BIODIVERSITAS
Volume 19, Number 1, January 2018
Pages: 134-139

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d190120

Vertical stratification of bird community in Cikepuh Wildlife Reserve, West Java, Indonesia

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Manuscript received: 1 October 2017. Revision accepted: 16 December 2017.

Abstract. *Dinanti RV, Winarni NL, Supriatna J. 2018. Vertical stratification of bird community in Cikepuh Wildlife Reserve, West Java, Indonesia. Biodiversitas 19: 134-139.* The complexity of heterogeneous strata can be used to determine the distribution of resources in bird communities. However, deforestation causes damage and may disturb the bird community in the forest. Cikepuh Wildlife Reserve in West Java, Indonesia is an example of degraded forest due to deforestation. Illegal logging in the area leads to approximately 7000 hectares of forest conversion into a plantation area. This study was conducted to test the hypothesis of the differences in the diversity of birds in each stratum of vegetation and the differences in the diversity of birds in forest and plantation. The study was conducted in March 2016. Point count method was used for bird surveys. The calculation of Shannon-Wiener diversity index showed that forest had a higher diversity of birds (H′ = 3.09) than plantation (H′ = 2.78). Based on the rank abundance graph, each vegetation stratum had a different type of curve. The middle canopy layer had the highest bird abundance while the emergent and understory layers had the lowest abundance.

Keywords: Bird community, Cikepuh, diversity, stratification

INTRODUCTION

Tropical forests have layers of canopy known as vertical stratification which provide microhabitat and resources for fauna, including birds (Pearson 1971; Whitehurst et al. 2013). In general, forests that have heterogeneous strata harbor high diversity of bird species. The complexity of heterogeneous strata can also be used to determine the distribution of resources in the bird community. A bird community spreads vertically with the unique composition in each stratum. Preference for a stratum can be the main factor which separates the feeding type in birds. For example, frugivorous birds often occupy the middle canopy because this layer has high diversity of fruits (Parker and Brown 2000).

According to Soerianegara and Indrawan (2005), canopy in tropical rainforests has several strata as follows: (i) emergent layer which is the top layer, consisting of trees with a height of more than 30 m and usually have discontinuous crown, tall and straight trunks and branch-free trunks. (ii) upper canopy consists of trees that are 20-30 m tall with continuous crown, and tree trunks that are usually much branched. Tree species of this stratum require less light. (iii) middle canopy is filled by trees that are 4-20 m high, having continuous crown. The trees in this stratum are low, small and heavily branched. (iv) understorey is commonly referred to as a layer of shrubs, 1 to 4 m high. This stratum is also formed by young tree species or in the seedling phase, small palms, large herbs, and large ferns. (v) Ground layer is a layer of vegetation covering the ground with height from 0 to1 m, generally dominated by tree seedlings and herbs. Saplings and seedlings have their own characteristics on the needs of light. Some can grow under the shade of the parent trees, some can grow if they get enough light.

Birds that live in the forest are highly dependent on the condition of forest vegetation, but deforestation damages and disturbs the bird community in it. According to Forest Watch Indonesia (2015), the rate of deforestation in Indonesia reaches 1.3 million hectares each year. Illegal logging, forest fires and illegal pouching have changed the forest ecosystems. Such deforestation also occurred in Cikepuh Wildlife Reserve in Sukabumi, West Java, an important habitat for Green turtle. Deforestation in Cikepuh Wildlife Reserve occurred at the beginning of 1999. Illegal logging has changed the forest into plantation area (Polosakan 2010; Ministry of Environment 2015).Understanding bird stratification may support conservation management of protected areas. Research on bird stratification is required to support conservation area management (Acharya and Vijaryan 2017). Understanding habitat and the relationship of the birds provides insights on habitat use, which ultimately aids the conservation of species. Because of this importance, this research was conducted to see the effect of vertical stratification on bird communities in Cikepuh Wildlife Reserve, specifically to determine (i) the differences in bird abundance and diversity among strata of vegetation (ii) the differences between bird communities in forest and plantation areas and the types of feeding guilds among strata of vegetation.

