

Avian diversity in geothermal power plant areas: Case studies in Kamojang, Darajat, and Gunung Salak, West Java, Indonesia

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Abstract. Husodo T, Mochtan KP, Shanida SS, Aminuddin SF, Wulandari I, Putra IS, Megantara EN. 2020. Avian diversity in geothermal power plant areas: Case studies in Kamojang, Darajat, and Gunung Salak, West Java, Indonesia. *Biodiversitas* 21: 1049-1059. Land cover changes that occur in the development of industrial areas have impact on the quality of biophysical and socio-economic environments. This study aimed to investigate the diversity of birds (avifauna) in three geothermal power plant areas in West Jawa Province, Indonesia (i.e., Kamojang, Darajat, and Gunung Salak). Transect and spotlighting methods were conducted in this study. We found that areas around geothermal power plant in Gunung Salak had the highest diversity of bird species with 105 species from 43 families, followed by Kamojang with 82 species from 34 families, and Darajat with 80 species from 40 families. In total, there were 134 species from 51 families in which two species are Endangered (EN) under the IUCN Red List category, five are endemic to Java, 11 are protected by CITES Appendix II and 14 are protected by national regulations. The presence of some birds was an indicator of ecosystem condition and functioning, including indicator of food chain, quality of water, quality of natural habitat, condition of riparian habitat, and the condition of open or disturbed habitat. Some birds were also associated with particular habitats, such as natural forests, riparians, a combination of natural forests and open habitats, tea plantations, and craters. The results of this study can be used as baseline information about the state of the surrounding environment in the three geothermal power plant areas and as a reference in biodiversity management in the future.

Keywords: Avifauna, Geothermal Power Plants, indicator

Abbreviation: UPJP: Generation Unit and Generation Service; PLTP: Geothermal Power Plant

INTRODUCTION

Changes or differences in habitat affect animal diversity and distribution including birds or avifauna (Altaf et al., 2018). For example, a gradient from arable fields to forest landscape showed different avifauna species (Kosickia and Chylarecki 2012). Birds are often recognized as bioindicator for the state of environment because of their strong sensitivity to ecosystem changes. As bioindicators, the presence of birds could explain to what extent human activities have changed the habitat quality and how it affects biodiversity in a more general context. 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; Iskandar and Iskandar 2015; Partasasmita et al. 2016), as shown in countries that hold their traditions such as Indonesia (Krisanti et al. 2017).

According to Frederick et al. (2009), birds are also good indicators for ecosystem restoration program. There is broad consensus among experts that birds are the most suitable biological indicators for monitoring the health of an ecosystem as they are eye-catching and sensitive towards environmental changes (Khan et al. 2013). Ecologically,

birds play tremendous importance because of their key roles as pollinators and agents of seed dispersal (Bibi and Ali 2013). Simple biological monitoring through bird surveys can demonstrate the condition of living systems in a landscape of interest. Such knowledge is more direct and integrative than information that comes from chemical or physical testings, which are generally more rigorous, expensive, time-consuming, and labor-intensive (Khan et al. 2013).

Industrial activities generally have negative impacts on the ecosystem and biodiversity in a landscape (Budiharta et al., 2018). As such, some industrial entities develop strategies to manage and conserve biodiversity. For example, an area for biodiversity conservation set aside within an industrial complex (Budiharta et al., 2010; Fiqa et al., 2019; Sudrajat and Putro, 2019). Another strategy includes minimizing the impacts of industrial activities by implementing environmentally friendly operation and production systems. This is particularly important for industry working on energy sector to produce eco-friendly energy, to maintain clean and green environment, and to mitigate impacts on biodiversity in which all of them are aimed to achieve environmental sustainability. Also, recently, some governments including Indonesia have

enacted regulations regarding environmental management in industrial sector in which one of the issues highlights biodiversity conservation (Act No. 4 of 1982).

Biodiversity monitoring using birds as bioindicators can be used to assess the impacts of activities of industry working on energy sector including in geothermal power plants. Although geothermal power plant is considered as an eco-friendly energy-generating powerhouse compared to other sources (e.g. coal-generated power plant), it is still important to know whether its operation affects biodiversity. This is because there are some potential environmental problems that arise, such as land cover changes caused by forest conversion during the development of geothermal power plants which have impacts on the quality of the biophysical and socio-economic environment in the surrounding areas.

This study aimed to investigate the diversity of birds (avifauna) in three geothermal power plant areas in West Java Province, Indonesia (i.e. Kamojang, Darajat, and Gunung Salak). The results of this study can be used as baseline information about the state of the surrounding environment in the three geothermal power plant areas, especially in the context of biodiversity, which is currently experiencing threats or disturbances. Further, the information can also be used as a reference in biodiversity management in the future

MATERIALS AND METHODS

Study area and period

The study was conducted in Kamojang (July 2017), Darajat (May 2018), and Gunung Salak (July 2018), all are located in West Java Province, Indonesia. Administratively, Darajat is located in Padaawas Village,

Pasirwangi Sub-district, Garut District. The land cover types in Darajat consisted of craters, riparian, lakes, natural forests, and existing buildings. Kamojang is located in Laksana Village, Ibum sub-district, Bandung District. The land cover types in Kamojang consisted of artificial parks, horticulture fields, plantations, pine forests, riparian, shrubs, swamps, natural forests, and existing buildings. Gunung Salak is located in Purwabakti Village, Pamijahan Sub-district, Bogor District. Gunung Salak is within the Halimun-Gunung Salak National Park. The land cover types in Gunung Salak consisted of natural forests, riparian, craters, shrubs, tea plantations, settlements, and existing buildings.

