sarawak Wildlife Protection Ordinance, 1998 were also recorded. These species included three totally protected (Cattle Egret, Green Imperial Pigeon, Black Hornbill) and 16 protected species (Little Egret, Intermediate Egret, Great Egret, Cinnamon Bittern, Yellow Bittern, Striated Heron, Purple Heron, Blue-eared Kingfisher, Stork-billed Kingfisher, Oriental Dwarf Kingfisher, White-breasted Kingfisher, Hill Myna, White-throated Needletail, Long-tailed Parakeet, Grey-and-buff Woodpecker, Black-thighed Falconet) were recorded in this study (*Table 2*). Dusky Munia which primarily feeds on grass seeds, seeds of weeds, and insects and endemic species in Borneo Island was also recorded in this study. Additionally, previous studies also reported the sightings of threatened and endemic species in oil palm estates (Amit *et al.*, 2015; 2021). Identification of bird species especially the endemic species is important in order to estimate the biodiversity conservation status in oil palm estates so that the conservation action plan can be taken to protect these important species from threat.

Bird Species Composition and Ecosystem Values in Oil Palm Areas

Birds are important bioindicators in ecosystems. Type of habitat complexity, food availability, shelter and breeding areas are the important factors that influence the bird's occurrence in an ecosystem for the viability of their population (Soderstrom and Part, 2000). Assessing the bird composition in the oil palm ecosystem is important to identify the biodiversity values and to understand the bird's role

TABLE 3. DIVERSITY INDICES FOR THE THREE OIL PALM ESTATES (SEBUNGAN AND SABAJU ESTATE: SSE; TINBARAP ESTATE: TINE; TANIKU ESTATE: TANE)

Data analysis	SSE	TINE	TANE
Shannon-Wiener diversity index, H'	3.02	2.785	3.22
Margalef's richness index, R1	7.51	6.69	6.37
Pielou's evenness index, E	0.40	0.33	0.61

TABLE 2. RELATIVE ABUNDANCE OF BIRD SPECIES AT THREE OIL PALM ESTATES (SEBUNGAN AND SABAJU ESTATE: SSE; TINBARAP ESTATE: TINE; TANIKU ESTATE: TANE) AND THEIR CONSERVATION STATUS UNDER INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN) RED LIST OF THREATENED SPECIES (LC: LEAST CONCERN; NT: NEAR THREATENED; VUL: VULNERABLE) AND SARAWAK WILDLIFE PROTECTION ORDINANCE, 1998 (TP: TOTALLY PROTECTED; P: PROTECTED)

