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The diversity of diurnal bird species on western slope of Mount Lawu, Java, Indonesia

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Abstract. *Krisanti AA, Choirunnafi' A, Septiana NO, Pratama FW, Amelia F, Manjaswari A, Septiningtyas PA, Wati AS, Satria JY, Ani IL, Wibowo T, Sugiyarto. 2017. The diversity of diurnal bird species on western slope of Mount Lawu, Java, Indonesia. Biodiversitas 18: 1077-1083.* Mount Lawu is one of the highest inactive volcanoes in Java Island, Indonesia. Mount Lawu attracts people to cultivate its area for agriculture, but without proper management, the biodiversity in Mount Lawu is in threat. This research aimed to get information about diurnal bird diversity on the western slope of Mount Lawu which includes a forest area (FA), an agroforestry area (AA), and a residential area (RA). Data collection was performed through point count method in 5 to 6 point per sites within certain time intervals after dawn and before sunset. There were 61 bird species from 26 families with a total number of 1416 birds being observed. The diversity index of the western slope was 2.480, and the highest H_{max} among observed areas was the forest area (3.714). *Collocalia linchi* (D_i 37.92) and *Pycnonotus aurigaster* (D_i 19.42) were very common almost in all observation areas. The most similar ecosystem was FA and AA (J 0.176), followed by AA and RA (J 0.24), and FA and RA (J 0.393). A better management of Mount Lawu is necessary to improve human and biodiversity wellness. The result of this study could be used as additional data to consider a stronger protection for the biodiversity in Mount Lawu.

Keywords: Birds, diurnal, diversity, Mount Lawu, Indonesia

INTRODUCTION

Birds are bioindicator for the environment because of their strong sensitivity to ecosystem changes. As bioindicator, birds presence could explain to what extent human activities have changed the habitat quality and how it affects biodiversity. In addition, birds have social, economic, and cultural functions such as for food, pet, and, source of folk songs and tales (Teixeira et al. 2014; Dandeniya et al. 2015; Iskandar and Iskandar 2015; Partasasmita et al. 2016), as shown in countries that hold dear their traditions such as Indonesia.

Indonesia as the top four countries with mega bird diversity has at least 1598 bird species constituting 17% of the total bird species in the world, and among that number, over 372 species are endemic to Indonesia (Sukmantoro et al. 2007). For centuries, birds have been the source of inspiration and happiness to Indonesian people because of its chirps and unique features. Bird is an environmental health indicator and holds many other diversity values (MacKinnon et al. 2010). Bird plays interrelationship role that depends on the environment, such as balancing the ecosystem through their feeding habits (Sekercioglu 2006), helping plant pollination (Sodhi et al. 2011)and seeds dispersion (Wenny et al. 2011). Moreover, a bird which could be found in almost all types of habitat has contributed to the richness of animal diversity in Indonesia. The presence of a certain species in a certain habitat is determined by how much the species prefers and depends on that particular habitat (Wisnu et al. 2014).

Mount Lawu (± 3265 meters above the sea level) is the third highest volcanic mount in Java Island and has been inactive since its last eruption in 1885 (Setyawan 2001). Mount Lawn which is located in Central Java province props up a unique ecosystem with fertile landscape. Mount Lawu's beautiful scenery, cool air, water abundance, and productive soil are attracting human population to settle down and develop infrastructures. However human activities around Mount Lawu unintentionally lead to the destruction of the natural ecosystem (Whitten and Soeriatmadja 1996). One solution to deal with the ecosystem destruction and diversity crisis is to expand the conservation area. However, wide terrestrial area for conservation purpose in Central Java province is obstructed by the limitation to create an arbitrary area in the conservation area network (Nijman and Sozer 1995).

The topography of Mount Lawu is exceptional in such a way that it can condense the wet South-East wind into rainfall. This condition made the southern side of Mount Lawu relatively fertile and grown with dense vegetation, even in the dry season. Mount Lawu is also a transition area of the dry area of East Java and the humid area of

West Java. Mount Lawn area has many flora and fauna species which could be found in East Java but not in West Java (Setyawan 2001). The western slope of Mount Lawu has typically three different habitats, which are the forest, the agroforestry area, and the residential area. This side of the mountain belongs to Karanganyar Regency that has at least 7.635 ha of forest area which consists of production forest (126 ha), protected forest (7.509 ha), and conservation forest (293 ha)**.**

