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Original research article

Response of Bird Community to Various Plantation Forests in Gunung Walat, West Java, Indonesia



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ABSTRACT

Different plantation forests possibly harbor different bird communities. This study was aimed to reveal responses of bird community to the different plantation (*Schima wallichii*, *Agathis loranthifolia*, *Pinus merkusii*, and mixed plantation), identify species shared in all plantation, and species confined to a particular plantation. The study site was plantation forests, using the point count method for 64 effective hours. There were 40 bird species (maximum prediction 52) in all forest plantations and each type had 26–31 species. Number of individuals, species density, and diversity index in Schima plantation were higher, followed by Agathis, Pinus, and mixed plantations. Mixed plantation could have harbored more species based on the prediction by Chao. Although there were some differences in tree species, tree sizes, and tree heights, the response of bird composition in all plantations was not differed (93–81% similarity) probably because of the short distances among the forests, the abundance of food insects, and the same late-successional stages. There were 15 (37.5%) widely distributed species in all forest types. Eight species were confined only to a specific forest type. Four species were considered true confined species, namely Javan sunbird (Schima forest), Grey-cheeked bulbul (in Pinus), Crescent-chested babbler (Agathis), and Mountain white-eye (Agathis).

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1. Introduction

Published studies on bird community in the Java have been conducted mostly in the natural forest (e.g. Wisnubudi 2009) with a complex multilayered tree strata of highly diverse tree species or in a less complex forest assemblages, such as in suburban areas (e.g. van Helvoort 1981), agroforest areas (Pudyatmoko et al. 2009), or botanical gardens (Diamond et al. 1987). Study on bird community in the plantation forest in Java has been lacking. In the outer islands, bird community was studied by Sheldon et al. (2010) in the *Acacia mangium* plantation, which was an alien tree species. Studies elsewhere (e.g. Dewi 2005) have shown that monoculture plantation forests have been known to harbor less species than mixed natural forests.

The objective of the research was to investigate the response of bird community to four types of plantation forests. To be specific,

this study was designed to reveal whether bird composition was different in four plantation forests adjacent to each other, identify widely distributed bird species that were shared by all plantation forests, and conversely identify species confined to a particular plantation forest. The study site was the plantation forest of Gunung Walat in West Java, Indonesia.

2. Materials and Methods

2.1. Study area

Gunung Walat (6°54'23"–6°55'35"S; 106°48'27"–106°50'29"E) is a 359 ha of old growth plantation forest under the authority of Perum Perhutani (Indonesia's estate forest company). The forest currently has been managed by Faculty of Forestry, Bogor Agricultural University, as an educational forest. The forest is located in Sukabumi District (West Java, Indonesia), about 115 km to the south of the capital city of Jakarta (Badan Eksekutif HPGW 2009) (Figure 1).

The study area is a series of low hilly area (500–720 m above sea level). The surrounding areas were mostly village settlements and intensive perennial/annual crops, creating a rural environment.

