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ORIGINAL ARTICLE

Preliminary Assessment of the Bird Species Composition and Feeding Guilds in Forest Plantation and Natural Forest Areas, Kinarut, Sabah Malaysia

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ABSTRACT - As one of the most noticeable inhabitants of vulnerable places, birds play a crucial part in the maintenance of the well-being of a forest ecosystem. The aforementioned causes related to land use change are putting pressure on the forest habitats, thus putting the local birds at risks of extinction. The purpose of this research was to examine the species compositions and identify the feeding guilds of birds presented in a natural forest (Kawang Forest Reserve) and a plantation forest (Kinarut Eco Forest Park) in Sabah, Malaysia. Mist-Net and Point-Count sampling techniques were applied in this study, to analyse the distributions of feeding guilds of birds in these radically different habitat types. A total of 15 species and 11 species of birds were captured by mist-nets in the natural forest and plantation forest respectively. The Pcynonotidae was the most common bird family detected at both study sites. The Carnivore, Carnivore-insectivore, Insectivore, Insectivore-Frugivore, Frugivore, and Nectarivore were the six registered feeding guilds, where the Insectivore-Frugivores and insectivores were the most prevalent guilds for birds presented in both habitat types. The Shannon-Wiener Diversity Index analysis of species diversity revealed that the difference was not significant between the two study sites, although the bird diversity was generally lower in the plantation forest (H'=2.78) than in the natural forest (H'=3.08). The estimated bird population densities (D) in the plantation forest and natural forest were 427 individuals per hectare (CV=21.6%) and 100 individuals per hectare (CV=30.1%) respectively. The variability in species composition and density of bird between the two habitat types may be caused by the variability in the microclimate, distribution, and forest structure. This research provides the initial attempt in understanding the role of habitats or land cover types, guild types and human interferences in shaping the density, abundance and diversity of bird, which also represent the well-being of a forest ecosystem. Such a knowledge is vital in providing the necessary information for implementing sustainable management practices.

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INTRODUCTION

Borneo Island is among the eight most important global biodiversity hotspots in Southeast Asia (Phillipps & Phillips, 2014), Southeast Asia's last intact forest, and the third largest island in the world after Greenland and Guinea. Its size is more than 500,000 square kilometers, slightly larger than Texas. Moreover, it is home to some of the most diverse rainforests in the world and also various species of outstanding wildlife, including the Bornean Orangutan (*Pongo pygmaeus morio*), Bornean Clouded Leopard (*Neofelis diardi borneensis*), and Malayan Sun Bear (*Helarctos malayanus*) [1; 2]. Despite the high biodiversity, over the

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past 40 years, human anthropogenic activities have caused profound changes to the tropical forests in Southeast Asia such as deforestation, agriculture expansion, and urbanization particulalry in the state of Sabah [3]. The phrase "biodiversity hotspots" refers to 35 worldwide, which are biologically rich and biologically rich locations that have retained 70% of their native habitat and Borneo island qualify as one of these location based on this two criteria's namely endemism and habitat loss [4]. Then, a biogeographic area is known as a biodiversity hotspot, where it plays a crucial role in serving as a reservoir for sustaining high biodiversity, but at the same time, it has been severely threatened by anthropogenic activity, thus ultimately leading to a catastrophic population loss [5; 6; 7].

Sabah, the second-largest state of Malaysia, is situated in the Northern region of Borneo Island. Sabah has an ever-wet climate due to its latitude and location toward the sea. Therefore, the vegetation type that naturally predominates the landscape of Sabah is determined to be the tropical evergreen rainforest [8]. The local tropical rainforests' wildlife communities are renowned worldwide for their high biodiversity. However, once the distinctive habitats, species assemblages, and natural processes have been disrupted or reduced in quality and quantity, an ecosystem, such as the tropical rainforest, is considered to be degraded. This can be determined on the tree cover loss, changes in the biodiversity and the reduction of carbon uptake due to loss of biomass and changes in species composition [9].