The agroforestry areas on the western side of Mount Lawu were planted by monoculture vegetations such as pines *(Pinus* sp.*)*, rubber *(Hevea* sp.*)*, tea *(Camellia* sp.*)*, and vegetables**.** The total area of tea agroforestry on the western slope of Mount Lawu is approximately 1.051 ha. Varied vegetation type composing Mount Lawu biome causes a diversity in bird species. Vegetation in Mount Lawu is relatively stable because of the absence of volcanic activity for a long period, and there are still many sites in the area that have natural ecosystems. (Setyawan 2001). It will come as no surprise to document new records of f ora and fauna species in the future exploration. Mount Lawu still has an opportunity to become a whole conservation area. Periodical recordings are needed to renew our knowledge about the individual ecosystem. This research was done with the main objective to get information about diurnal bird diversity on the western slope of Mount Lawu which includes forest, residential, and agroforestry areas.

MATERIALS AND METHODS

The observation area was the western slope of Mount Lawu, Ngargoyoso sub-district, and its surrounding, Karanganyar Regency of Central Java, Indonesia. The western slope was composed of several types of habitat. We used three habitats as three representative terminals, i.e, the forest area (FA), the agroforest area (AA), and the residential area (RA). For the forest area, we observed two different forests namely Segorogunung Forest and Parangijo Forest. For the agroforest area, we observed three agroforestry systems, namely Kemuning tea agroforest, Kemuning rubber trees agroforest, and Ngargoyoso pine trees agroforest. For the residential area, we observed three villages, i.e., Segorogunung Village, Berjo Village, and Anggrasmanis Village (Figure 1). These sites lie on the western slope of Mount Lawu and have different elevations above the sea level (Table 1). We tried to uncover the richness of bird species on the western slope of Mount Lawu by observing each dominant above mentioned.

Bird surveys were conducted in June to August 20015 during the dry season. We used point count technique to carry out field surveys based on the sightings of birds during the first four hours after dawn (6.00-10.00 a.m.), and two hours before sunset (3.00-5.00 p.m.). We used three terminals with approximately 200m long tracks on each site. Two observers were walking along the tracks then stopped for about 5 to 10 minutes to count and identify or describe the sighted birds. We repeated our observation in another day to ensure the presence of certain bird species in certain sites.

We used binoculars (8x24 magnitude), tally sheets, camera, GPS instrument, smartphone, and other supporting tools for field survey. We collected data of bird which included species, the number of birds seen, bird's activities, time, and supporting description for unidentified species. MacKinnon (2010) identification book was used as the guide in identifying the bird species.

The collected data were analyzed using diversity index $(H' = -\Sigma P_i \ ln \ (P_i))$, maximum diversity value $(H_{max} = log(S))$, and evenness $(J = H'/H_{max})$ (Odum 1971). P_i is the proportion of species in a sample (habitat) of *S* species. *S* is the number of species present in the sample area (habitat) (Whittaker 1975). Also, the abundance index of species was calculated using formula$D_i = (n_i / N)100$, in which n_i represents the total number of species i and *N* indicate the total number of species found.

RESULTS AND DISCUSSION

Of a total of 1.416 individual observed, there were 61 bird species found and classified into 26 families. The total number of species on each terminal (FA, AA, and RA) was46, 35 and 22 species, respectively. Species found at all terminals were*Pycnonotus aurigaster* (Sooty-headed Bulbul),*Gallus varius* (Green Junglefowl), *Collocalia linchi* (Cave-Swiftlet), *Todirhamphus chloris* (Collared Kingfisher), *Streptopelia chinensis* (Spotted-Dove), *Cacomantis merulinus* (Plaintive Cuckoo), *Spilornis cheela* (Crested-serpent Eagle), *Halcyon cyanoventris* (Javan Kingfisher), *Pericrocotus cinnamomeus* (Small Minivet), *Lanius schach* (Long-tailed Shrike), *Megalaima haemacephala* (Coppersmith Barbet), *Cacomantis sepulcralis* (Rusty-breasted Cuckoo), and *Lonchura leucogastroides* (Javan Munia). Of all26 bird families, Sylviidae had more species than others, i.e., *Cettia vulcania, Megalurus palustris, Prinia familiaris, Prinia inornata, Orthotomus ruficeps, Orthotomus sutorius,* and *Phylloscopus borealis* (Figure 2).