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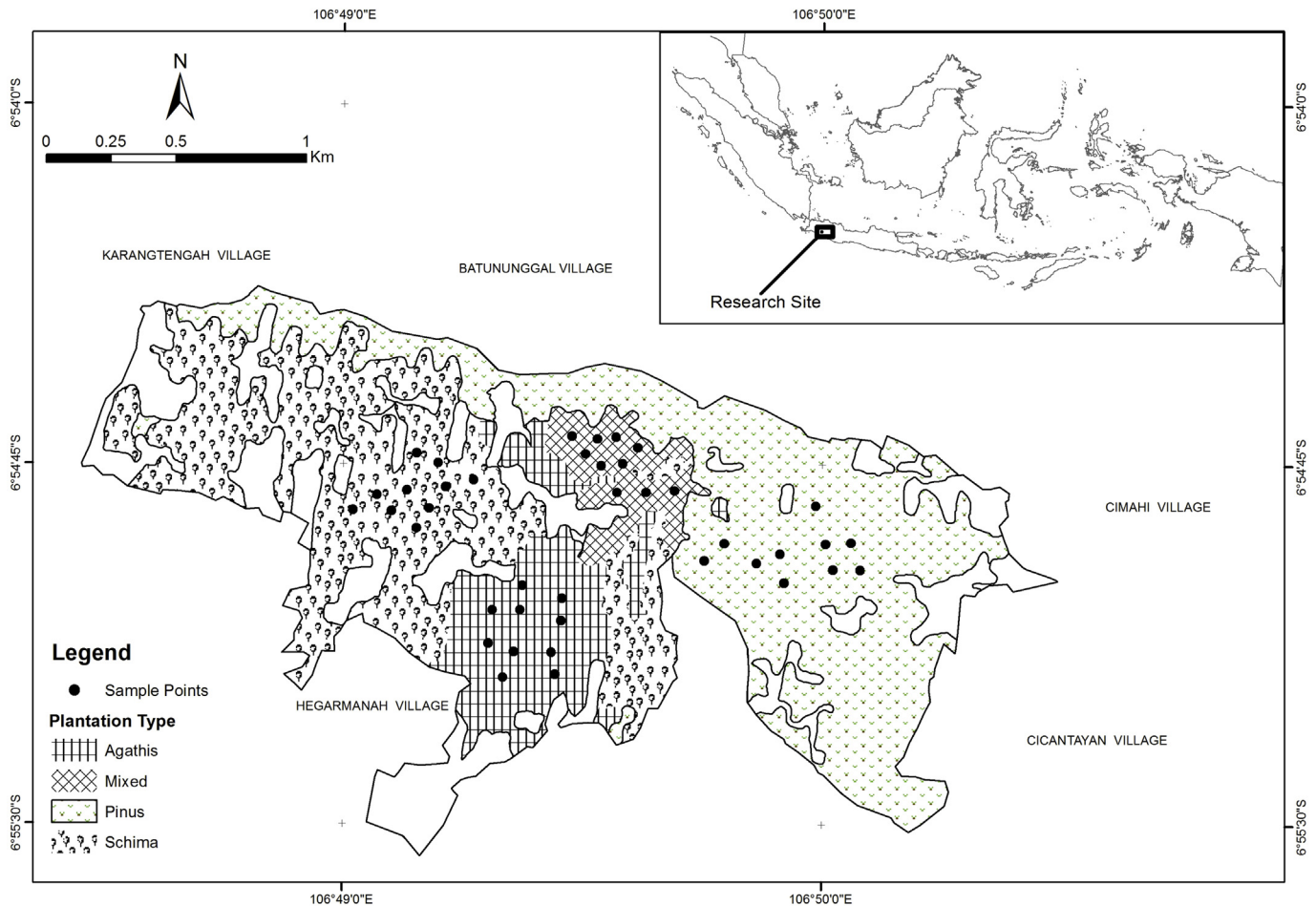


Figure 1. Map of research site.

Gunung Walat received 1600–4400 mm of rainfall annually (type B of Schmidt and Ferguson system). Temperature was constant during the study, with a minimum of 22°C during the coldest night and maximum of 30°C in the hottest day (Badan Eksekutif HPGW 2009).

Although there was no exact record of the planting date, it can be confirmed that all forest stands were at least 40 years old and currently resembled near-natural stand structure. Of the 10 existing plantation forests (or forest blocks), four dominant forest plantations were used for this study, namely *Schima wallichii* plantation (hereafter referred to as *Schima*), *Agathis loranthifolia* (*Agathis*), *Pinus merkusii* (*Pinus*), and mixed plantation (*mixed*) of the three species (i.e. *Agathis*, *Pinus*, and *Schima*). All four tree species are native to Indonesia.

The four forest plantations were located in the same landscape, adjacent to each other. Of the 59 ha *Schima* forest plantations, approximately 10 ha (17%) were used for research. The undergrowth was covered by woody shrubs of *Calliandra haematocephala*, *Etlingera solaris*, *Clidemia hirta*, *Melastoma candidum*, *Sellaginella doederleinii*, *Cynodon dactylon*, *Curculigo latifolia*, *Claoxylum indicum*, *Leea sambucina*, *Equisetum debile*, and *Coffea arabica*. During the study, the *Schima* trees were in the peak of flowering.