Procedures

Transect and spotlighting

Data was collected using transect and spotlighting methods. The transect method was carried out every day in the morning starting at 05.30-11.00 a.m. and in the afternoon starting at 02.00-05.00 p.m. Data collection was conducted on foot (± 2 km/hour) by recording avifauna species either they were visible and/or they were only audible. This transect method was based on the proportion of the area observed and the time available for observation.

The spotlighting method was carried out to record nocturnal species and conducted at 07.00-11.00 p.m. using flashlight and headlamp. Night-watching was repeated on the track that has been traversed in the morning or carried out at locations that were considered to have the potential in encountering the avifauna.

Data analysis

Data was analyzed qualitatively. The species were identified using MacKinnon and Phillipps (1993).

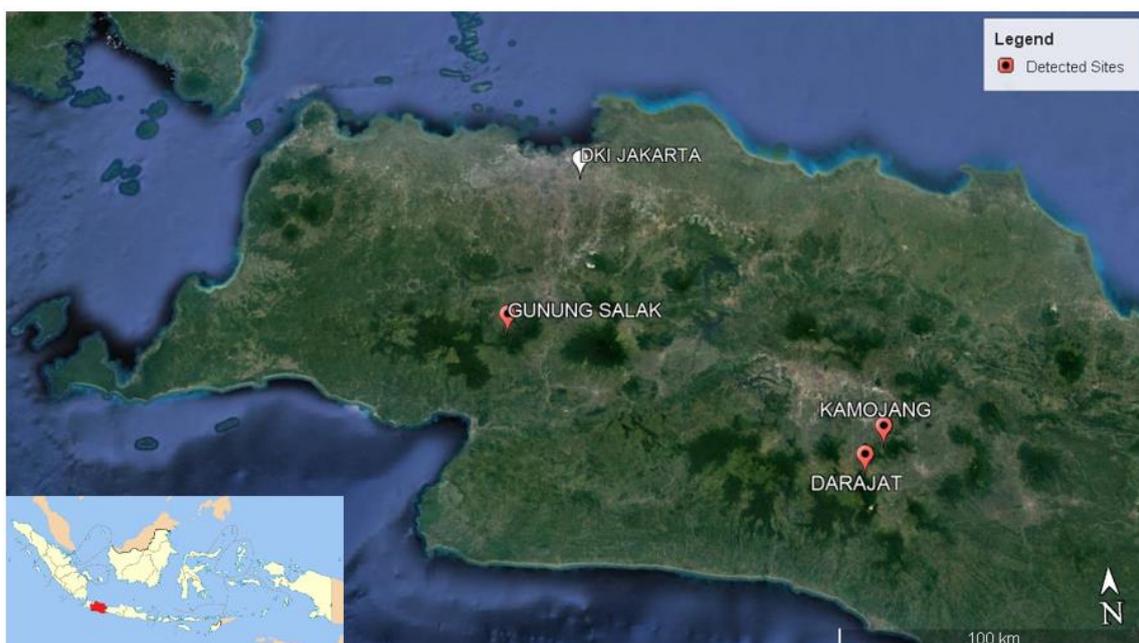


Figure 1. Study areas in West Java, Indonesia: Darajat, Kamojang and Gunung Salak. Map source: Google Earth (2019)

RESULTS AND DISCUSSION

Avifauna diversity

A total of 134 species from 51 families were recorded in Kamojang, Darajat and Gunung Salak (Table 1). Muscicapidae was the most recorded family in this study. In Kamojang there were 82 species from 34 families while in Darajat there were 80 species from 40 families, and in Gunung Salak there were 105 species from 43 families. There were 49 species found in all study locations. Based on these results, it is assumed that those three locations had the availability of food and shelter to meet the needs of birds. Also, it can be assumed that these species had a high tolerance of human disturbances.

Conservation status

Among 134 species, there are two species with EN (Endangered) conservation status under the IUCN Red List, eight species with NT (Near Threatened), and three species with VU (Vulnerable) (Table 1). Of 49 species found in three locations, one of them has Vulnerable status (i.e. *Cochoa azurea*) while other species are under the Least Concern status. In addition, there are 11 species protected by CITES in the Appendix II category and 14 species protected by national protection regulations.

Species with EN conservation status are *Chloropsis cochinchinensis* and *Nisaetus bartelsi*. Species with NT conservation status are *Caprimulgus pulchellus*, *Chrysophlegma mentale*, *Eurylaimus javanicus*, *Laniellus albonotatus*, *Loriculus pusillus*, *Megalaima javensis*, *Prinia familiaris*, and *Pycnonotus bimaculatus*. Species with VU conservation status are *Cochoa azurea*, *Otus angelinae*, and *Rhyticeros undulatus*.