Table 1. Geographical coordinates of the observation areas (forest, residential, and agroforestry)

Stations		Geographical position	Altitude (m asl)
FA	Segorogunung Parangijo	S 7°37'07.4" E 111°8'54.2"	1520
RA	Segorogunung Village Berjo Village Anggrasmanis Village	S 7°37'49.9" E 111°7'33.0"	2472
AA	KemuningTea Kemuning Rubber Ngargoyoso Pine	S 7°35'43.0" E 111°8'2.00"	2475

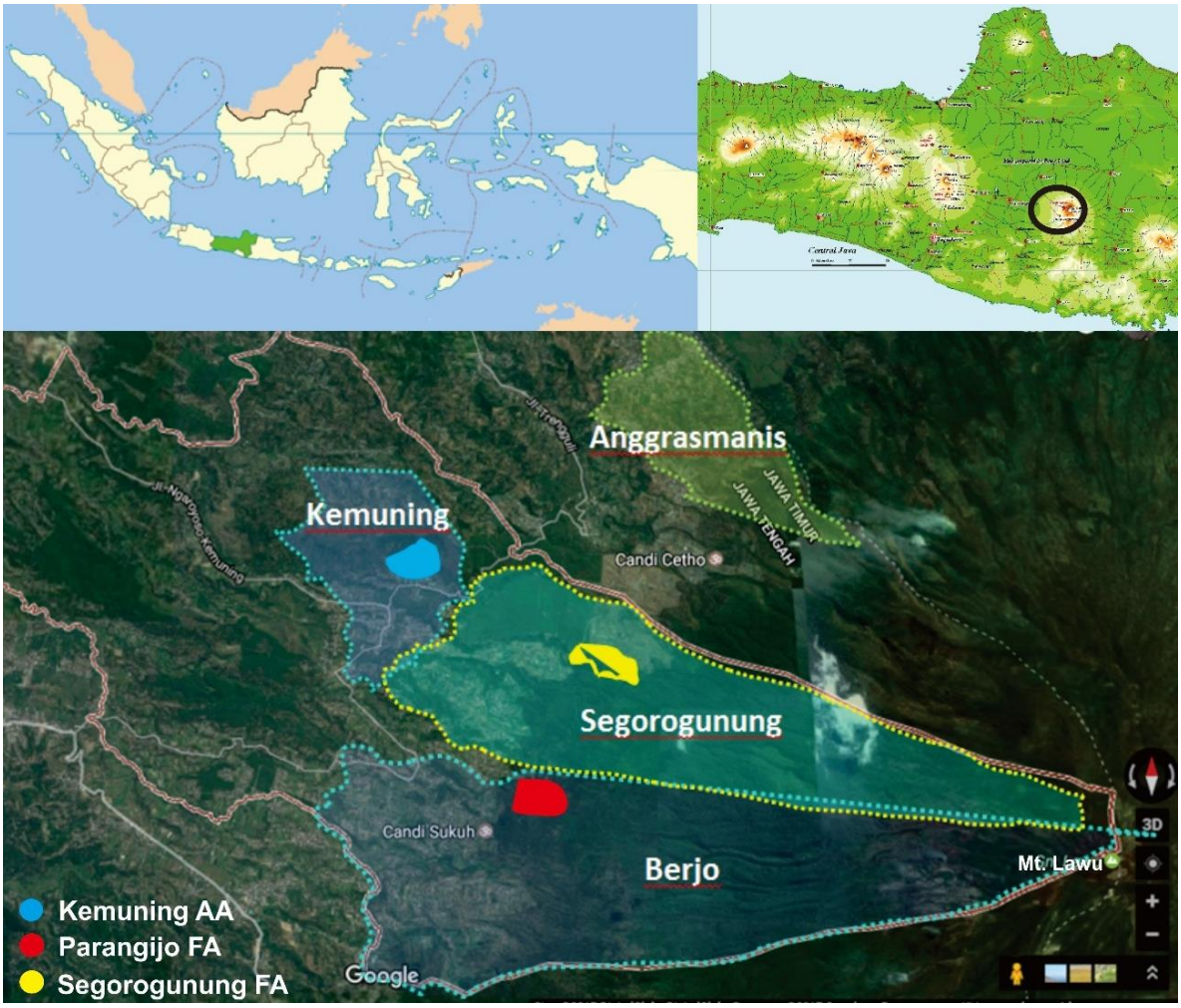

Figure 1. Survey locations on the western slope of Mount Lawu and its surroundings, Central Java, Indonesia