MATERIALS AND METHODS

Study area

The research was conducted in Cikepuh Wildlife Reserve, Sukabumi, West Java, Indonesia in March 2016 (Figure 1). Cikepuh Wildlife Reserve has suffered from continuous deforestation which occurred at the beginning of 1999 that changed the forest into plantation area (Polosakan 2010; Ministry of Environment 2015). The general topographic condition of the area is heterogeneous, from flat to hilly and steep slopes. The average annual rainfall was 3400 mm (Polosakan 2010) and the climate was categorized as climate B in Oldeman classification, meaning that the area has 7-9 of consecutive rainy months. The area consists of secondary forest composed of Indian rosewood (*Dalbergia latifolia*), fig tree (*Ficus variegata*), burflower-tree (*Neolamarckia cadamba*) and teak plantation. The area is surrounded by coconut plantation, paddy fields, and villages. The study was carried out at both the forest and the coconut plantation (Figure 2). We set up 3 transects in the secondary forest area, while 3 other transects were located in the plantation area. The length of each transect was approximately 1.2 km with 6 count points on each transect. The distance between each transect was 500 m, while the distance between the points was 200 m (Figure 3) (Bibby et al. 2000).

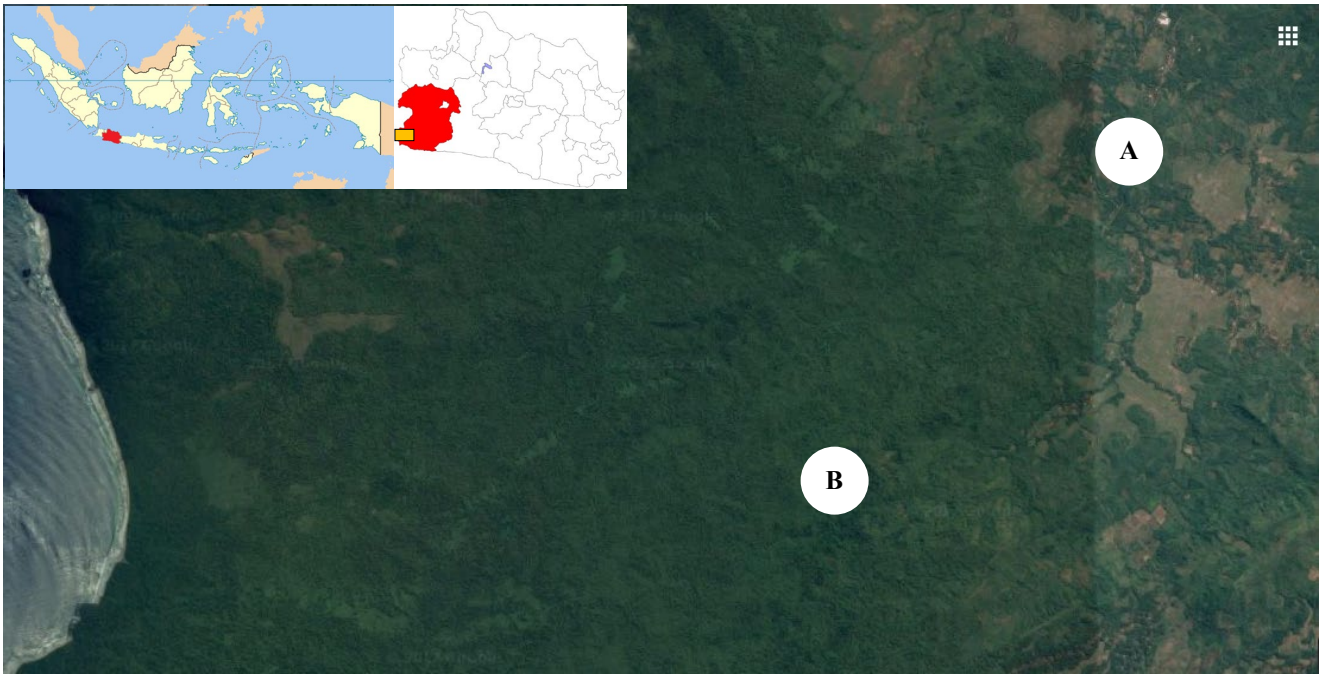

Figure 1. Map of Cikepuh Wildlife Reserve, West Java, Indonesia. A. Coconut and teak plantation, B. Secondary forest