Family	Common species	Scientific name	IUCN	SWLPO	Relative abundance (%)		
					SSE	TINE	TANE
Ardeidae	Little Egret	*Egretta garzetta*	LC	P	0.90	0.15	
	Intermediate Egret	*Ardea intermedia*	LC	P	0.77	0.38	0.56
	Cattle Egret	*Bubulcus ibis*	LC	TP		0.08	
	Great Egret	*Ardea alba*	LC	P		0.08	
	Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC	P	0.51	0.69	1.31
	Yellow Bittern	*Ixobrychus sinensis*	LC	P	0.64	0.31	1.69
	Striated Heron	*Butorides striata*	LC	P	0.26	0.15	
	Purple Heron	*Ardea purpurea*	LC	P			0.19
Nectariidae	Purple-naped Sunbird	*Kurochkinegramma hypogrammica*	LC		0.26		0.56
	Plain Sunbird	*Anthreptes simplex*	LC		1.28	0.54	1.31
	Brown-throated Sunbird	*Anthreptes malacensis*	LC		2.30	2.22	3.75
	Ruby-cheeked Sunbird	*Chalcoparia singalensis*	LC				0.75
	Crimson Sunbird	*Aethopyga siparaja*	LC				0.19
	Little Spiderhunter	*Arachnothera longirostra*	LC		0.51		0.38
	Olive-backed Sunbird	*Cinnyris jugularis*	LC			0.08	
Columbidae	Spotted Dove	*Streptopelia chinensis*	LC		6.91	7.65	6.00
	Zebra Dove	*Geopelia striata*	LC			0.61	
	Grey-capped Emerald Dove	*Chalcophaps indica*	LC		0.13		
	Green Imperial Pigeon	*Ducula aenea*	NT	TP	0.13		
	Pink-necked Green Pigeon	*Treron vernans*	LC		2.43	0.31	6.00
Cuculidae	Plaintive Cuckoo	*Cacomantis merulinus*	LC		0.90	0.84	1.13
	Greater Coucal	*Centropus sinensis*	LC		8.45	6.89	6.57
	Lesser Coucal	*Centropus bengalensis*	LC		1.28	0.23	1.69
	Chestnut-bellied Malkoha	*Phaenicophaeus sumatranus*	LC		0.13	0.54	
	Chestnut-breasted Malkoha	*Phaenicophaeus curvirostris*	LC		0.13		
Timaliidae	Bold-striped Tit-babbler	*Macronus bornensis*	LC		6.40	2.37	2.25
	Fluffy-backed Tit-babbler	*Macronus ptilosus*	NT		0.38		
	Chestnut-winged Babbler	*Stachyris erythroptera*	NT		0.90	0.15	0.38
	Black-throated Babbler	*Stachyris nigricollis*	NT			0.23	
Cisticolidae	Yellow-bellied Prinia	*Prinia flaviventris*	LC		5.38	2.60	4.13
	Ashy Tailorbird	*Orthotomus ruficeps*	LC		0.77	1.68	1.69
	Dark-necked Tailorbird	*Orthotomus atrogularis*	LC		0.13	0.23	
	Rufous-tailed Tailorbird	*Orthotomus sericeus*	LC		1.28	1.68	3.19
Alcedinidae	Blue-eared Kingfisher	*Alcedo meninting*	LC	P	0.13		
	Stork-billed Kingfisher	*Pelargopsis capensis*	LC	P	0.64		0.19
	Oriental Dwarf Kingfisher	*Ceyx erithaca*	LC	P	0.13		
	White-breasted Kingfisher	*Halcyon smyrnensis*	LC	P		0.08	2.63
Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus simplex*	LC		10.63	13.54	7.69
	Olive-winged Bulbul	*Pycnonotus plumosus*	LC		1.92	0.99	2.44
	Asian Red-eyed Bulbul	*Pycnonotus brunneus*	LC			0.08	0.38
Sturnidae	Asian Glossy Starling	*Aplonis panayensis*	LC		1.28	1.99	3.75
	Hill Myna	*Gracula religiosa*	LC	P	1.02	0.15	2.63
	Common Myna	*Acridotheres tristis*	LC				0.38

Accipitridae	Black-shouldered Kite	*Elanus axillaris*	LC		0.51	0.15	
	Crested Serpent Eagle	*Spilornis cheela*	LC		0.77	0.15	0.56
	Changeable Hawk-eagle	*Nisaetus cirrhatus*	LC			0.08	
Dicaeidae	Yellow-rumped Flowerpecker	*Prionochilus xanthopygius*	LC		0.13		
	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	LC		0.13		
	Yellow-breasted Flowerpecker	*Prionochilus maculatus*	LC			0.08	
Hirundinidae	Pacific Swallow	*Hirundo tahitica*	LC		0.13	0.84	3.56
	Barn Swallow	*Hirundo rustica*	LC			2.60	
Estrildidae	Dusky Munia	*Lonchura fuscans*	LC		0.90	0.23	
	Chestnut Munia	*Lonchura atricapilla*	LC			2.68	4.69
Corvidae	Large-billed Crow	*Corvus macrorhynchos*	LC		0.13	0.15	
	Slender-billed Crow	*Corvus enca*	LC				0.19
Aegithinaidae	Green Iora	*Aegithina viridissima*	NT		0.26		
	Common Iora	*Aegithina tiphia*	LC			0.23	
Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	LC		6.66	6.35	10.13
Musicapidae	Oriental Magpie-robin	*Copsychus saularis*	LC		11.52	16.83	9.57
Rhipiduridae	Malaysian Pied Fantail	*Rhipidura javanica*	LC		5.51	3.83	2.81
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	LC		0.13	0.38	
Apodidae	White-throated Needletail	*Hirundapus caudacutus*	LC	P			0.38
Psittaculidae	Long-tailed Parakeet	*Psittacula longicauda*	VUL	P	13.06	16.99	2.63
Laniidae	Long-tailed Shrike	*Lanius schach*	LC		0.13	0.54	
Bucerotidae	Black Hornbill	*Anthracoceros malayanus*	NT	TP	0.13		0.38
Megalaimidae	Blue-eared Barbet	*Psilopogon cyanotis*	LC		0.26		
Passeridae	Eurasian Tree Sparrow	*Passer montanus*	LC		0.51	0.15	
Meropidae	Blue-throated Bee-eater	*Merops viridis*	LC		0.13	0.15	0.75
Picidae	Grey-and-buff Woodpecker	*Hemicircus concretus*	LC	P	0.13		
Artamidae	White-breasted Woodswallow	*Artamus leucorynchus*	LC				0.38
Coraciidae	Oriental Dollarbird	*Eurystomus orientalis*	LC				0.19
Falconidae	Black-thighed Falconet	*Microhierax fringillarius*	LC	P		0.08	