Agathis forest plantations were the tallest among others, and densely covered, although some gaps existed and created some openings. There was 35 ha of *Agathis* plantations in total, and 10 ha (29%) was selected as the study site. Some shrubs still can be found,

mostly in the openings at the plantation edges, including *Daemonorops melanochaetes*, *Etlingera solaris*, *Equisetum debile*, *Melastoma candidum*, *Curculigo latifolia*, *Smilax leucophylla*, *Sellaginella doederleinii*, and *Leea sambucina*.

Pinus forest plantation in the education forest covered 35 ha, of which 10 ha (29%) was observed. Tree plantations were sparsely spread, thus allowing many shrubs, seedlings, and saplings thrive, for example, *Syzygium* sp., *Maesopsis emini*, *Swietenia macrophylla*, *Artocarpus communis*, *Bambusa* sp., *Daemonorops melanochaetes*, *Calliandra haematocephala*, *Mangifera indica*, *Clidemia hirta*, *Sellaginella doederleinii*, *Leea sambucina*, *Cynodon dactylon*, *Oplismenus burmanni*, *Wedelia trilobata*, *Melastoma candidum*, *Ostus speciosus*, *Eugenia cymosa*, *Etlingera solaris*, and *Plantago major*.

In mixed forest plantation, the major tree species were *Pinus merkusii* (slightly dominant), *Agathis loranthifolia*, and *Schima wallichii*. Other plant species found among the major tree species were *Maesopsis eminii*, *Bambusa* sp., *Orthosiphon stamineus*, *Sellaginella doederleinii*, *Leea sambucina*, *Cynodon dactylon*, *Oplismenus burmanni*, *Melastoma candidum*, *Ostus speciosus*, *Wedelia trilobata*, *Etlingera solaris*, and *Eugenia cymosa*. The total area of mixed plantation was 35 ha, of which 10 ha (29%) was used for this study.

2.2. Methods

Bird habitats were sampled by using a 10 × 50 m plot for each forest plantation. Tree diameter and tree height of sampled trees ($n = 10$) were measured by using measuring tapes (to the nearest centimeter) and Hagameter (to the nearest meter), respectively.