Among the various elements comprising the rich biodiversity of Sabah, the bird community is essential in maintaining a healthy ecosystem and offering a wide variety of ecological functions [10; 11]. The local bird communities have been extensively investigated by numerous past studies [7; 9; 12] since they can react swiftly to any changes that occur in their surrounding environments, hence serving as reliable biological indicators, for a given habitat, and this can be access trough the species richness, relative abundance and species compisition [5; 13; 14]. According to Phillipps and Phillipps [15], the known avifauna in Borneo consists of at least 669 species, of which 51 species are determined to be endemic. However, the existing state of a forest significantly impacts the shaping of the local bird composition and diversity [16; 17]. For instance, human activities such as logging and plantation activities can reduce the food supply, which can result in a scarcity of a wide range of bird species, and subsequently shaping the composition and diversity of birds presented in a particular habitat [10; 18]. In other words, logging and plantation activities pose a severe threat to the survival of tropical birds because of the destruction and loss of their natural habitats [6; 19].

The comparison of bird communities presented in the highly-disturbed and least-disturbed forests in the Western region of Sabah is seldom investigated by researchers [11; 17; 20] and, the comparison between highly-disturbed and least-disturbed forests is crucial for understanding the impacts of human activities and environmental changes on biodiversity. This approach allows researchers to identify specific ecological responses to disturbances, which can inform conservation strategies and forest management practices. Therefore, this research was conducted at Kawang Forest Reserve (KFR) and Kinarut Eco Forest Park (KEFP) to compare the birds in a natural forest reserve with those in a plantation forest. This study aimed to obtain a comprehensive list of birds found at the understory layer of the natural and plantation forests to get an impression of the difference in bird composition and population between these two forest habitats. The ecological differences between natural forest reserves and plantation forests significantly influence bird composition. By understanding these differences is essential for conservation efforts and habitat management such as habitat structure, food resources, microclimate variability and the level of human disturbances.

MATERIALS AND METHODOLOGY

Study area

Natural Forest: The Kawang Forest Reserve was selected to represent the natural forest in the present study. This forest reserve is located around 30 km south-east of Kota Kinabalu. KFR is a logged-over natural forest classified as a Class I Protection Forest Reserve in 2014 by the Sabah Forestry Department, with an area of approximately 1,555 ha [21]. The regeneration process occurred from logging to a logged-over natural forest, can profoundly affect bird species composition, species richness and altered food resources.

It was established mainly to conserve the local watershed and maintain the stability of essential climatic and other environmental factors. The altitude of KFR ranges from 6 m to 610 m above sea level, and it comprises natural hill dipterocarp forest (19%), secondary forest (69%), early secondary forest (8%), and bare vegetation (4%). The height of the canopy in the hill dipterocarp forest is about 40 m to 60 m, with the *Koompasia excelsa* highly prominent in the canopy. Pioneer species like Vernonia arborea, *Commersoia incana*, and *Ficus spp* dominate the secondary forest area. In contrast, the early secondary forest consists of tree species like *Melastoma malabatricum*, *Syzygium spp*., and *Eupatorium odoratum*. The local terrain is majorly hilly, with the slopes reaching about 25°, and the ridge system runs in a North-South direction. KFR provides gravitational water to the natives who live near this forest area for their consumption. It also functions as a habitat for many tropical bird species [20].

Plantation Forest: The Kinarut Eco Forest Park was selected to represent the plantation forest in the present study. This plantation forest is managed by the Sabah Forestry Development Authority (SAFODA) and is mainly used to produce timber, pulp, and paper. KEFP is located in Kinarut, Papar, around 25 km south of Kota Kinabalu. This state-owned forest plantation area covers an area of 411 hectares, and it is primarily marginal or impervious grassland. The *Acacia* spp. (*A. aula hevea*, *A. crassi*, *A. mangium*, *A. auriculiformis*, and *A. hybrid*) were selected due to their capabilities to survive and thrive in the local environment. The trees are over 15 years old, with diameters of 20 to 40 cm and a height of 10 to 20 m. KEFP was established in 2002 as part of the rehabilitation project initiated by JICA, FUJITSU, and several universities in Japan. These Japanese agencies provide financial sponsorship for tree planting programs, aiming to rehabilitate and provide a carbon-sink area. The research locations of the present study are shown in Figure 1 below.