Shannon-Weiner diversity index of the western slope of Mount Lawu was 2.480. Diversity index of FA was 3.031 which was the highest compared to those of AA (2.329) and RA (1.308) (Figure 3). The maximum diversity (H_{max}) of the FA, AA, and RA was 3.714, 3.638, and 3,091, respectively (Figure 3). We assumed that the highest bird species diversity in the western slope of Mount Lawu was found in the forest area, although it is located approximately 1000m higher than the agroforestry area, and approximately 1500m higher than the lowest residential area. It is likely that the elevation factor had little influence on the species diversity. Thus, other factors that caused the richness of species in the forest area needs to be evaluated. These notions are supported by a bird distribution study in Java island by van Balen (1999) which showed that there was abnormal appearance pattern on bird dispersion at different elevations. The study showed that the number of bird species was decreasing at hills zone (300-1500 m asl) and this condition was due to the negative effect of human activities on wildlife especially birds (van Balen 1999). From our point of view, our result showed that the forest is a proper habitat which is preferable by and suitable for many bird species.

We tried to compare the similarities among our observation area to reveal the primary potential disturbance for the bird's life. Figure 3 shows the value of similarity index (*J*) of each terminal. FA and AA showed a similarity index of 0.176, while AA and RA showed a similarity index of 0.24. The similarity index of FA and RA showed that both ecosystems were the least similar (0.393) ecosystem of all the comparisons.While other biotic-abiotic factors were out of our study plans, we consider looking at the anthropogenic activities as the most influential factor that affect birds existence. Residential areas had the highest human population with their various daily activities occurring from early morning until before midnight. Agroforest areas were less crowded by human activities, with the activities peaks from after the sunrise until before the sunset. Of all the areas observed, the forest had the least human activities. In the forest area, the local people conduct a limited set of activities such as animals hunting, seeds and fruits harvesting, charcoals making, and woods or grasses gathering.

Table 2. Bird species observed in each habitat type; Forest (FA), Residential (RA), and Agroforestry (AA)

Family	Species	Survey location		
		FA	AA	RA
Accipitridae				
	Pernis ptilorhynchus	✓	✓	
	Spilornis cheela	✓	✓	✓
	Ictinaetus malayensis	✓	✓	
Phasianidae				
	Gallus varius	✓	✓	✓
Columbidae				
	Ptilinopus porphyreus	✓	✓	
	Macropygia unchall	✓	✓	
	Streptopelia bitorquata	✓	✓	
	Streptopelia chinensis	✓	✓	✓
Cuculidae				
	Cacomantis sonneratii	✓	✓	
	Cacomantis merulinus	✓	✓	✓
	Cacomantis sepulcralis	✓	✓	✓
	Centropus sinensis	✓		
Apodidae				
	Collocalia linchi	✓	✓	✓
	Collocalia vulcanorum		✓	
Hemiprocnidae				
	Hemiprocne longipennis	✓	✓	
Alcedinidae				
	Halcyon cyanoventris	✓	✓	✓
	Todirhamphus chloris	✓	✓	✓
Capitonidae				
	Megalaima armillaris	✓	✓	
	Megalaima haemacephala	✓	✓	✓
Picidae				
	Celeus brachyurus		✓	
	Dendrocopos moluccensis	✓	✓	
	Dendrocopos macei			✓
Campephagidae				
	Coracina javensis	✓		
	Pericrocotus cinnamomeus	✓	✓	✓
	Pericrocotus miniatus	✓		
	Pericrocotus flammeus			✓
Aegithinidae				
	Aegithina tiphia			✓
Pycnonotidae				
	Pycnonotus aurigaster	✓	✓	✓
	Pycnonotus goiavier		✓	✓
	Iole virescens/ Ixos	✓	✓	
Laniidae				
	Lanius cristatus		✓	
	Lanius schach	✓	✓	✓
Turdidae				
	Brachypteryx leucophrys	✓	✓	
	Enicurus velatus		✓	
	Myophonus glaucinus	✓		
	Turdus poliocephalus	✓		
	Zoothera citrina	✓		
	Zoothera dauma	✓		
Timaliidae				
	Pnoepyga pusilla		✓	
Sylviidae				
	Cettia vulcania	✓		
	Megalurus palustris		✓	✓
	Prinia familiaris	✓		
	Prinia inornata		✓	✓
	Orthotomus ruficeps	✓		
	Orthotomus sutorius	✓		
	Phylloscopus borealis	✓		
Muscicapidae				
	Ficedula hyperythra	✓		
	Ficedula westermanni	✓	✓	
	Culicicapa ceylonensis	✓		
Rhipiduridae				
	Rhipidura phoenicura	✓		
Paridae				
	Parus major	✓		
Dicaeidae				
	Dicaeum sanguinolentum	✓		
	Dicaeum trochileum			✓
Nectariniidae				
	Cinnyris/ Nectarinia jugularis			✓
Zosteropidae				
	Zosterops palpebrosus			✓
	Zosterops montanus	✓		
Estrildidae				
	Lonchura leucogastroides	✓	✓	✓
Dicruridae				
	Dicrurus macrocercus	✓		
	Dicrurus leucophaeus	✓	✓	
Artamidae				
	Artamus leucorynchus	✓	✓	
Corvidae				
	Corvus macrorhynchos		✓	