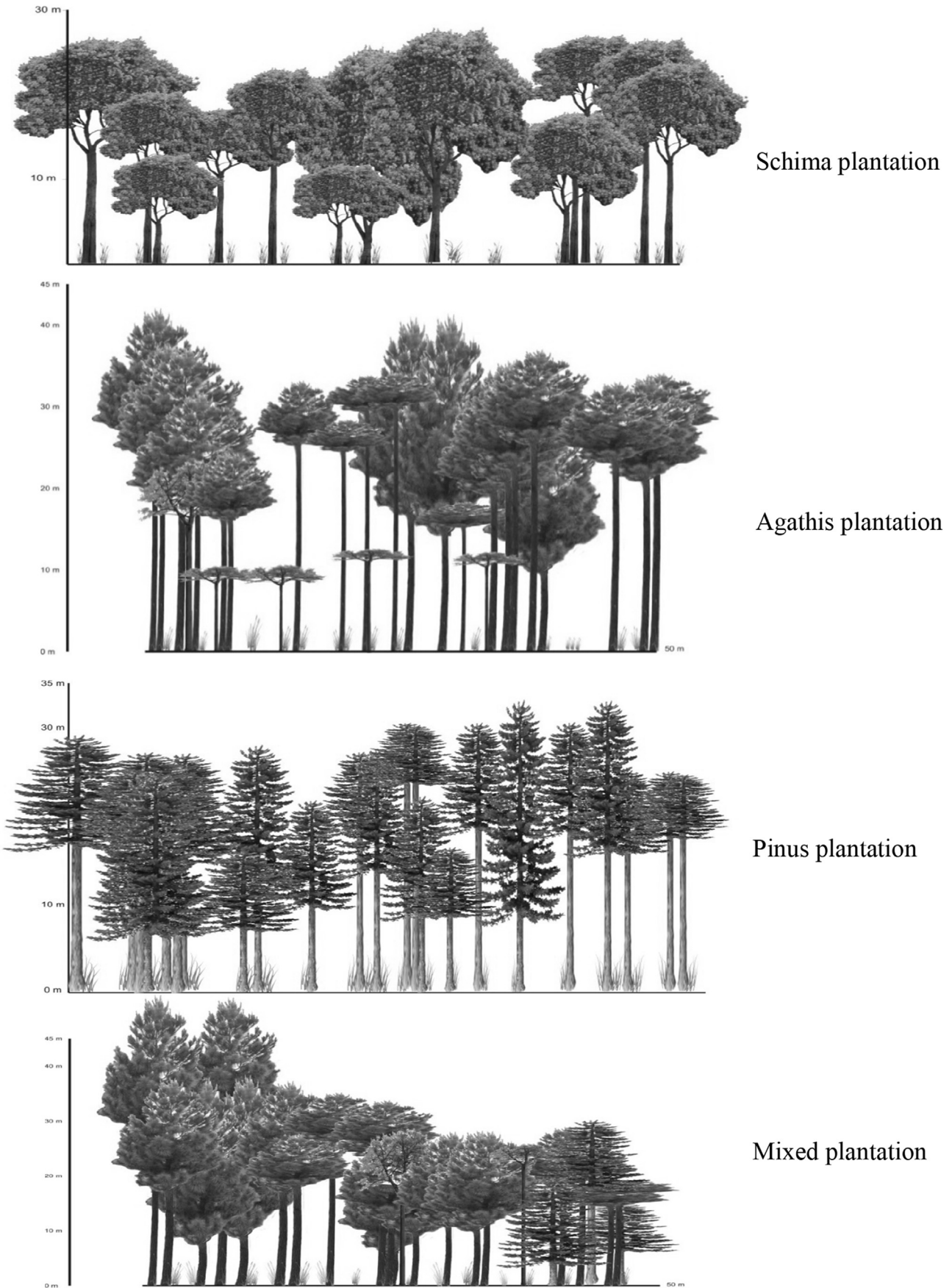


Figure 2. Profile diagrams of *Schima wallichii*, *Agathis loranthifolia*, *Pinus merkusii*, and mixed species plantation in Gunung Walat.

Profile diagrams for all four forest plantations were generated to aid interpretation.

Birds were observed daily by using the standard point count method (Bibby *et al.* 2000) for a full month in August 2011, coincided with the late dry season. The total effective time for the bird survey was 64 hours. In each forest plantation type, 10 random points (radius, 30 m) were established to sample the bird communities, at least 50 m from the stand edges to minimize influence from other adjacent habitats. Encounter rates were calculated as number of species and individuals per hour. Species identification follows the study by MacKinnon *et al.* (1998).

Duration for bird observation in each point was 10 minutes, after a 2-minute wait. Data recorded were species name and its number. Birds that were identified from their song or calls only were excluded from calculation. Each point was replicated three times in different days to ensure a representative result. Observation was conducted twice a day, in the morning (05:30–9:00 AM) and in the afternoon (3:30–6:00 PM), and thus nocturnal birds were excluded. Bird survey was not conducted in heavy cloudy days, rainy days, or when thick mist occurred.

Differences in tree heights and diameters, if any, were tested using F tests and followed by Tukey's test for pair comparisons. Maximum species richness in each plantation was estimated by using the prediction of Chao (Henderson 2003). Encounter probability was calculated as number of birds per total observation hour. Bird density was calculated as individual per hectare. Shannon-Wiener diversity indices (H') (Magurran 2004) were used to quantify and compare bird diversity among different tree plantations, followed by t tests (Magurran 1988) to reveal the statistical difference between plantations. Evenness and dominance (D ; van Helvoort 1981) were also calculated for each tree plantation. Jaccard's similarity indices (Krebs 1985) were used to examine similarity/dissimilarity of bird community among the four tree plantations.

3. Results

3.1. Habitat condition

The four forest plantations being studied showed differences in tree heights ($F = 3.36$; degrees of freedom = 3; $p < 0.05$) but not in diameter ($F = 1.67$; degrees of freedom = 3; $p > 0.05$). Further pair comparison tests revealed that mixed plantations (Agathis and Pinus trees) were significantly taller than other plantations (Tukey's test, 31.00 ± 9.06 ; $p < 0.05$ for all pairs).

Diagram profiles (Figure 2) showed that canopy closures in all plantation types were more or less closed and dense, without much

gaps or openings in between. However, shrubs and understory plants still can be found, except in Agathis plantation where light penetration to the forest floor was very limited. In all monoculture plantations, tree heights and distances were highly varied because of diverse topographic and soil conditions.