Sampling Methods

Mist-Net Sampling: This sampling technique was used to capture the understory birds that inhabited the lower stem stratum for 46 days at the two study sites selected for this study. Five mist nets (5 mm^2 mesh size, 10 m length, and 4 m height) were used and placed randomly across the study sites in KFR and KEFP. The mist nets were relocated to new areas at three to four-day intervals to cover a large sampling area with different forest characteristics at the two study sites. The mist nets were open from 06:00 to 18:00 hours, and then they were checked once every 2 hours to avoid inflicting excessive stress on the captured bird individuals throughout the entire sampling period of this research [17]. All captured bird individuals were identified and categorized according to their respective species group, feeding guild, and habitat type before being released back into the wild.

Point-Count Sampling: This sampling technique was applied to estimate the densities, abundances, and diversities of birds presented at the two selected study sites [22]. The sampling areas covered about 2.0 ha of natural and plantation forests in this study. Sampling points were established along the existing trails and newly opened trails. The bird individuals were visually observed and counted from each sampling point, and then the distance of each detected bird from the sampling point was measured and recorded using the laser range finder equipment in meter scales. The time duration spent in bird-counting at each sampling point was five minutes. Then, the species of each detected bird individual was identified immediately on the field by referring to the field guide written by Phillipps and Phillipps [15].

