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UNDERSTORY AVIAN COMMUNITY IN A TEAK FOREST OF CEPU, CENTRAL JAVA

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Teak forest in Java island is commonly planted using a mix agroforestry system at an early stage of development, which later forms a monoculture forest ecosystem. As a consequence, the understory ecosystem is unique and different from other forest systems. This study investigated the role of understory layer in teak forest plantation of Central Java. Four different teak plantation conditions were selected: clonal, conventional, agroforestry and old-grown teak plantation, in the forest management unit of Cepu, Central Java. Point-count samples were placed systematically, recording different species inhabiting the forest floor, habitat features and feeding behavior of each species. Species were grouped according to the guild and stratum of the forest. It was found that the forest floor of teak plantation provided habitat, more for insectivorous and omnivorous, and less for frugivorous. Among other guilds, the encounter rates of insectivorous were highest in agroforest, conventional and old growth teak plantation. Whereas, the granivorous was highest in clonal teak plantation. Thus, the study confirmed that teak plantation plays a role as a refuge for understory bird communities. However, surrounding landscape conditions provide additional resources for the avian communities, rather than only within the compartment. Further improvement of habitat surrounding the compartments, including riparian, is needed for supporting avian biodiversity conservation in forest plantation.

Keywords: Birds diversity, conservation, forest production, forest plantation, certification

INTRODUCTION

Forest plantations, which include *Tectona grandis* (teak) and *Acacia mangium*, have replaced a significant proportion of natural forest in the world and had subsequently decreased biodiversity (Fujita et al. 2014). There was a clear indication of dropped natural forest area followed by increased planted forests from 167.5 to 277.9 million hectares in the world during 1990 to 2015 (Payn et al. 2015). Teak forests in Indonesia, which features prominently in Javan island, make up 35% of the world's supply, covering 1.269 million ha (FAO 2011, Pandey & Brown 2000, Purnomo et al. 2009). The teak tree is not an endemic species from Java, but was introduced and naturalised in this island from the 14th to 16th century (Pandey & Brown 2000).

Teak forest functions as a wood source, habitat for various vegetation and diversity of fauna (Djuwantoko 1991, Pandey & Brown 2000, FAO 2011, Kaewkrom et al. 2005, Tangmitcharoen et al. 2006, Koonkhunthod et al. 2007, Harikrishnan et al. 2012). Among other taxa, birds are commonly used as an indicator in the measurement of sustainable forest/plantation management which is widely applied by measuring its diversity, mainly focused at stand or landscape levels (Elbakidze et al. 2011, Brockerhoff et al. 2013, Coote et al. 2013).

Environmental conditions in various vertical stratum of the forest such as vegetation, food, light change over time affect a noticeable vertical distribution of avian species (Walther 2002, Aikens et al. 2013, Huang et al. 2014). Also, vertical strata of forest plays an essential role in the distribution and foraging behavior of avian communities (Walther 2002, Sasaki et al. 2012). Teak forest in Java island is commonly planted using a mix agroforestry system at an early stage of development, which later forms a monoculture forest ecosystem. As a consequence, the understory of the forest comprises a complex interaction between humans and ecosystem factors. Among forest stratum, understory avian communities face the most substantial threat from human activities, as compared to other parts, and potentially affect its biodiversity (Jean-Luc et al. 2011, Visco et al. 2015).

Studies on the interaction between teak forest and avian communities are limited to comparative studies with other plantations (Sidhu et al. 2010, Mandal and Shankar-Raman 2016). There is insufficient understanding of

the community assemblage response of birds on the micro-level, such as understory, which is essential in fully comprehending the impacts of silvicultural technique on biodiversity. Therefore, understanding avian community at understory level may provide a clearer picture of the effects of human intervention on biodiversity in teak forest. To gain further insight into the impact of human intervention through silviculture treatments on birds, the study assessed on how the avian community uses teak forest understory in Central Java.

MATERIALS AND METHODS

Four different teak forest compartments were selected, representing different teak conditions: clonal, conventional, old-growth and agroforestry teak plantations in Cepu district under the management of Perum Perhutani DIVRE, Jawa Tengah (Figure 1). The clonal teak plantation is a product of tree selection since 1983 from existing teak trees in Java (Budiadi et al. 2017). Field observation was conducted from June to July 2015 by collecting data on the vegetation stratum in each teak condition, through the establishment of 20 × 60 m plots. The vertical structure of vegetation in each forest condition was projected using SExi-FS 2.1.0 software (Harja & Vincent 2008). Also, ground and canopy cover was measured in each point count samples adopting the work of Noon (1981). Vegetation densities were also collected at different heights i.e., 0–30 cm, 30–100 cm, 100–200 cm and 200–300 cm. All habitat feature data were statistically analysed to provide comparative information on forest conditions.