3.2. Bird community composition in four forest plantation types

Summary of bird community observed in the study area and its habitat characteristics is shown in Table 1. The total number of birds observed in all four forest plantations was 1190 individuals, belonging to 40 species (maximum predicted species richness, 52), representing 24 families (Table 2). Important families (having at least four species members) found in the study sites were Cuculidae (cuckoo), Timaliidae (babblers), Sylviidae (priniads and tailorbirds), and Nectariniidae (sunbirds).

Comparing among all four forest plantations, each plantation had about 26–31 species from 17 to 18 families. Number of individuals, species density, and diversity index in Schima plantation were the highest, followed by Agathis, Pinus, and mixed plantations. However, Chao's prediction of maximum species richness revealed that mixed plantation might contain higher species number (42 species) because of many singletons and doubletons found in this plantation type.

Considering that all tree plantations were adjacent to each other and located in the same landscape, analysis of similarity in bird community composition among forest stands showed that each forest stands was moderately shared, between 83% and 93% (Figure 3). Bird composition in Schima forest was slightly differed with other three forest types.

Evenness, referring to how close each species (in numbers) is to each other in certain plantation types, showed high values in all plantation types (0.83–0.89). In Agathis plantation, evenness was the lowest, indicating that there was few species (i.e. Little spiderhunter, Common iora, Oriental white-eye, and Spotted dove) that significantly dominated the bird community.

3.3. Widely distributed and confined species

There were 15 widely distributed species that can be found in all four forest types (for species having $D > 0.3$) (Table 3). Based on food types, these widely distributed species were mainly insectivorous (66.6%) and granivorous (20.0%).

Based on the species occurrences in each forest type, most of these species still showed preferences on certain forest type(s). Species that inhabit all forest types and showed no preferences on any specific forest types were Common tailorbird, Horsfield's

Table 1. Summary of the habitat quantification and bird community in four forest plantations in Gunung Walat

Variables	Schima	Agathis	Pinus	Mixed
Size (approximately); ha	59	35	35	35
Relative geoposition	West	South	North	East
Stand type	Monoculture	Monoculture	Monoculture	Oligoculture
Major tree species	<i>Schima wallichii</i>	<i>Agathis loranthifolia</i>	<i>Pinus merkusii</i>	<i>Pinus merkusii</i> <i>Schima wallichii</i> <i>Agathis loranthifolia</i>
Average tree height \pm SD ($n = 10$); m	22.8 \pm 5.21	45.0 \pm 11.46	37.8 \pm 12.49	40.5 \pm 10.89
Average tree diameter \pm SD ($n = 10$); cm	40.8 \pm 8.09	28.9 \pm 4.63	30.0 \pm 10.05	31.0 \pm 8.87
Number of bird family	17	18	17	17
Number of bird species	31	31	26	30
Number of bird species (maximum—Chao)	35	39	29	42
Number of individual bird/hr	23.2	19.6	16.4	15.1
Bird diversity indices (H')*	3.03 ^a	2.79 ^a	2.73 ^a	2.73 ^a
Evenness	0.89	0.83	0.85	0.89

SD = standard deviation.

* The same superscripts (a) denote nonsignificant difference ($p > 0.05$).

Table 2. Bird species found in four forest plantations in Gunung Walat and its encounter probability; nomenclatures and sequence follow MacKinnon et al. (1998)