To determine species that dominated a particular area of the three terminals (FA, AA, and RA), we evaluated the abundant index of each of the bird species. Species dominating the three terminals (FA, AA, and RA) are *Collocalia linchi* (D_i 37.92) and *Pycnonotus aurigaster* (D_i 19.42). Those species are very common and easy to spot almost in every place we visited since their needs such as seeds for food and trees for building nest, are abundantly available.*P. aurigaster*and*P. cinnamomeus* were the dominant species in the forest areas. Species with low abundance (D_i=0.3846) in the forest area were *Streptopelia bitorquata*, *Iole virescens*, *Parus major*, *Orthotomus sutorius*, *Dicrurus macrocercus*, *Myophonus glaucinus*, *Prinia familiaris*, and *Zoothera dauma*. *C. linchi* and *P. aurigaster* were the most abundant species in agroforest area, while *Streptopelia bitorquata*, *Cacomantis merulinus*, *Celeus brachyurus*, *Halcyon cyanoventris*, *Pycnonotus goiavier*, *Corvus macrorhynchos*, *Pernis ptilorhynchus*, *Ptilinopus porphyreus*, *Prinia inornata*, and *Lanius cristatus* were present with relatively low abundance (D_i=0,1773). *C. linchi* and *P. aurigaster* also dominant in the residential area, while*Gallus varius*, *Streptopelia chinensis*, *Cacomantis merulinus*, *Spilornis cheela*, *Halcyon cyanoventris*, *Megalaima haemacephala*, *Cacomantis sepulcralis*, and *Prinia inornata* were present with a very low abundance (D_i=0,2045).

All the bird species we found were at least concern (LC) status according to IUCN's Red List (IUCN 2015). A few species are decreasing in population number both in the wild and at the breeding sites. Therefore, those species are protected under Indonesia's law concerning fauna and wildlife protection (Table 3).