Figure 2. Survey location in Cikepuh Wildlife Reserve, West Java, Indonesia. A. Coconut plantation, B. Teak plantation, C. Secondary forest

The procedures

Point count method was used to survey the bird abundance and diversity. This method was performed by standing at a point for 10 minutes and recording the birds around the point including species, number of individuals, and height of birds (Bibby et al. 2000). Bird detection was done by audio or visually. Whenever needed, bird calls were recorded and Xeno-canto website (http://www.xeno-canto.org/) was used to identify the bird calls. The bird observation started at 6 a.m and ended at 10 a.m, and at least 3 times replications were carried out in each point.

Data analyses

The diversity of birds in each location and stratification was calculated using Shannon-Wiener (H') diversity index (Bibi & Ali. 2013). Simpsons dominance index (D) was calculated to see the dominance of bird community at each stratum (Singh et al. 2013). The Margalef Index was used to identify species richness in different strata of vegetation (Margalef 1958). Bird abundance at each location and strata was also analyzed visually using rank abundance curve (Figure 4). This analysis changes the number of individuals (pi) of each species to log 10 (pi) (Magurran 2004).

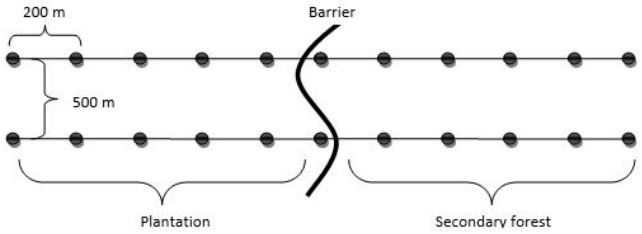

Figure 3. Illustration of point count method in Cikepuh Wildlife Reserve, West Java, Indonesia

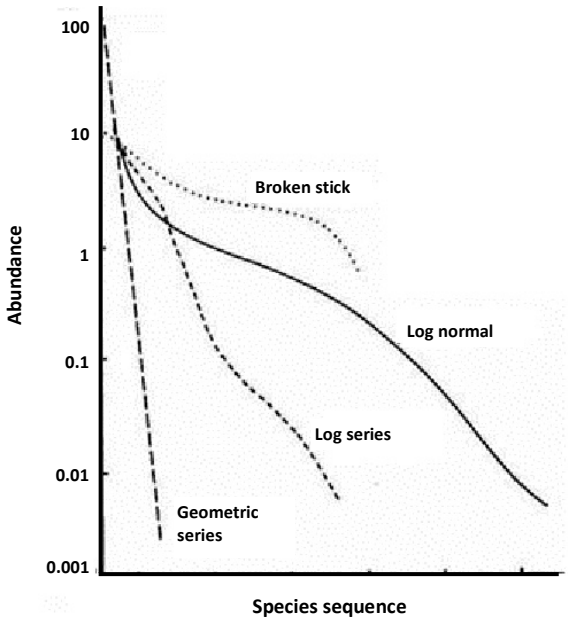

Figure 4. Graph model of rank abundance curve

Shannon Wiener Diversity

$$H' = - \Sigma \, pi \ln pi$$

$$pi = ni / N$$

with,
H' = value of Shannon-Wiener diversity index
pi = proportion of species *i*
ni = number of individual species *i*
N = number of species in community