Point count samples were placed systematically in each forest condition with a distance of 200 m between samples. Figure 1 shows the distribution

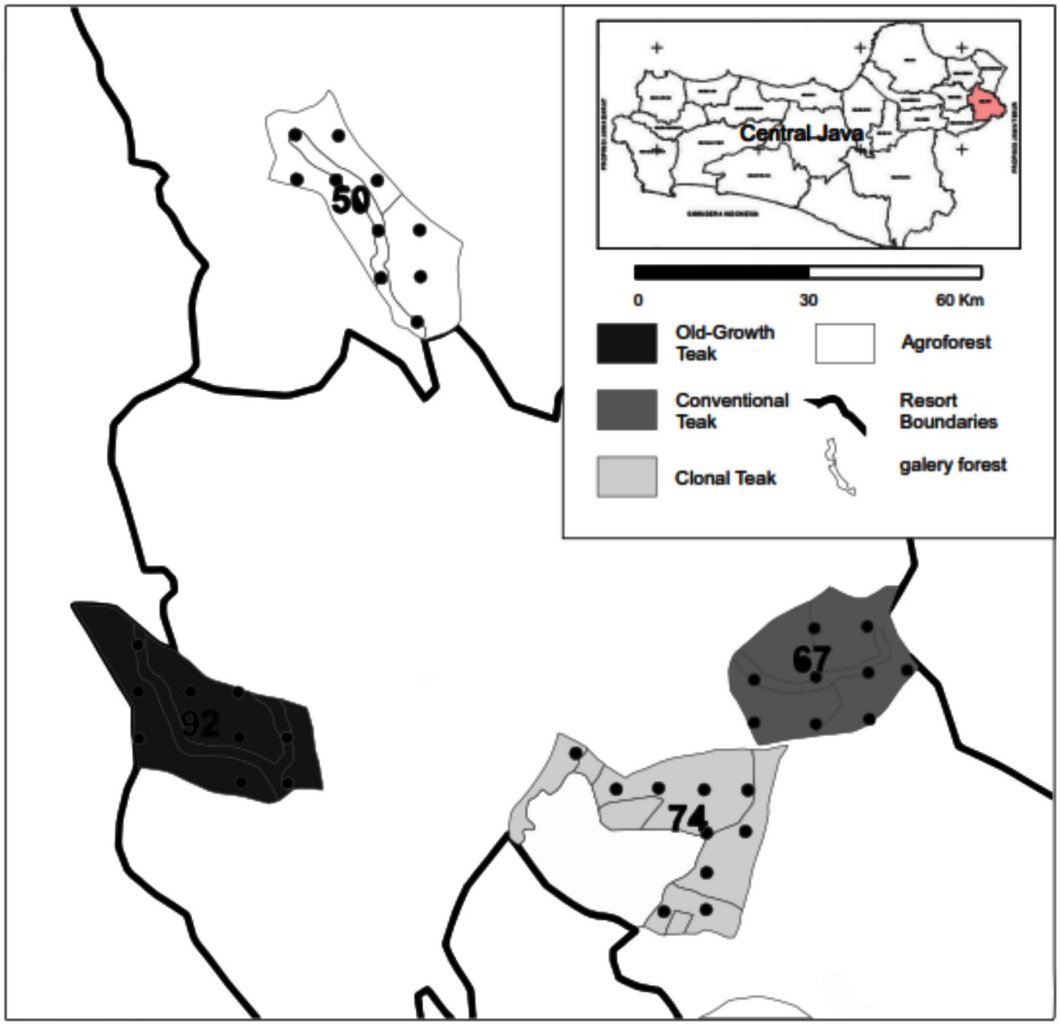

Figure 1 Map of study area and systematic arrangement of point count samples in each teak condition: clonal teak (a), agroforest (b) conventional teak (c) old-growth teak (d)

of point count samples in each observation units. Bird species were recorded during ten minutes of observation in each point count sample. The observation was limited to a maximum height of 4 m, and the heights were classified into three groups i.e., 0 m, 0–2 m and 2–4 m. All detected bird species were recorded within a radius of 50 m, and repeated three times.