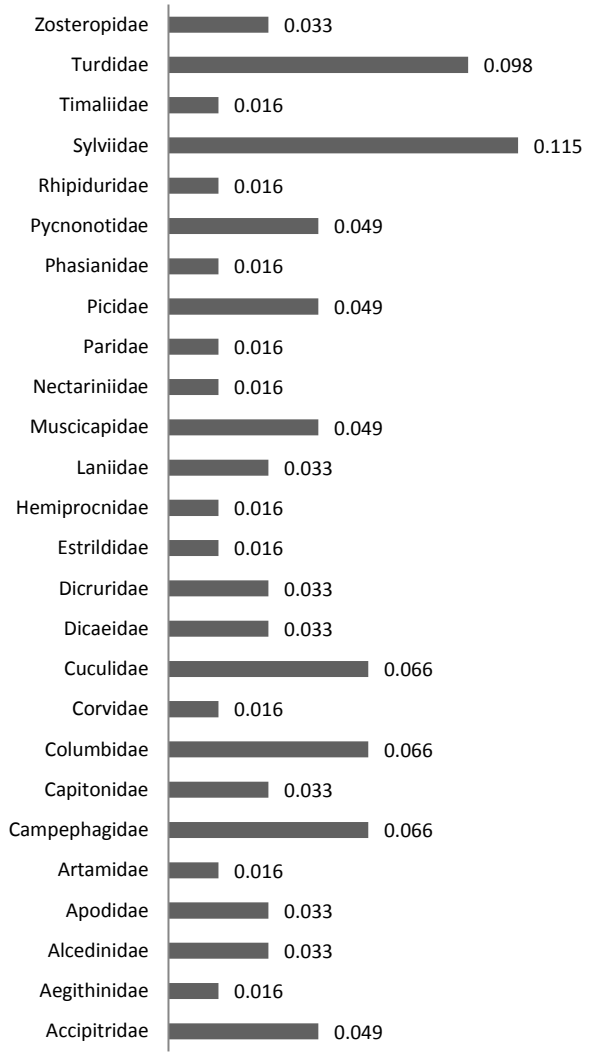

Figure 2. Bird species frequency percentage from each family

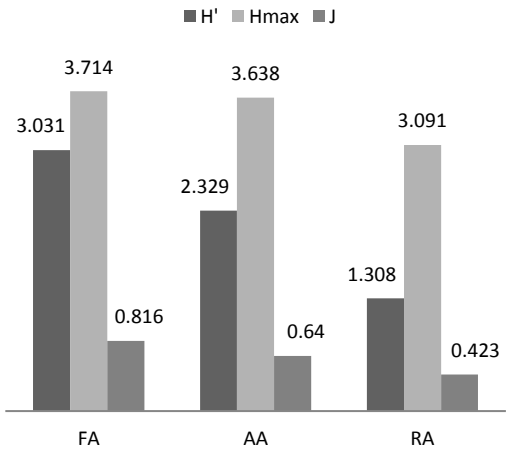

Figure 3. The Diversity Index *(H')*, Maximum Diversity Index *(H_{max})*, and Evenness *(J)* of each area observed.

Table 3. Conservation and Indonesian law status of several bird species found in Mount Lawu, Java, Indonesia

Species	IUCN Status*	Population Trend	Indonesia's Law**
Ictinaetus malayensis	LC	Decreasing	A,B
Spilornis cheela	LC	Stable	A,B
Pernis ptilorhynchus	LC	Stable	A,B
Rhipidura phoenicura	LC	Stable	A,B
Nectarinia jugularis	LC	Stable	A,B
Todiramphus chloris	LC	Stable	A,B
Halcyon cyanoventris	LC	Stable	A,B

Note: *IUCN 2015; **Indonesia Laws: A. ActNo. 5 made in 1990; B. Government RegulationNo. 7 made in 1999.

From the observation carried out diurnally (at FA, AA, and RA)on the western slope of Mount Lawu, we found a very different result in the number of species from each terminal. There were 46 bird species found in FA, 35 species in AA, and 22 species in RA. The total birds sighted individually were 1.416. Birds that could only be heard through its chirping but could not be seen nor be identified directly were excluded to avoid further misunderstanding.

In the forest areas (Parangijo and Segorogunung forests), 46 bird species were found. These areas had the highest diversity index (*H'* 3.031) among the other two areas (AA and RA). The H_{max} (3.714) and *J* (0.816) values of the forest area were also the highest. The higher the diversity index of an ecosystem, the more stable that ecosystem; and *vice versa*, the lower the index, the less stable the ecosystem, i.e. the ecosystem is under a stressful condition (Kachare et al. 2011). This result suggests that the forest is a vital habitat that provides abundant food, water, and shelters for birds to sustain their life. The absence of forest might lead to the extinction of birds and other species. Moreover, the distribution rate of bird is an important indicator to assess biodiversity sustainability in a particular area (Trainor et al. 2000). June was the early period of the dry season, and in the mid-August, the forest condition undergoes a phase of drought, although it was not a complete drought. This condition affected the sighting frequency of some water-dependent species, such as *Enicurus leschenaulti* (White-crowned Forktail) which is easier to be sighted in waterfalls or streams during the wet season.

The second-most proper habitat for birds is agroforest area (Ayat 2011). The villager's capability in farming has given a chance for the forest organizer to allocate a portion of forest area for agroforestry land. The agroforestry land on the western slope of Mount Lawu are grown with pine trees, tea trees, rubber trees and vegetable fields. This study indicates that the value of H_{max} and *J* are 3.638 and 0.64, respectively. It has been noted that agroforest areas like rubber or coffee plantations often have high bird diversity. Agroforest area has quite abundant resources second after the primary and secondary forests. Although an agroforest area has more open canopies than a forest, it is still a suitable habitat for birds (Ayat 2011). An important point

to consider concerning its roles in maintaining the ecosystem balance is that whether the species composition found on each terrain is reasonable.