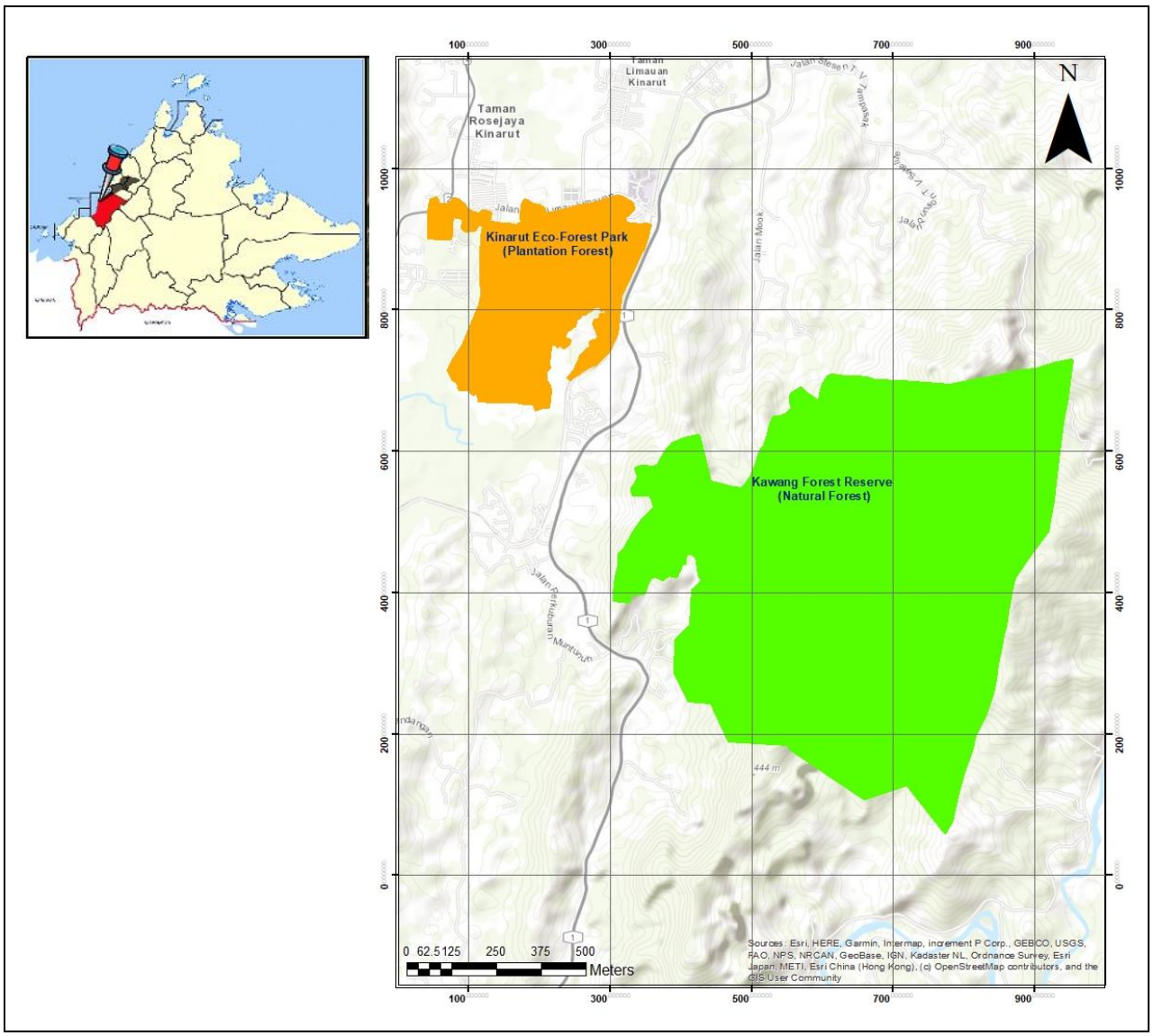

Figure 1. Locations of the two study areas examined in this research are (1) Kinarut Eco Forest Park (Plantation Forest) and (2) Kawang Forest Reserve (Natural Forest), which is located in Kinarut.

RESULTS AND DISCUSSION

A total of 30 bird individuals from 15 different species were caught in the natural forest, while 47 bird individuals from 16 different species were caught in the forest plantation in this research. The *Pcynonotus plumosus* (Olive-winged bulbul) was caught most frequently (5 individuals) in the natural forest. In comparison, the *Merops viridis* (Blue-throated bee-eater) was the most frequently caught species (9 individuals) in the plantation forest. Most frequently caught bird species in the natural forest also appear in the plantation forest, except for the most frequently caught *Pycnonotus plumosus*.

The absence of *P. plumosus* (the Olive-winged bulbul) in plantation forests, despite its abundance in natural forests, can be attributed to several ecological factors such as habitat structure, food availability, microclimatic conditions, and interspecific interactions competition and predation [23; 24]. Nine out of the eleven species only found with one or two individuals in the natural forest did not appear in the

plantation forest. In comparison, ten bird species were caught in the plantation forest but not in the natural forest. Figure 2 shows the number of bird individuals caught with the mist-nets method in the natural forest and plantation forest.