Encounter rate was calculated for all bird species according to guild or feeding behavior in each forest condition. The assignment of each species into guilds and their diet routine was classified using existing information from Mackinnon et al. (2010). The encounter rate was calculated by counting the number of each species within each guild from all point count samples. The results were then compared with total efforts during field observations, and projected against height. The frequency of occurrences of each behavior was compared between forest compartments to show how avian communities used the forest floor.

RESULTS

Vegetation stratum

Agroforestry compartment showed a clear indication of providing more habitat variation for forest floor avian communities than other forest conditions. In this compartment, the teak trees were relatively young, low and mixed with agricultural plants between trees. A small part of the compartment consisted of riparian/gallery forest at a relatively old age and higher strata, thus, providing a variety of vegetation in the area for avian communities. The conventional teak forest plantation of ten years old created two layers of strata, resulting from different individual growth within the compartment (Figure 2). Whereas, at the same age, the clonal teak did not perform differently from the conventional teak. The clonal teak only produced one stratum with relatively similar vegetation characteristics. The old-growth teak plantation provided a natural condition and showed the tallest single layers, among others. The habitat characteristic comparison showed that all factors are significantly different among forest types, except for temperature and canopy cover (Table 2).

Avian communities

During the observation, 23 bird species were found inhabiting the forest floor, consisting of one species of carnivorous, one species of frugivorous, two species of granivorous, nine species of insectivorous, two species of nectarivorous and eight species of omnivorous (Figure 3). In which insectivorous, nectarivorous and omnivorous were observed in all forest types, however the guilds were not equally distributed among the compartments. Table 1 shows the diet of each species found in each habitat types.

Insectivorous birds were shown to be the primary user of the teak forest floor in all compartments except clonal teak plantation. Encounter rates for insectivorous in all sites

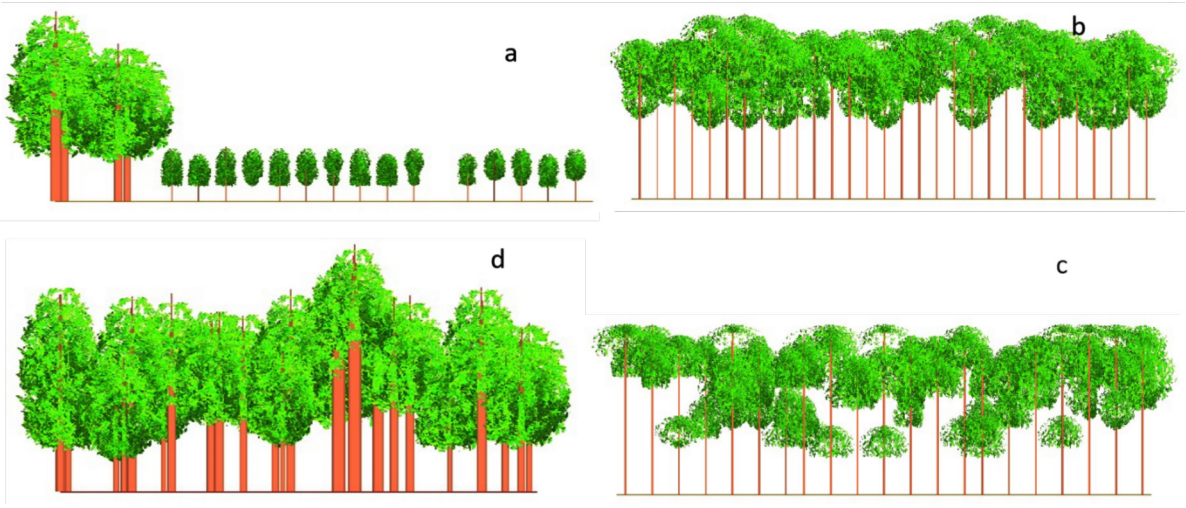

Figure 2 Vertical characteristics of trees in each teak stand: agroforest (a) conventional (b) clonal teak plantation (c) and old-growth (d)

Table 1 Diet of avian species found in teak forest plantation of Cepu, Central Java