No.	Common name	Latin name	Encounter probability in all stands (ind/hr [*])	Observed number			
				Schima	Agathis	Pinus	Mixed
Accipitridae							
1	Crested serpent eagle	<i>Spilornis cheela</i>	0.15	4	4	1	2
2	Black eagle	<i>Ictinaetus malayensis</i>	0.01	1	0	0	0
Turnicidae							
3	Barred buttonquail	<i>Turnix suscitator</i>	0.39	8	13	6	1
Columbidae							
4	Black-naped fruit dove	<i>Ptilinopus melanospila</i>	0.11	6	1	0	1
5	Spotted dove	<i>Streptopelia chinensis</i>	0.92	13	35	1	17
Cuculidae							
6	Plaintive cuckoo	<i>Cacomantis merulinus</i>	0.10	2	1	3	1
7	Rusty-breasted cuckoo	<i>Cacomantis sepulcralis</i>	0.40	18	5	4	2
8	Asian Drongo-cuckoo	<i>Surniculus lugubris</i>	0.10	3	1	2	1
9	Lesser coucal	<i>Centropus bengalensis</i>	0.01	1	0	0	0
10	Banded bay cuckoo	<i>Cacomantis sonneratii</i>	0.17	5	3	3	1
Apodidae							
11	Cave swiftlet	<i>Collocalia linchi</i>	1.33	38	27	17	14
Alcedinidae							
12	Collared kingfisher	<i>Halcyon chloris</i>	0.72	12	12	9	19
Pittidae							
13	Banded pitta	<i>Pitta guajana</i>	0.63	8	11	13	13
Hirundinidae							
14	Pacific swallow	<i>Hirundo tahitica</i>	0.01	0	1	0	0
Aegithinidae							
15	Common iora	<i>Aegithina tiphia</i>	1.61	36	37	9	34
Pycnonotidae							
16	Black-headed bulbul	<i>Pycnonotus atriceps</i>	0.25	12	4	0	2
17	Sooty-headed bulbul	<i>Pycnonotus aurigaster</i>	0.25	12	4	0	2
18	Gray-cheeked bulbul	<i>Criniger bres</i>	0.03	0	0	2	0
Turdidae							
19	Lesser shortwing	<i>Brachypteryx leucophrys</i>	0.14	0	1	6	3
Timaliidae							
20	Black-capped babbler	<i>Pellorneum capistratum</i>	0.63	10	9	18	8
21	Horsfield's babbler	<i>Malacocincla sepiarium</i>	0.94	19	13	19	17
22	White-bibbed babbler	<i>Stachyris thoracica</i>	0.01	0	1	0	0
23	Crescent-chested babbler	<i>Stachyris melanothorax</i>	0.11	0	2	0	6
Sylviidae							
24	Brown prinia	<i>Prinia polychroa</i>	0.07	0	0	4	1
25	Bar-winged prinia	<i>Prinia familiaris</i>	0.03	1	0	0	1
26	Olive-backed tailorbird	<i>Orthotomus sepium</i>	1.57	18	19	44	32
27	Common tailorbird	<i>Orthotomus sutorius</i>	0.94	13	21	15	19
Acanthizidae							
28	Golden-bellied gerygone	<i>Gerygone sulphurea</i>	0.19	12	0	2	0
Paridae							
29	Great tit	<i>Parus major</i>	0.39	8	13	6	1
Sittidae							
30	Blue nuthatch	<i>Sitta frontalis</i>	0.36	9	1	14	2
Dicaeidae							
31	Scarlet-headed flowerpecker	<i>Dicaeum trochileum</i>	0.03	0	0	1	1
Nectariniidae							
32	Ruby-cheeked sunbird	<i>Anthreptes singalensis</i>	0.03	0	0	1	1
33	Olive-backed sunbird	<i>Cinnyris jugularis</i>	0.24	9	1	4	3
34	Javan sunbird	<i>Aethopyga mystacalis</i>	0.07	5	0	0	0
35	Little spiderhunter	<i>Arachnothera longirostra</i>	1.74	41	37	26	21
Zosteropidae							
36	Oriental white-eye	<i>Zosterops palpebrosus</i>	1.86	42	35	38	19
37	Mountain white-eye	<i>Zosterops montanus</i>	0.03	0	2	0	0
Estrildidae							
38	Javan munia	<i>Lonchura leucogastroides</i>	0.28	7	13	0	0
Dicruridae							
39	Black drongo	<i>Dicrurus macrocercus</i>	0.11	5	2	0	1
40	Ashy drongo	<i>Dicrurus leucophaeus</i>	0.13	7	2	0	0

* In all tree stands (ind/64 hr).

babbler, and Banded pitta. Being dispersed in all forest plantation types, these three species were not dominant in each forest type. Species that dominated each forest type (Table 4) were mostly insectivorous of various guilds, except for Spotted doves, which rely on seeds for their diet.