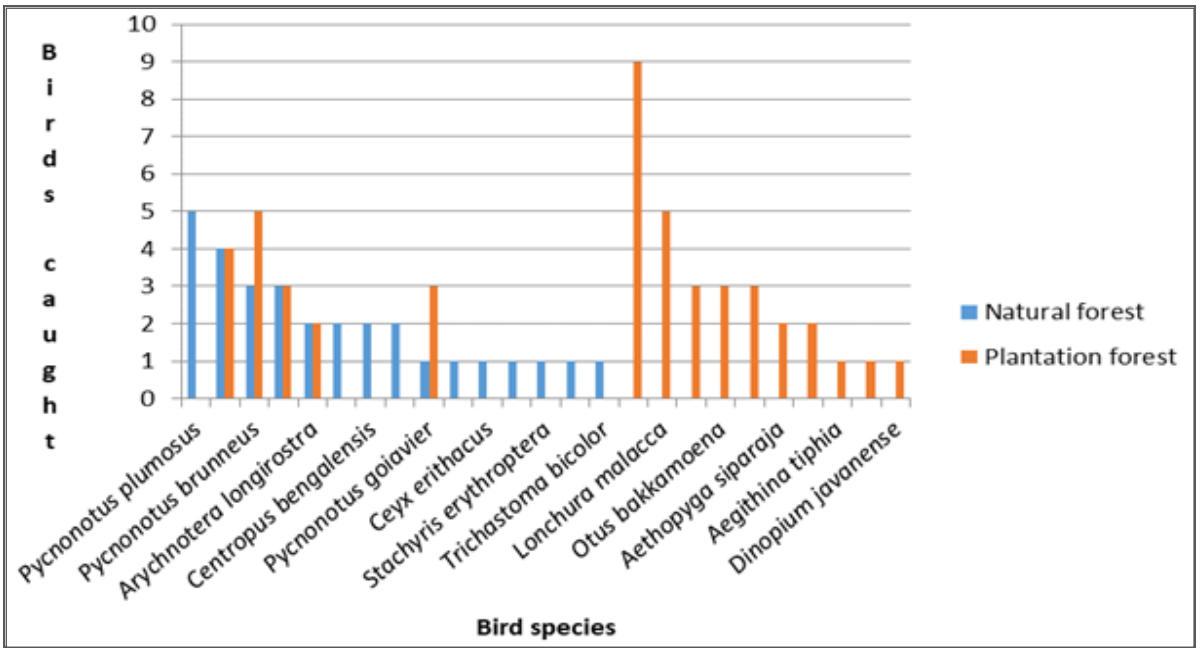

Figure 2. Number of bird individuals caught with the mist-nets method in the natural forest and plantation forest.

Feeding Guilds

Assessing the feeding guilds of the detected bird individuals was critical in understanding the complexity of an ecosystem structure and providing updated information on each type of habitat present in the ecosystem [9]. The feeding guilds of bird individuals captured/detected in the natural and plantation forests are tabulated as shown in Table 1 below. According to Table 1, the highest number of species in the two study sites was the Insectivore/Frugivore, followed by the Insectivore. More than 80% of the birds captured in both forest types were the Insectivore/Frugivore, Insectivore, and Carnivore. The frugivorous birds were found abundant in both natural and plantation forests.

A total of 13 individuals were captured in the natural forest and 12 individuals in the plantation forest in this study. The most frequently captured bird was the Bulbul, with 40% in natural forests and 23.4% in plantation forests. Frugivorous birds' abundance in both natural and plantation forests, despite differing environmental conditions, can be attributed to several ecological factors such as availability of fruits, adaptability of bird species and microhabitat diversity. Both forest types provide essential resources, albeit in varying quantities and qualities, which support these bird species [25; 26].

Table 1. Feeding guilds of bird individuals captured/detected in the natural forest and plantation forest.

Feeding Guild/Species	Number of Bird Individual	
	Natural Forest	Plantation Forest
Carnivore (Vertebrate)		
Kingfishers (Ceyx spec.)	1	2
Owl (Otus bakkamoena)	0	3
Carnivore/Insectivore (Arboreal Foliage Gleaning Carnivore/ Insectivore)		
Cuckoo	0	1
Coucals (Centropus spec.)	2	0
Insectivore (Terrestrial Insectivore)		
Babbler (Stachyris spec.)	1	0
Arboreal Foliage Gleaning Insectivore		
Robin (Copsychus saularis)	2	0
Babblers (Stachyris spec., Trichastoma spec.)	2	0
Bee-eater (Merops viridis)	0	9
Bark Gleaning Insectivore		
Woodpecker (Dinopium javanense)	0	1
Insectivore/Frugivore (Arboreal Foliage Gleaning Insectivore/ Frugivore)		
Broadbill (Calyptomena whiteheadi)	2	0
Crows (Platysmurus leucopterus)	0	1
Sparrow (Passer domesticus)	0	3
Munia (Lonchura malacca)	0	5
Terrestrial Insectivore/Frugivore		
Dove (Chalcophaps indica)	4	4
Sallying Frugivore/Insectivore		
Swallow (Hirundo tahitica)	1	2
Frugivore (Arboreal Foliage Gleaning Frugivore)		
Leafbird (Aegithina tiphia)	0	1
Broadbill (Calyptomena viridis)	1	0
Bulbuls (Pycnonotus spp.*)*	12	11
Nectarivore		
Spiderhunter (Arychnotera longirostra)	2	2
Sunbird (Aethopyga siparaja)	0	2
Total	**30**	**47**

Density and abundance of species

Table 2 shows the population density and abundance of birds in the natural and plantation forests in terms of density (individual/hectare) and abundance (individual/total study area). The bird density in the plantation forest was estimated and validated to be four times as high as that in the natural forest. The significantly higher bird density observed in plantation forests compared to natural forests can be attributed to several interrelated factors, including vegetation structure, food availability, and habitat characteristics. The plantation forests may offer advantages in terms of specific food resources and habitat structure that favor certain bird species' densities, they often do so at the cost of overall biodiversity compared to natural forests. The management practices employed in plantations play a crucial role in shaping these dynamics

[27]. The coefficients of variation were relatively small for an investigation of birds, especially in the case of the plantation forest.