Residential areas (Segorogunung, Berjo, and Anggrasmanis villages) had the lowest number of H_{max} (3.091) and *J* (0.423). The most likely reason might be due to many anthropogenic activities in this habitats. The main subsistence of the villagers is from vegetable and fruit farming, the skill they mastered naturally from the childhood.The cultivated plants in the villager's gardens and backyards attracted birds. However, often time those birds died because of pesticide poisoning, habitat loss, or being shot by slingshot or airgun (MacKinnon et al. 2010). In ancient time, villagers might be right by trying to save their plants through killing the "pest" birds. As the bird populations are decreasing day by day, people started to be aware of birds important roles, for example as bio-pollinator for plants, and as natural pest predators such as Prinias, Munias, and some raptors. Anthropogenic activities like clothes washing, the use of motorized vehicles, livestock, bathing, and waste dumping have contributed to the increase in environmental pollution. Human encroachment is ever increasing and gives adverse effect to the bird population (Kachare et al. 2011).

The considerable number of trees in the fallow land and the boundary of agricultural land accommodate a large number of bird population. Thus, planting trees in agricultural lands can increase bird population (Mariappan et al. 2013). Vegetation structure of a habitat is important and determines how many species could live in it. Vegetative cover an important component of a habitat, along with the surrounding landscape and management history might influence the composition of the breeding bird species (Wolf et al. 2012). Some shrubs, like tea plants, are necessary, but without a proper management control, there is potential for encroachment. Vegetation planted in this area give the birds places to gain foods, build nest, and shelter. The high diversity of birds is due to the more diverse plant species, providing more choices for the food preference, nesting and breeding place for birds. For example, tea agroforest arranged by shrubs, some clusters, and near the stream, is a highly comfortable area for birds, but only if there are not many human activities (Mariappan et al. 2013)

The number of undetectable bird species is decreasing. The difference in detectability of each species itself is due to the habitat and topographic feature and population densities which are influenced by many factors. An area with high densities may abridge the detectability because individual birds could invest more time in territory defense, such as by singing more frequently (Newson et al. 2008). The most common species found in almost all the sites, with higher D_i (19.42), was *P. aurigaster*. This species could associate closely to human and live in the group that surrounds buildings, and feed on small crops which are grown on many fields (MacKinnon et al. 2010).A species that exhibit the highest D_i (37.92) was *C. linchi*. This species morphologically resemble *C. fuciphaga* with a smaller body length (9.5cm) and a white colored belly. This species builds their nest inside big trees with a large canopy, it lives close to human and is endemic to Sunda land.

All species found are listed as least concern in theIUCN's Red List (IUCN 2015), in which some of them are protected by the Indonesian law. One of the species which under the protection ofIndonesiaActNo. 5 made in 1990 is *Ictinaetus malayensis*, a commonly found raptor in Mount Lawu. It has a large territorial and spreading area, but the population is decreasing because of habitat destruction and illegal trading. In addition, Government Regulation of The Republic of Indonesia No. 7, Year 1999 also protects many species included in the family Accipitridae, such as *Ictinaetus malayensis*, *Spilornis cheela*, and *Pernis ptilorhynchus* and family Nectariniidae such as *Nectarinia jugularis*.

Forest areas with no protection are significantly degraded, thus, the future conversion of such areas should be halted (Barve and Warrier 2013). Visiting the forest for the purpose of climbing and recreation should be carefully considered. Visitation of many protected areas for the express purpose of engaging with wildlife could be a potential disturbance for certain species (Steven et al. 2011). If the number of visitors increases while the number of birds is decreasing, there will be an increase in the minimum distance between the birds and visitors (Collins-Kreiner et al. 2013).It is imperative that the Indonesian government pays more attention to their mega biodiversity land and takes true actions against illegal logging, wildlife persecution, and habitat fragmentation, as well as upholds a stricter law that guarantee the well-being of the wildlife.

In conclusion, the western slope of Mount Lawu still has a diverse species of diurnal birds. This study identified61 species from the total of 1.416 individual birds observed. These numbers exclude the unseen unidentified chirping birds. For a future study, a comprehensive identification of birds, including the nocturnal birds, will give a more accurate picture of the bird diversity. To prevent bird diversity crisis caused by careless anthropogenic activities in the future, we suggest that Mount Lawu conservation area should be extended and a better management and regulation control effort from the stakeholders should be implemented. More research and periodical recordings will help to stay alerted if ecosystem changing or succession are occurring in the future.

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