Simpsons Dominance Index

$$D = \Sigma \frac{ni}{N} \, x \, 100$$

With,
D = value of Simpsons Dominance Index
ni = number of individual species i
N = number of species in community

Margalef Index

$$R = (S-1)/(\ln N)$$

With,
R = value of Margalef Index
S = number of species
N = number of individual

RESULTS AND DISCUSSION

During the study, 1386 bird individuals were recorded, belonging to 27 families and 61 species. The number of species encountered in the forest was 51, while in the plantation area was 44. The bird with the highest abundance in both forest and plantation was Sooty-headed Bulbul (*Pycnonotus aurigaster*). In term of vegetation strata, the layer with the highest diversity and species richness was the middle canopy. Middle canopy is a layer of forest with various vegetations which support animal use of this layer (Table 1) (Pearson 1971; Parker and Brown 2000; Khakim et al. 2015).

The lowest species diversity and richness were found at the ground layer. Only 2 species were found at the ground layer of the forest which were terrestrial birds, namely Banded Pitta (*Pitta guajana*) and Red Junglefowl (*Gallus gallus*), whereas Banded Pitta (*Pitta guajana*) and Javan Munia (*Lonchura leucogastroides*) were found at the ground layer of the plantation. The low diversity in the lower and uppermost stratification is influenced by the availability of food and environmental conditions. The ground layer in Cikepuh was quite dry which might be a further limiting factor for birds (Polosakan 2010).

Table 1. Species richness and diversity based on vegetation strata in Cikepuh Wildlife Reserve, West Java, Indonesia

Layer	Number of Species		SRI (Margalef)		SDI (Shannon-Wiener)	
	Forest	Plantation	Forest	Plantation	Forest	Plantation
Ground layer	2	2	0.4	0.4	0.4	0.7
Understorey layer	15	18	3.3	3.4	2.4	1.9
Middle canopy	36	27	6.1	4.3	2.6	2.3
Upper canopy	23	23	4.6	4.6	2.6	2.5
Emergent layer	4	4	0.7	0.6	0.8	0.5
Total	51	44	7.8	6.4	3.1	2.8

The uppermost stratum or emergent layer in Cikepuh area was not available because the trees were small, which gave less support for the bird community. The presence of secondary forest trees such as *Macaranga* sp., *Mallotus* sp. and several species of the family Moraceae were an indicator that forest destruction had occurred in Cikepuh reserve area (Polosakan 2010, Slik et al. 2003). Tall trees in this forest were very rare and the bird species that could be found in this layer were generally Cave Swiflet (*Collocalia linchi*) and Crested Serpent Eagle (*Spilornis cheela*).

The patterns of community stratification for forest and plantation areas are of the log normal type (Figure 5). Although both have the same type, there are still differences in gradient and curve length. Forested areas have gentler sloping and longer graphs than plantation areas. The gradient of the graph describes the species evenness, while the length of the graph describes the species richness. Forest areas with gentler and longer graphs mean that species evenness in the forest was higher and there was no significant dominant species (Chmel et al. 2016).

The curves of rank abundance in forest understorey, middle canopy and upper canopy, decline quite slowly and equally (Figure 6 left). It explains that forest area had higher species evenness. The presence of rare species in forest was also smaller than in plantation area. The curves of rank abundance in plantation understorey, middle canopy and upper canopy have steeper slope and sharply decline (Figure 6 right). From points 3 until 9 in plantation area there are significant differences in the decline of the curve. It means that the evenness was smaller than in forest area because there were more dominant species in plantation. The curves of ground layer and emergent cannot be explained clearly because the level of species encounter was smaller.