In contrast to the widely distributed species, there were eight species that confined only to a specific forest type. If singletons were excluded because of possibility of vagrant species, four species were considered confined species, namely Javan sunbird

(Schima forest), Gray-cheeked bulbul (Pinus), Crescent-chested babbler (Agathis), and Mountain white-eye (Agathis).

4. Discussion

4.1. How birds respond to different types of forest plantations

Bird communities are often being used as good indicators of their habitat because of their fast response to disturbances as the

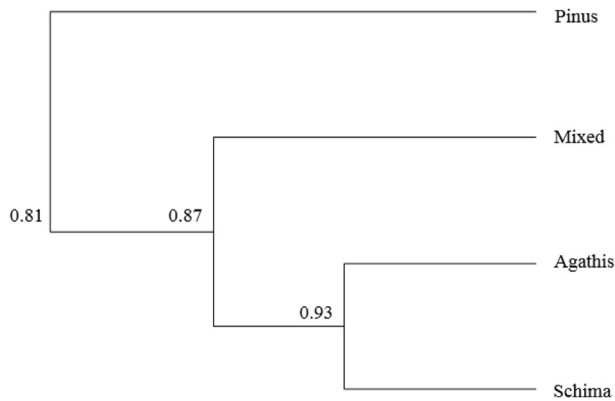


Figure 3. Dendrogram of similarity of bird community in four tree stands in Gunung Walat.

Table 3. Species widely found in all forest types in Gunung Walat and their preferences

No.	English name	Forest type preference
1	Rusty-breasted cuckoo	Schima
2	Cave swiftlet	Schima
3	Barred buttonquail	Agathis
4	Spotted dove	Agathis
5	Great tit	Agathis
6	Blue nuthatch	Pinus
7	Collared kingfisher	Mixed
8	Black-capped babbler	Schima, Pinus
9	Little spiderhunter	Schima, Agathis
10	Olive-backed tailorbird	Pinus, mixed
11	Common iora	Schima, Agathis, mixed
12	Oriental white-eye	Schima, Agathis, and Pinus
13	Banded pitta	No preference
14	Horsfield's babbler	No preference
15	Common tailorbird	No preference

Table 4. Dominant bird species ($D > 10.00$) and its dominant value for each forest type in Gunung Walat

Forest type	Dominant species (value)
Schima	Little spiderhunter (11.02)
	Oriental white-eye (11.29)
	Cave swiftlet (10.22)
Agathis	Little spiderhunter (11.78)
	Oriental white-eye (11.15)
	Common iora (11.78)
	Spotted dove (11.15)
Pinus	Oriental white-eye (14.50)
	Olive-backed tailorbird (16.79)
Mixed	Common iora (14.05)
	Olive-backed tailorbird (13.22)

diversity of bird communities has been known to be positively correlated with habitat complexity (MacArthur and MacArthur 1961). Compared with other published research (e.g. van Helvoort 1981; van Balen 1999), the bird communities in the study area were closely resembled to those in rural Java.

From previous research in the tropics, it has been known that the bird diversity was positively correlated with vegetation complexity and food availability (Marsden and Pilgrim 2003; Terborgh and Weske 1969) as well as microclimate factors (i.e. temperature, relative humidity, and light intensity) (Rajpar and Zakaria 2015). Furthermore, bird species composition, distribution, relative abundance, and richness are known to be strongly influenced by food availability, tree size, tree height, and cover percentage (Carrascal and Diaz, 2006; Godinho *et al.* 2010; Honkanen *et al.* 2010; Shochat *et al.* 2002).

Forest plantations in Gunung Walat differed each other in term of species being planted, tree size, tree height, and cover percentage (not quantified in this study), of which overall might lead to differences in food types and availability. The four forest plantations moderately shared bird community, suggesting that many factors contributed to the response. Differences in tree species, tree sizes, and tree heights still leads up to 63% similarity among bird community among four forest types under study.

Clearly, some other factors might influence to the similarity of the bird community. The possible factors that could have played significant roles are the short distance between two adjacent forest types, especially for bird species with large daily ranges; the abundance of insect food, which occurred in all over the study site; and the similar successional stages (i.e. late succession) of all forest types.