Species		Insect	Caterpillar	Grains	Ant	Spider	Small fruit	Beetle	Lizard	Grass	Larva	Frog	Insect eggs	Grasshopper	Tiger's claw nectar	Epiphyte nectar	Invertebrates	Smaller bird	Hemiptera	Molluscs	Scorpion	Termite	Worms	Moth	Crab	Fish	Tiger's claw fruit	Papaya fruit	Banana fruit	Noni fruit	Ficus fruit	Plant shoots
Carnivorous																															
Wooly-necked stork	*Ciconia episcopus*	v										v								v						v					
Frugivorous																															
Island collared dove	*Streptopelia bitorquata*			v						v																					
Granivorous																															
Scaly-breasted munia	*Lonchura punctulata*			v						v																					
Zebra dove	*Geopelia striata*	v		v																											
Insectivorous																															
Lesser coucal	*Centropus bengalensis*	v	v			v								v																	
Greater coucal	*Centropus sinensis*		v					v	v			v		v					v												
Savanna nightjar	*Caprimulgus affinis*	v			v																	v		v							
Fulvous-breasted woodpecker	*Dendrocopos macei*	v			v						v										v										
Common tailorbird	*Orthotomus sutorius*	v	v					v			v		v																		
Chesnut-breasted malkoha	*Rhamphococcyx curvirostris*	v	v		v				v									v							v						
Horsfield's babbler	*Malacocincla sepiarium*	*v*																													
Small minivet	*Pericrocotus cinnamomeus*	v	v			v					v																				
Fulvous-chested jungle flycatcher	*Rhinomyias olivacea*	v																													
Nectarivorous																															
Olive-backed sunbird	*Cinnyris jugularis*	v				v									v	v												v		v	

Table 1 Continued

Species		Insect	Caterpillar	Grains	Ant	Spider	Small fruit	Beetle	Lizard	Grass	Larva	Frog	Insect eggs	Grasshopper	Tiger's claw nectar	Epiphyte nectar	Invertebrates	Smaller bird	Hemiptera	Molluscs	Scorpion	Termite	Worms	Moth	Crab	Fish	Tiger's claw fruit	Papaya fruit	Banana fruit	Noni fruit	Ficus fruit	Plant shoots
Streaky-breasted spiderhunter	*Arachnothera affinis*	v				v									v																	
Omnivorous																																
Green junglefowl	*Gallus varius*	*v*		v			v			v																						
Scarlet-headed flowerpecker	*Dicaeum trochileum*	*v*		v																												
Collared kingfisher	*Halcyon chloris*	*v*	v						v			v											v									
Common Iora	*Aegithina tiphia*		v	v	v	v		v					v																			
Black-headed bulbul	*Pycnonotus atriceps*	v			v		v																								v	
Sooty-headed bulbul	*Pycnonotus aurigaster*	v					v																									
Barred button-quail	*Turnix suscitator*			v													v															v
Common myna	*Acridotheres tristis*	v																									v		v			
Number of species	23	18	7	7	5	5	3	3	3	3	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