Table 2. Population density and abundance of birds are presented in the natural and plantation forests.

Habitat type	Density (individuals/ha)	CV (%)	DF	95% Confidence Interval	Abundance
Natural forest	100	30.1	19	±120	1,000
Plantation forest	427	21.6	62	±556.5	1,280

Species Diversity

48 different bird species were recorded from the mist-net and point-count samplings in the two selected study sites. An impression of the bird diversity presented at each study site was estimated through the Shannon-Weiner Diversity Index (H'). The value of this index was expected to be high if a high number of rarely detected species were presented in a community [9]. In the plantation forest, the H' index was estimated to be 2.78, which was lower than that of the natural forest (H'=3.08). The higher bird density in plantation forests despite lower species diversity reflects complex ecological interactions involving habitat structure, food availability, competition, and human management practices. These insights contribute to a nuanced understanding of biodiversity and population dynamics in different forest types [27].

This showed that the birds in the natural forest (KFR: 15 species) were generally more diverse than those in the plantation forest (KEFP: 11 species) examined in this study. Nonetheless, the total number of bird individuals recorded in the natural forest was 30, which was lower than those observed in the plantation forest (47 individuals). Table 3 shows species diversity and bird abundance in natural and plantation forests.

Table 3. Species diversity and abundance of birds in the natural forest and plantation forest.

Habitat type	Shannon-Weiner Diversity Index (H')	Number of captured/detected bird species	Number of captured/detected bird individual
Natural	3.0803	15	30
Plantation	2.7829	11	47

Various species of *Pcynonotus* (Bulbul) were determined to be most abundant in both the natural and plantation forests because these bird species are known as colonizer or secondary forest species, which are commonly found in disturbed habitats [16; 28]. The *Pcynonotus* species and the *Chalcophaps indica* (Emerald dove) that lived in both habitat types were frugivorous and insectivorous-frugivorous species, respectively. This indicated that these bird species could alternate their diets between insects and fruits, depending on the type of food available. In the natural and plantation forests, secondary plants that bore small fruits, such as the *Macaranga* sp., *Ficus* sp., and *Trema* sp., were abundant. The bulbuls prefer these small fruits, explaining their high abundances observed at KFR and KEFP in this study (Pegan et al., 2018). *Calyptomena* sp. (Broadbill) and *Stachyris* sp. (Babbler) were sighted only in the natural forest. *Calyptomena* sp. is commonly found in the interior forest that is far from the disturbed environment, while the abundance of *Stachyris* sp. is closely related to the food availability presented in a habitat [17; 28]. Henceforth, the presence of Calyptomena sp. and Stachyris sp. only at KFR emphasized that the local environmental condition was more favorable to these species when compared to that of the plantation forest of KEFP [9]. In the plantation forest, the *Merops viridis* (Bee-eater) was identified as the most abundant species. This insectivorous species finds its food (e.g., honey bees, poisonous insects, ants, sawflies, and flying insects) near hives or around flowering trees (e.g., *Ficus* spp., *Acacia* spp., and *Macaranga* spp.),

which are abundant in the plantation forest [5; 16]. The second most abundant *Lonchura malacca* (Munia) belonged to the Insectivore/Frugivore guild. Therefore, this bird species consumed the grass seeds, which could also be abundantly found in the plantation forest [9]