in balancing the ecosystems. This study divided the bird species composition according to bird families recorded at each oil palm estate (*Figure 2*). A total of 30 families have been recorded in this study. Overall, a good representation of Ardeidae, Nectariidae, Cuculidae and Columbidae were recorded in oil palm areas.

The most diverse species recorded in this study was the family Ardeidae. TINE recorded seven species, followed by SSE with five species and TANE with three species. The occurrence of the most diverse bird family Ardeidae (bitterns, egrets, heron) in this study with eight species is linked to the presence of aquatic habitats such as water drainage systems in oil palm planted on peat land that offer foraging areas for waterbirds. Drainage systems play a significant role in managing water levels in oil palm plantations established in peat land areas for flood-control management systems (Hasnol *et al.*, 2010). According to Azhar *et al.* (2013) the waterbird biodiversity conservation highlights another aspect of these drainage systems. This study stated that properly managed drainage systems can create diverse aquatic habitats that attract various waterbird species. These species are normally observed as solitary or in groups in the drainage system searching for food. Species such as Intermediate Egrets together with Little Egrets have been observed to follow excavators during the maintenance of the drainage system in oil palm estates while searching for food.

Family Nectariidae (sunbirds and spiderhunters) was the second diverse bird family recorded in this study with seven species. Six species were recorded in TANE, SSE four species and TINE three species. The presence of these species might be attributed to the flowering plants, such as native and beneficial flowering plants in oil palm areas. Sunbirds and spiderhunters are nectar feeder specialists which also feed on insects and small berries. These species play an important role as flower pollinator agents in the ecosystems besides bees, insects, bats, and squirrels (Phillipps and Phillips, 2014). Two common sunbirds were recorded in oil palm areas namely, Plain Sunbird and Brown-throated Sunbird. Species such as Olive-