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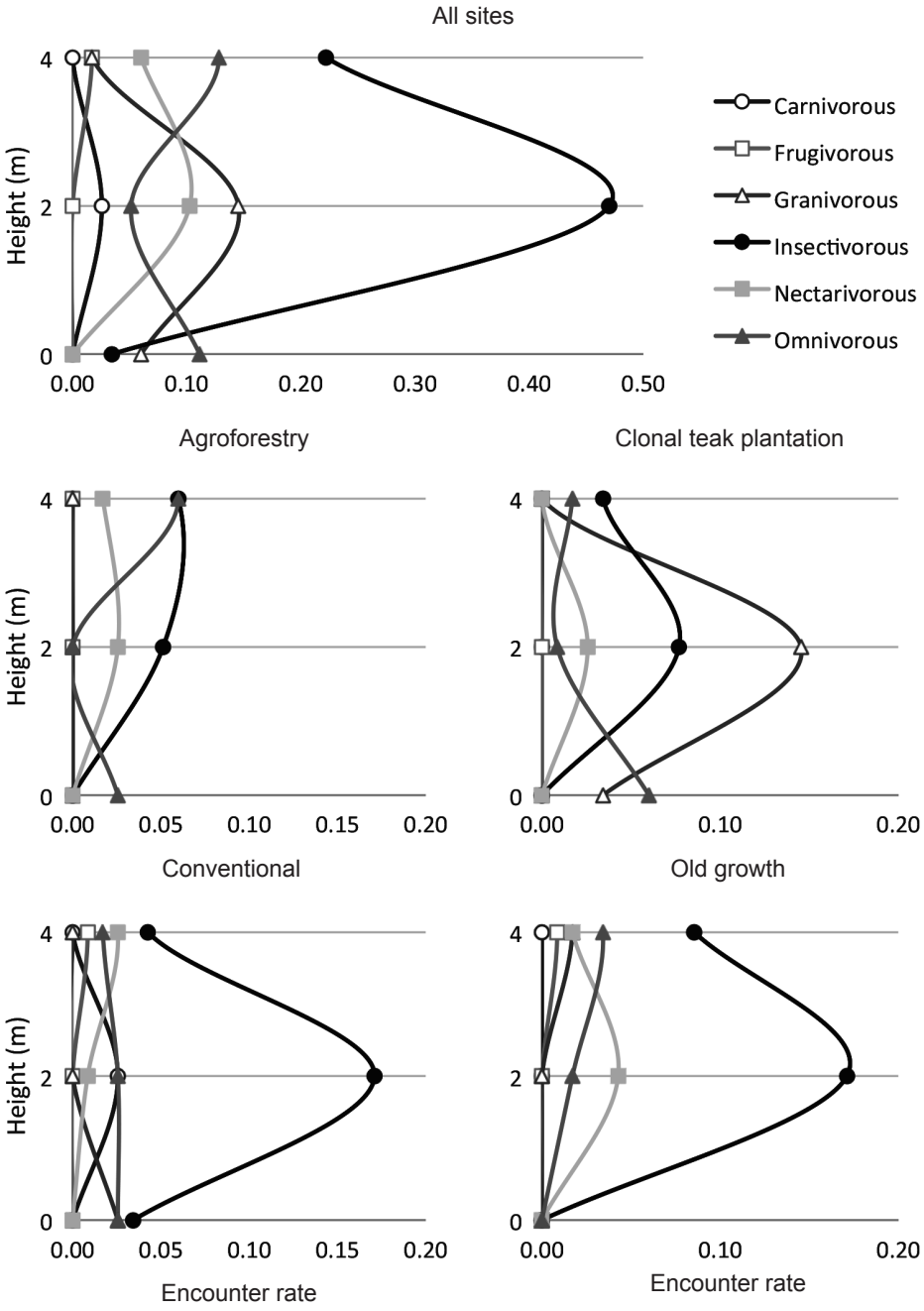

Figure 3 Encounter rates of each guild in different compartment in teak forest plantation

Table 2 Group comparison on habitat characteristics in each compartment

No	Variable	Group comparison test method	Significance
1	Temperature	One way ANOVA	0.17
2	Humidity	One way ANOVA	1.88e-06 ***
3	Vegetation density 0–30 cm	Kruskal-wallis	0.0002735***
4	Vegetation density 30–100 cm	Kruskal-wallis	0.001149**
5	Vegetation density 100–200 cm	Kruskal-wallis	0.002044**
6	Vegetation density 200–300 cm	Kruskal-wallis	0.0001571***
7	Crown cover	Kruskal-wallis	0.3396
8	Ground cover	Kruskal-wallis	0.02544*

* = significant, ** = highly significant, *** = very highly significant

(agroforestry, traditional teak, clonal teak plantation) were parabolic with the peak of encounter rate at 0–2 m height (Figure 3). Although showing a similar trend, the insectivorous species did not reach the highest encounter rate in clonal teak plantation compartment at 2–4 m, but granivorous did. A similar pattern was observed for agroforest compartment, showing higher encounter rate at 2–4 m and gradually lowering at 0–2 m and 0 m. Although encounter rates for nectarivorous and omnivorous were not high at all height levels, these species were found in all compartments (Figure 4).