The *Pcynonotus* sp. (Bulbul) and other bird species, such as *Arychnotera longirostra* (Spiderhunter) and *Merops viridis* (Bee-eater), were found abundant in both the natural forest and plantation forests. These species can tolerate high ambient temperatures and light intensity. Hence, they were frequently found feeding on fruits, insects, and flower nectar during the hot mid-afternoon in this study [29]. The ambient temperature and light intensity in plantation forests and logged-over natural forests are higher than those in the primary forest because human activities such as thinning and weeding have created many significant canopy gaps. The differences in ambient temperature and light intensity between natural and plantation forests play critical roles in shaping bird species' feeding patterns and activity levels. While plantation forests may support higher densities of individual birds due to favorable conditions for foraging and breeding, natural forests maintain greater biodiversity through complex ecological interactions. Understanding these dynamics is essential for effective conservation strategies that consider both population density and species diversity across different forest types. On the contrary, the shade-preferring babblers (*Stachyris* sp. and *Trichastoma* sp.) were more abundant in the natural forest than in the forest plantation. This is because these avian species are most adversely impacted when their habitats are altered [5; 9] which explains their low intolerance to high light intensity and ambient temperature until many of them avoid crossing through small sunlight patches. Furthermore, babblers are insectivorous species usually found in the forest understory. Hence, their food sources (insects) might also be different significantly between the two study sites due to the difference in vegetation complexity, although the level of change to the bird composition remains dependent on the level of disturbance presented at a given site[7; 9; 28]. Nevertheless, some other factors could potentially result in these findings obtained in the present research. First of all, poor weather conditions, such as heavy rain, could halt the activities of birds because most bird species are not resistant to rain [22]. Some of them might occasionally venture out to search for food during rainy days, but in small numbers, thus could affect the findings obtained in this study. Besides that, the condition of wet mist-nets due to the rain makes the mist-nets more visible to the birds, allowing them to avoid the mist-nets, which obstruct their flight path quickly. In other words, these situations posed difficulties for the researchers in observing and capturing the bird individuals at the selected two study sites.

CONCLUSION

The findings of this study reveal that more bird species have been observed in the natural forest of KFR (15 species) than in the plantation forest of KEFP (11 species). The distinct differences between bird species found exclusively in natural versus plantation forests highlight the importance of habitat complexity and resource availability. While plantation forests may support certain adaptable species, natural forests are vital for preserving specialized avian biodiversity. A natural forest has a higher plant diversity than a plantation forest. Thus, the food availability is higher in the natural forest than in the plantation forest, which ultimately results in more bird species of different guilds detected in the natural forest than in the plantation forest in this study. The family Pcynonotidae is the most abundant in both study sites. Among the six feeding guilds registered in this research, the Insectivore and Insectivore-Frugivore guilds are identified as the most common feeding guilds of birds presented in both habitat types. The notable differences in insect species and fruiting plants between natural and plantation forests significantly influence bird feeding guilds and their dominance within these habitats. Natural forests typically support a more diverse array of insects and fruiting plants, fostering greater biodiversity among bird species. In contrast, plantation forests may favor generalist species that can adapt to simplified environments with fewer resources. Understanding these dynamics is essential for effective conservation strategies aimed at maintaining avian biodiversity across different forest types. The diversity richness of avifauna at the plantation forest (H'=2.78) is generally lower than that obtained for the natural forest (H'=3.08). The estimated bird population densities (D) in KEFP and KFR are 427 individuals per hectare (CV=21.6%) and 100 individuals per hectare (CV=30.1%), respectively. The higher population density in plantation forests, despite their lower species diversity, reflects complex ecological interactions driven by resource availability, habitat structure, and human management practices. Understanding these dynamics is crucial for

developing effective conservation strategies that balance the needs of biodiversity with land use practices. A particular bird species can be a biological indicator when it exhibits a causal response to the change in the environmental condition of its surrounding habitat, such as the *Pycnonotus plumosus* and *Arachnothera longirostra* serve as effective biological indicators of environmental change due to their sensitivity to temperature fluctuations, habitat alterations, and extreme weather events. Monitoring these species can provide valuable insights into ecosystem health and help guide conservation efforts aimed at mitigating the impacts of climate change and habitat loss. The distribution and abundance of food sources and habitat suitability (e.g., cover, nest, and niche) may also be the main factors shaping the species composition, distribution, and abundance of birds in this habitat. Implementing these management strategies in plantation forests can enhance habitat quality for bird species while maintaining the ecological integrity of natural forests. By introducing specific plant species that provide food and shelter, creating mixed-species plantations, managing understory vegetation, ensuring habitat connectivity, and retaining key habitat features, it is possible to foster greater biodiversity in both forest types. This balanced approach will support avian populations while also meeting economic objectives associated with forest management. Therefore, these aspects must be considered when managing a forest for the long term, mainly to conserve and enhance the existing local bird density, abundance, and diversity.

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