The species that dominated the forest ground layer was Banded Pitta (*Pitta guajana*) (Table 2). This species can be found in primary or secondary forest areas especially near the water stream with forest floor covered by leaf litter (Rheindt and Eaton 2010). The plantation ground layer was dominated by Javan Munia (*Lonchura leucogastroides*). This species is one of the seed-eater birds, so the paddy field near coconut plantation was the main food source for Javan Munia. The forest understorey was dominated by Lesser Coucal (*Centropus bengalensis*) and Horsfield's Babbler (*Malacocincal sepiarium*), while the plantatation understorey was dominated by Lesser Coucal (*Centropus*

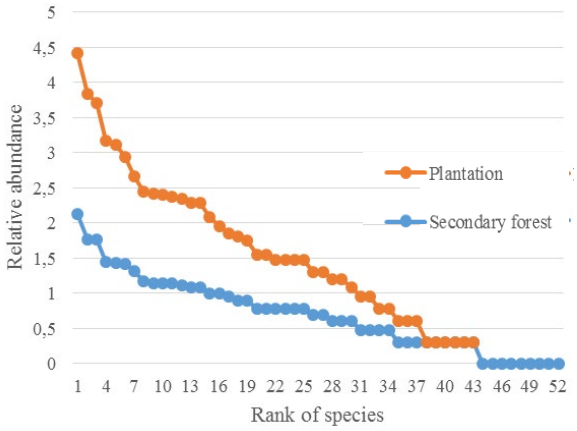

Figure 5. Rank of abundance plots of bird community in Cikepuh Wildlife Reserve, West Java, Indonesia

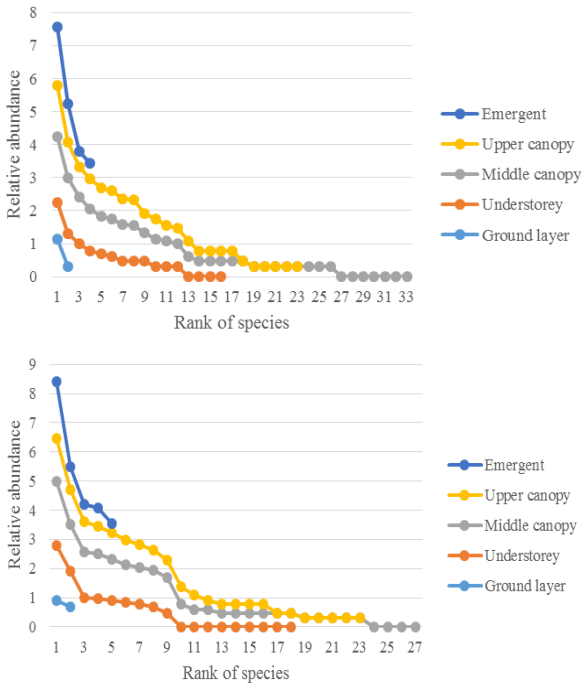

Figure 6. Rank of abundance plots of bird community on forest (*above*) and plantation (*bottom*) in Cikepuh Wildlife Reserve, West Java, Indonesia

Table 2. Dominant species in each layer of Cikepuh Wildlife Reserve, West Java, Indonesia

Secondary forest			Plantation		
Layer	**Species**	**Df (%)**	**Layer**	**Species**	**Df (%)**
Ground layer	*Pitta guajana*	87.5	Ground layer	*Lonchura leucogastroides*	61.5
	Gallus gallus	12.5		*Pitta gujana*	38.5
Understorey	*Centropus bengalensis*	19.4	Understorey	*Lonchura punctulata*	51.3
	Malacocincla sepiarium	14.9		*Centropus bengalensis*	10.7
Middle canopy	*Pycnonotus aurigaster*	30.1	Middle canopy	*Pycnonotus aurigaster*	39.3
	Dicaeum trochileum	16.2		*Nectarinia jugularis*	9.1
Upper canopy	*Pycnonotus aurigaster*	30.3	Upper canopy	*Pycnonotus aurigaster*	25.2
	Pycnonotus goiavier	9.8		*Streptopelia chinensis*	12.6
Emergent	*Collocalia linchi*	74.3	Emergent	*Collocalia linchi*	84.6
	Hemiprocne longipenis	17.9		*Acridotheres javanicus*	5.7