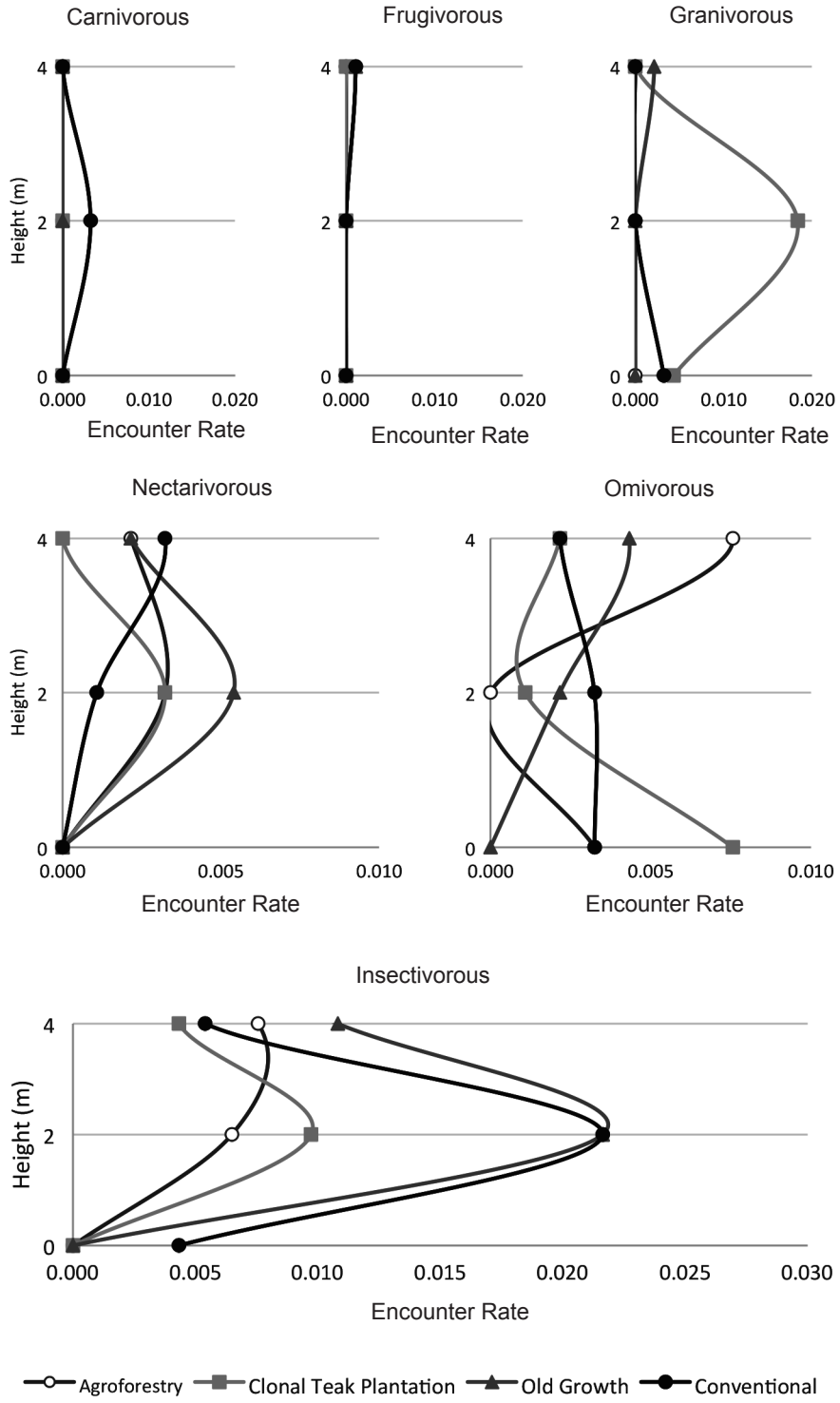

Figure 4 Encounter rate of each bird guilds at different high stratum and silvicultural treatment in teak forest plantation

DISCUSSION

As the primary goal of teak plantation in Java is producing high-quality timber product, it requires individual quality of the trees and does not necessarily need high-quality ecosystem services, including habitat for birds. The presence of bird species, as results of ecosystem product, has not been examined at the smallest scale of the plantation, particularly at compartment level, as well as at forest floor or understory. Although there were less number of species than findings from Pudyatmoko (2008), the study confirmed that teak plantation in Java holds essential roles for avian biodiversity. The teak plantation is a prominent picture of a forest in Java, and this study was the first to investigate the roles of different teak forest conditions for avian community inhabitation in the forest floor. The findings enhanced the insight into functional ecology of the avian community under various silvicultural practices of a teak plantation in Java.

The silvicultural practices in teak plantation play critical roles in creating vegetation layers which contribute to avian species composition in the forest floor. Although it starts with agroforestry system, further silvicultural practices including pruning and thinning have profound effect on the stratum development in teak forest. It was expected that old-growth teak plantation would have more stratum than other forest conditions, but the findings showed that old-grown teak has only one layer. Thinning has particular roles in selecting individual teak trees which are less productive and have a bad shape (Budiadi et al. 2017). Therefore, only conventional teak and agroforestry performed more than one vegetation strata. The conventional teak and agroforestry plantation performed dual-strata during observation, but when it comes to thinning periods, the strata might be similar to clonal teak compartment. Similar results were seen in old-growth teak plantation, with thinning performed in the past, resulting in a current single stratum. Also, habitat conditions for all forest conditions were different, representing the effect of vegetation for avian habitation.