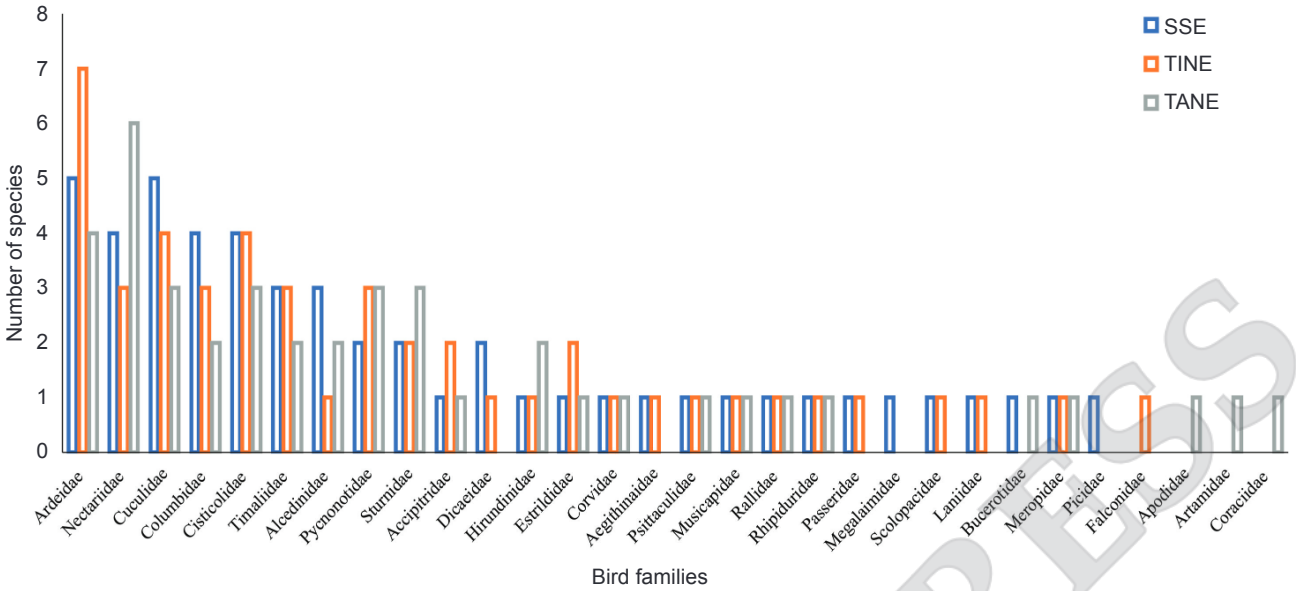

Figure 2. Bird species composition is divided according to bird families recorded at each oil palm estate.

backed Sunbird, Brown-throated Sunbird and Little Spiderhunter are normally found in gardens, cultivated or open areas, while the other sunbirds are birds of forest (Phillipps and Phillipps, 2014). Olive-backed Sunbird has been spotted visiting flowers of beneficial plants like *Turnera subulate* in the oil palm estate. These findings showed the importance of flowering plants in supporting and conserving nectar feeders and bird species like sunbirds and spiderhunters in oil palm areas. Other studies also recorded these species in oil palm areas (Amit *et al*., 2021; Hawa *et al*., 2016; Jambari *et al*., 2012; Mohd-Azlan *et al*., 2019).

Family Cuculidae (cuckoo, coucals and malkohas) is the third most diverse family in this study with five species. Five species were found in SSE, TINE with four species and TANE with three species. This family feeds on insects, small vertebrates, and fruits (Myers, 2009). Three common cuculid species recorded in oil palm areas were Plaintive Cuckoo, Lesser Coucal and Greater Coucal. Family Columbidae (doves, pigeons) with five species were recorded in this study. SSE recorded four species followed by TINE with three species and TANE with two species. Two species commonly recorded in oil palm areas were Spotted Dove and Pink-necked Pigeon. Myers (2009) mentioned that dove species prefer to feed on grains and seeds, while pigeon feeds on fruits. Pink-necked Pigeon has been observed to feed on *Melastoma* fruits (a native plant) in oil palm areas and this finding is similar to the study by Myers (2009).

Dominant Bird Species and Its Ecosystem Function in Oil Palm Areas

Twenty six out of 72 total species recorded in this study were common in the three oil palm estates. Oriental Magpie Robin, Long-tailed Parakeet, Yellow-vented Bulbul, Greater Coucal, White-breasted Waterhen, Spotted Dove, and Malaysian Pied Fantail were the dominant species recorded in this study. These species are considered dominant species in this study if they exceeded 2% of the total number recorded in each estate and consistently recorded more than 2% at other estates. Oriental Magpie Robin was the most dominant species (relative abundance of more than 5% of the total individuals for each estate), followed by Long-tailed Parakeet, Yellow-vented Bulbul, Greater Coucal, White-breasted Waterhen, Spotted Dove, and Malaysian Pied Fantail.

Oriental Magpie Robin is usually seen solitary or sometimes in pairs hopping from one palm frond to another frond, hunting for insects found on the ground in oil palm areas. This species has the common bird sounds that can be heard in oil palm areas, consists of various sound calls. The study conducted by Manshor and Gawin (2020) in a suburban area in Kota Samarahan, Sarawak mentioned that this species has six distinctive types of call. This species has been reported to feed on all kinds of insects, caterpillars, beetles, grasshoppers, flies, dragonflies, and ants in oil palm habitat (Chenon and Susanto, 2006) and hence, have an essential role in controlling the insect pest population in the oil palm area. This species was also reported as a dominant species in oil palm estates by Amit *et al.* (2015) and Azhar *et al.* (2013) through the point count method.