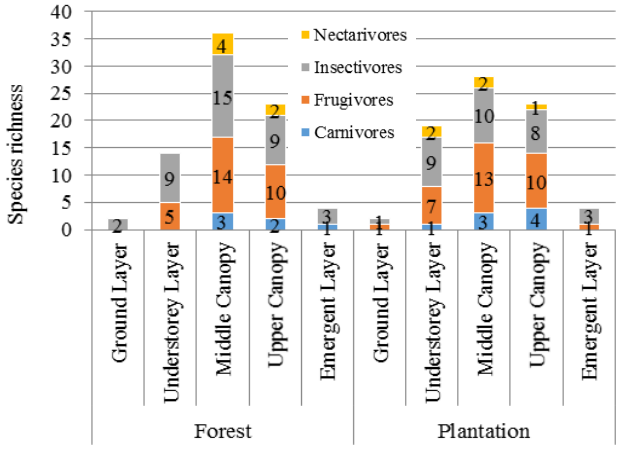

Figure 7. Species richness based on feeding guilds on each layer of Cikepuh Wildlife Reserve, West Java, Indonesia

bengalensis) and Spotted Munia (*Lonchura punctulata*). Horsfield Babbler (*Malacocincla sepiarium*) was not found in the plantation because the plantation understorey had lower diversity than the forest understorey. Cave Swiflet (*Collocalia linchi*) dominated the emergent layer. This species belongs to the Apodidae family which has very small feet, so it rarely perches except when it is in its nest. The emergent layer becomes the most suitable layer due to the abundance of insects as a food source and the lack of branches that can disrupt the movement of this species (Wisnubudi 2009; Manchi and Sankaran 2010).

Sooty-headed Bulbul (*Pycnonotus aurigaster*) was the dominant species at the middle canopy and upper canopy (Table 2). Although according to IUCN (2016) data, Sooty-headed Bulbul population decreased, in some areas it is still dominant. IUCN considers an overall population estimate for countries or worldwide, but the abundance of local habitats can support a large number of this spcies, as shown in this study; it even had the highest values among all species. This dominance is probably due to Sooty-headed Bulbul's preference for open secondary forest areas rather than closed forest areas (Van Balen et al. 1986). In addition, this research was conducted during the fruiting season so that Sooty-headed Bulbul as one of frugivore species was more easily observed.

Based on the data obtained, each stratum had a group of birds pertaining to different feeding guilds (Figure 7). Feeding guilds represent a group of species that utilize a common trophic resource (O'Connell et al. 2000). Among the recorded species, 3 species were nectarivores, 5 species carnivores, 21 species frugivores and 34 species insectivores. Insectivores and frugivores were the most common guild in the Cikepuh Wildlife Reserve. Both guilds were more concentrated in the understorey and canopy. The canopy layer was the densest stratum. The presence of insects in the foliage and fruit on the branches of trees influences the number of frugivore and insectivore bird's activity in the canopy. In addition, at the time of the study many trees were in fruiting time so that the frugivore birds were more easily observed. This is in accordance with the results of Chmel et al. research (2016) which stated that insectivores and frugivore were abundant in the thick vegetation strata.

In conclusion, forest area of Cikepuh Wildlife Reserve had a higher species richness (51 species) than the plantation area (44 species). Each layer of vegetation also had different bird species composition. The stratum with the highest abundance was found in the middle canopy, presumably because this layer provides various resources required by various species. Emergent and ground layers had the lowest abundance because the Cikepuh Wildlife Reserve had experienced deforestation and forest fires that reduced the abundance of of tall trees and short plants. The guild types of insectivore and frugivore dominated the understorey and canopy. This is likely because of the abundant insects and fruit in that layer.

ACKNOWLEDGEMENTS

We thank Universitas Indonesia which gave PITTA Grant for this research. We are also grateful to Dimas Haryo Pradana, Endah Septi Fauzi, Sandy Leo, Destario Metusala, Nur Avifah, Rifqa Kahirunnisa, Muhammad Suherman and Mang Duyeh who helped us to carry out this study.