Villard *et al.* (1999) as well as Soderstrom and Part (2000) reported that birds often prefer to use multiple habitats and depend on the quality and productivity of the habitats (i.e. food availability, cover, and nesting sites) to maintain viable populations. The short distances between/among the forest types seemed facilitating the multiple habitat use in Gunung Walat. As for insectivores, all dominant species in each forest type were insectivorous, with the exception of Spotted dove.

Daniels *et al.* (1990) reported that in India there was an apparent increase in diversity in the human-modified types; bird diversity in teak and eucalypt plantations even was higher than natural evergreen and semievergreen forests. Furthermore, Cavard *et al.* (2011) re-emphasized that mixed forest stands might have a higher diversity of forest birds if the forest stands have a greater variety of niches. Mixed stands in this study had the average number of bird species, although Chao's predictor suggested the highest. Clearly, more observation time in this plantation type was necessary to uncover the real species richness.

4.2. The presence and absence of certain bird species

Cuculidae stands out as a family with many members found in the study area. Six species of Cuculidae were present in almost all forest stands in the study area, and only one species, that is, *Centropus bengalensis*, has been known as a nonparasitic species based on information provided by Goyman (2005). Brood parasitism required a complex breeding strategy as egg laying has to be synchronized with appropriate hosts (Petrie and Moller 1991). Previous research on the Old World family Cuculidae revealed that there were about 50 species of obligatory parasites, either host generalists or host specialists (Winfree 1999).

Research on interspecific brood parasitism in the tropical Asia, specifically in Indonesia, has been extremely lacking, and there was no published information on the host species parasitized by the cuckoo. Based on the list provided by Kaban (2013), in the study area, the potential hosts were prinias, tailorbirds, ioras, minivets, bulbuls, and babblers. Competition to find compatible host species must be very high, especially for the three congeneric species of Cacomantis (i.e. *C. sonneratii*, *C. merulinus*, and *C. sepuclaris*) that used the same Pinus and mixed stands.

Two species of raptors were present, indicating a sufficient number of preys in the surrounding sites. Most of the birds, however, were insectivores and a mix of granivores-nectarivores, which forage mostly in lower part of the tree canopy. Medium-sized frugivorous (doves) were lacking and represented by Black-naped fruit dove and Spotted dove, probably because of a shortage of food resources, as also reported by Waltert *et al.* (2004) in plantation forest of Sulawesi.

It is rather surprising that the hole nester was absent in all tree stands, despite the fact that the forest was considered in the late-successional stages. This is contradictory with the research by

Laiolo *et al.* (2002) in South America, which demonstrated that the population of hole nester increased significantly with stand age because of the greater availability of holes and crevices in mature stands. In the tropical forests in Indonesia, the common hole-nester species that might have been present in the study area are *Dendrocopos macei* and *Dendrocopos moluccensis* (Dewi 2005).

4.3. Conservation implication

As stated by the Intermediate Disturbance Hypothesis (Connell 1978) and supported by various field research (e.g. Mardiasuti *et al.* 2015; Waltert *et al.* 2004), late-successional stages contain less bird diversity compared with the mid-disturbance or mid-successional habitat. Early and mid-successional habitat differs in their effects on light and soil conditions for the understory compared with a late-successional ecosystem (Cavard *et al.* 2011). If necessary, bird diversity in Gunung Walat can be maximized by creating a small scale disturbance to reverse the successional stages.

Two bird species, the Felvet-fronted nuthatch and Banded pitta, need to get a special attention in the study area as these two species have been hardly found in a rural plantation forest. Recently, Banded pitta became increasingly rare in tropical forest in Indonesia. Its colorful plumage makes this species popular for bird cage, resulting in population decline in its natural habitat because of an uncontrolled harvest. This species is a poor disperser and mostly terrestrial and uses understory areas.

Pittas are also very shy birds and thus very difficult to observe (Erritzoe 2004). Surprisingly, the Banded pitta was found in all four forest stands in the research area, although the rate encounter was considerably low. The presence of this species can serve as a good reason to conserve the area for conservation purposes.

Oriental white-eye, Common iora, and Sooty-headed bulbul also need to be monitored. These species was listed as 10 top-ranked traded cage birds in Jakarta's bird market, and the Oriental white-eye even was ranked as the first (Chng *et al.* 2015). Protection against illegal poaching of these songbirds is important for their survival.

Conflict of Interest Statement

There is no conflict of interest.

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