The Long-tailed Parakeet feeds on fruits, seeds, flowers, and lead buds, and is listed as Vulnerable in the IUCN Red List. They have been reported to feed on oil palm fruitlets (Parr and Juniper, 2010). However, in this study, this species was not spotted at the oil palm fruitlets. They are usually observed in a large number of groups around palm fronds and fly from one place to another in the oil palm area

with their noisy sound. As the estates have large scale forest patches and are also located adjacent to or surrounded by peat swamp forests, especially SSE and TINE, the abundance of this species might be associated with these features of oil palm areas.

Yellow-vented Bulbul can be found in a wide variety of open areas (Phillipps and Phillipps, 2014). This species was reported as the most abundant bird species using the mist-netting method in the oil palm area by Amit *et al.* (2015). This species is normally observed solitary or sometimes in pairs flying from one palm frond to another palm. It is reported that this bird feeds on a wide range of diets, such as caterpillars, small beetles, wasps, and fruits (Chenon and Susanto, 2006). Amit *et al.* (2015) reported that this species feeds on oil palm pollinators (*Elaeidobius kamerunicus*), insects, small arthropods, and fruits. Hence, due to the open area, they can feed on a wide range of diets available in the oil palm area which may contribute to their abundance in this habitat.

Greater Coucal is a big-sized bird normally observed jumping on the oil palm frond or feeding insects on the ground. Chenon and Susanto (2006) mentioned that this species feeds on small vertebrates and insects such as Hemiptera, Lepidoptera, Orthoptera and Diptera in the oil palm area. Amit *et al.* (2021) also reported that this species was observed to feed on small birds such as Prinia and tailorbirds in the oil palm area. According to Myers (2009), this species feeds on small mammals, nestlings and eggs, lizards, frogs, large insects, and invertebrates.

White-breasted Waterhen is a bird that is linked to the presence of water. They are normally observed at the edge of oil palm drainage systems as this system plays a role in flood-control in oil palm planted peat land. This omnivorous bird feeds on small fishes, worms, and aquatic insects but not on the pests of oil palm (Chenon and Susanto, 2006).

The Spotted Dove is a seed eater bird that is frequently observed in groups, feeds on the seed of grasses on the ground at the harvesting paths and the road, and sometimes they are spotted perching on the oil palm fronds.

Malaysian Pied Fantail was also recorded as dominant in the oil palm area in this study. This species is a common fantail that prefers open areas, gardens, mangroves area, and secondary forests (Myers, 2009). They are normally observed to be noisy and constantly fan their tails when flying and sallying and actively feed on insects on the ground and mid-storey. Boles and Christie (2020) mentioned that this species feeds on insects, with items brought to nestlings, including caterpillars, flies, and moths. This species has the potential to prey on insects found in oil palm areas; however, no research has been conducted to determine which insects they prefer to feed on.

Most of the dominant bird species recorded in this study primarily or partially feed on insects. These species include Oriental Magpie Robin, Yellow-vented Bulbul, White-breasted Waterhen, Greater Coucal, and Malaysian Pied Fan tail. Hence, this study concludes that oil palm area is capable of providing a good habitat and insects as food resource to support the bird population. It is recommended that all oil palm estates have land patches that have trees and natural vegetation to support the birds' species and biodiversity in their oil palm areas. A study conducted by Soon *et al.* (2022) showed that interaction between insectivorous bird and overall arthropods neither decreased nor increased the number of arthropods, contrary to their expectation that when there is more insectivorous bird predator, there should be less arthropod prey. According to Stevens (2010), higher insectivorous bird abundance could also contribute to the surge in arthropod numbers as food resource.

CONCLUSION

A better understanding of bird composition in oil palm estates provides better information on the status of the bird biodiversity in oil palm areas and their important role in the ecosystem. Through our study, we found that species composition of Ardeidae, Cuculidae, Nectariidae and Cisticolidae were the most diverse bird families in oil palm areas where they play ecological importance in oil palm ecosystems. Thus, high priority should be given to the oil palm areas for conservation and monitoring bird species to support Malaysia as one of the megadiverse bird biodiversity in the world. Further study should be done on the interaction between dominant insectivorous birds and arthropod prey in oil palm areas in order to understand their roles in balancing the ecosystem.

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