REFERENCES

Acharya BK, Vijayan L. 2017. Vertical stratification of birds in different vegetation types along an elevation gradient in the Eastern Himalaya, India. Ornithol Soc Japan 16: 131-140.

Bibby CM, Jones, Marsden S. 2000. Expedition field techniques: Bird survey. BirdLife International, Cambridge.

Bibi F, Ali Z. 2013. Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. J Anim Plant Sci 23 (2): 469-474.

Birdlife International. 2016. Pycnonotus aurigaster. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22712699A94343785.en. [accessed 20 May 2017].

Chmel K, Riegert J, Paul L, Novotny V. 2016. Vertical stratification of an avian community in New Guinean tropical rainforest. Popul Ecol 58: 535-547.

Forest Watch Indonesia. 2015. Intip Hutan. Bogor, Indonesia.

Khakim, MFR., Mardiastuti A, Iskandar E. 2015. Pattern of vertical space utilization and daily exploration of Sumatran Orangutan (*Pongo abelii*, Lesson 1827) in west block of Batang Toru forest, North Sumatera. Media Konservasi 20 (2): 125-131.

Magurran AE. 2004. Measuring Biological Diversity. Blackwell Publishing, Victoria.

Manchi SS, Sankaran R. 2010. Foraging habits and habitat use by edible nest and glossy swiftlet in the andaman island, India. Wilson J Ornithol 122 (2): 259-272.

Margalef R. 1958. Information Theory in Ecology. Gen Syst 3: 36-71.

Ministry of Environment. 2015. Illegal logging Cikepuh Wildlife Reserve Sukabumi. Ministry of Environment, Jakarta. http://www.menlh.go.id/kasus-perambahan-forest-suakamargasatwa-cikepuh-kabupaten-sukabumi/. [accessed 15 March 2017].

O'Connell TJ, Jackson LE, Brook RP. 2000. Bird guilds as indicators of ecological conditions in the Central Appalachians. Ecol Appl 10 (6): 1706-1721.

Parker GG, Brown MJ. 2000. Forest canopy stratification-is it useful ?. Amer Nat 155 (4): 473-484.

Pearson DL. 1971. Vertical stratification of birds in a tropical dry forest. Condor 73: 46-55.

Polosakan R. 2010. Composition of type and structure of forest vegetation in Cikepuh Wildlife Reserve, Sukabumi, West Java. Jurnal Teknik Lingkungan 11 (2): 147-155.

Rheindt FE., Eaton JA. 2010. Biological species limits in the Banded Pitta, *Pitta guajana*. Forktail 26: 86-91.

Singh, R., Kour DN, Ahmad F & Sahi DN. 2013 Species diversity, relative abundance and habitat of bird communities od=f Tehsil Chenani, Distric Udhampur, Jamu and Khasmir, India. Indian Journal of Life Science 2 (2): 81-90.

Slik JWF, Kebler PJA, Welsen PCV. 2003. *Macaranga* and *Mallotus* species (Euphorbiaceae) as indicators for disturbance in the mixed lowland dipterocarp forest of East Kalimantan (Indonesia). Ecol Indicat 2: 311-324.

Soerianegara I, Indrawan A. 2005. Forest Ecosystem in Indonesia. Forest Ecology Laboratory, Bogor Agricultural University, Bogor.

Van Balen S, Hernowo JB, Mulyani YA, Putro HR. 1986. The Birds of Darmaga. Media Konservasi 1 (2): 1-5.

Whitehurst AS, Swatantran A, Blair JB, Hofton MA, Dubayah R. 2013. Characterization of canopy layering in forested ecosystems using Full Waveform Lidar. Rem Sens 5: 2014-2036.

Wisnubudi G. 2009. The use of vegetation strata by the birds in the tourist area of National Parks Halimun-Salak Mountain. Vis Vitalis. 2: 41-49.