Findings of this study showed that in the context of avian biodiversity, teak forest plantation played essential roles as refuge area for many bird species. However, observation of the composition of the understory community showed that the clonal teak plantation did not provide suitable habitat for forest species. Among other forest types, the clonal teak plantation is a product of genetic improvement, resulting in high cumulative wood production. The fast-growing tree characteristics of the clonal teak plantation lead to canopy closure competition which can reach 13% higher than conventional teak plantation (Budiadi et al. 2017, Suryatmojo & Imron 2018). During observation, it was found that the canopy was dense with limited light penetration to the forest floor. The high canopy closure has caused significant departure on the hydrological properties, notably the canopy interception plantation (Suryatmojo & Imron 2018). The current study showed that granivorous had the highest encounter rates in this plantation, departing from other forest types. The presence of an agricultural area, dominated by paddy field, supported the evidence. Therefore, role of surrounding landscape for avian community should be understood to complement the results of this study. Also, since the clonal plantation has a shorter rotation (less than 30 years), a precautionary effort should be emphasised for managing the clonal, as younger rotation tends to provide less diverse bird species (Riffell et al. 2011).

The response of avian communities to old-growth teak and conventional teak were similar in the study. Thinning and pruning, as silvicultural treatments, contributed in shaping vegetation stratum and affected the avian assemblages and behavior (Kalies et al. 2010). Similarity between conventional (10 years old) teak and old-grown teak shows evidence that old growth teak plantation did not support habitat of fauna during a particular time of the year (Harikrishnan et al. 2012). Furthermore, there was no visual difference between teak forest plantation and gallery forest or riparian strip forest in the study area, except for old-growth teak forest, because those strip ecosystems were also planted with teak. Maintaining floristic diversity within gallery forest or riparian strip forest contributes significantly to bird diversity, playing a role as stepping stone or corridor for birds (Hawes et al. 2008, Seaman and Schulze 2010). Forest plantation, however, could not mimic biophysical factors of understory in natural vegetation (Aubin et al. 2008). Therefore, silvicultural intervention on teak forest plantation may be done through increasing species diversity of plants within the riparian.

The findings highlight and support the importance of height heterogeneity for avian communities (Huang et al. 2014). Among three strata within understory, each guilds response differently. For examples, at the height of 0–2 m, most of the guilds showed highest encounter rates than 4 and 0 m. Understory communities play essential roles and are potentially used as indicators for sustainable forestry. Keeping the original condition of understory vegetation community is vital to maintaining the ecological function of understorey (Lencinas et al. 2011). However, caution should be emphasised during harvesting periods because Perum Perhutani implements clear cutting, involving forest floor cleaning and killing of trees before cutting, for wood quality improvement. The good news is that the clear-cutting is only applied at a compartment level, which is relatively small with an average of 50 ha. Maintaining understory vegetation, surrounding the harvested compartment including gallery forest, will provide a refuge area for the birds (Hawes et al. 2008).

Intervention for habitat improvement can be done through the addition of vegetation species to the forest floor, applied through agroforestry system using local native species (Michon et al. 1986, Imron and Djuwantoko 2003, Bali et al. 2007, Harvey and Villalobos 2007, Graham et al. 2014). Also, increasing vegetation variation can be applied to a gallery or riparian forest, mainly using soil-water conservation vegetation such as bamboo and legume, which also invite predators (Lorica and Heaney 2013, Kalle et al. 2014). Although the study had limited silvicultural treatments, understanding the landscape context provides insight into meta-population (Imron and Djuwantoko 2003, Imron et al. 2011, Riffell et al. 2011).

CONCLUSIONS

Teak plantation acted as a refuge for understory bird communities such as insectivorous, granivorous, frugivorous, omnivorous, nectarivorous and few carnivorous, where insectivorous was the highest. However, surrounding landscape conditions provided additional resources for the avian communities rather than only conditions within the compartment. Further improvement of habitat involving surrounding conditions of a compartment, including riparian, is needed for supporting avian biodiversity conservation in the teak plantation.

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