Families with the entire species are protected by CITES in all three locations are Accipitridae, Bucerotidae, Falconidae, Psittacidae, and Strigidae. Within Accipitridae family, there were 5 species in which one species has EN conservation status, which is *Nisaetus bartelsi* (Javan hawk-eagle). This *N. bartelsi* is an endemic raptor of Java Island which is currently severely threatened by both wildlife trade and habitat loss (Nursamsi et al. 2018).

Birds as indicators in ecosystem

In the three study areas of geothermal power plant complex, several species were found as ecosystem indicators, including *Ictinaetus malaiensis* and *Spilornis cheela* which acted as indicators of habitat quality. This species is a predator that controls the food chain in ecosystem, resulting in a balance of ecosystem. While carnivorous birds that hunt and prey on small animals, such as rodents, would keep the population of the vermin under control, leaving the food chain structures balanced through this act of predation (Praptiwi et al. 2019).

Alcippe pyrrhoptera and *Psilopogon armilaris* are indicators of natural habitats quality. The existence of this species is commonly found in natural forests and eating forest fruits, such as walen (*Ficus ribes*), manganese (*Mallotus sp.*), and fig (*Ficus rostrata*). Another species,

Arachnothera affinis, is known as a natural pollinator. The existence of these species indicates that in the study locations natural pollination and seed dispersal still occur. According to Praptiwi et al. (2019), when birds ingest fruits from fruit-bearing trees, they would leave the seeds undigested, excreting them to the ground and leaving them ready for germination. Birds that consume pollen from flowering plants would carry them along with pollens, transporting and inadvertently distributing the pollens into nearby flowers, causing them to be pollinated.

Enicurus leschenaulti is an indicator of riparian habitat quality. This species is often found in river with but not swift streams. This species has also been found looking for leaf litter on river rocks to make nests. *Halcyon cyanoventris* from the Alcedinidae Family is an indicator of water quality. This species indicates that the condition of the aquatic ecosystems in these three regions is still good.

Megalurus palustris, *Lonchura leucogastroides*, *Pycnonotus aurigaster*, and *Passer montanus* are indicators of open and disturbed habitat. Suryawan et al. (2017) said that *Passer montanus* is commonly found around the housing of residents in villages. These species have a high tolerance level to the presence and interference of humans, indicated by their ability to make nests in residential and development areas. Although they were found in disturbed habitats, if the site can still provide resources for the species, the site will certainly continue to be utilized for their survival.

Based on the description above, the presence of some species of birds as bio-indicators suggests the quality of ecosystems around the three geothermal power plant complexes in West Java. These ecosystem indicators include indicator of food chain, good water quality, quality of natural habitats, riparian habitats, and open or disturbed habitats. Birds as one of the most visible residents of the threatened areas hold a key role in the functioning of the ecosystem. They perform services essential for the regulation of ecosystem health, such as seeds dispersal, pollination of tropical plants and pest control (Philpott et al. 2009, Sekercioglu 2012). 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 (Krisanti et al. 2017).

Bird diversity and habitat characteristics

Natural forest

Species found in the core of natural forest were *Megalaima javensis*, *Psilopogon corvinus*, *Rhyticeros undulatus*, *Ducula badia*, *Macropygia emiliana*, *Macropygia ruficeps*, *Laniellus albonotatus* and *Macropygia unchall*. These species were often found in tall and large trees for their nesting place and fruit source. Similar to *Megalaima armillaris*, these species are indicators of natural habitat. For these species, forest is a vital habitat that provides abundant food, water, and shelters to sustain their life. The absence of forests might lead to their extinction (Krisanti et al. 2017).

Table 1. Bird diversity in three geothermal power plant complexes in West Java

Family Species	English Name	Local Name	Locations			Conservation Status		Endemic	
			KMJ	DRJ	GS	RI	IUCN		CITES
Acanthizidae									
<i>Gerygone sulphurea</i> (Wallace, 1864)	Golden-bellied Gerygone	<i>Rametuk Laut</i>		1	1		LC		
Accipitridae									
<i>Ictinaetus malaiensis</i> (Temminck, 1822)	Black Eagle	<i>Elang Hitam</i>	1	1	1	+	LC	II	
<i>Nisaetus bartelsi</i> (Stresemann, 1924)	Javan Hawk-eagle	<i>Elang Jawa</i>			1	+	EN	II	J
<i>Nisaetus cirrhatus</i> (Gmelin, 1788)	Crested Hawk-Eagle	<i>Elang Brontok</i>	1		1	+	LC	II	
<i>Pernis ptilorhynchus</i> (Temminck, 1821)	Oriental Honey-buzzard	<i>Sikep-madu Asia</i>	1				LC	II	
<i>Spilornis cheela</i> (Latham, 1790)	Crested Serpent Eagle	<i>Elang-ular Bido</i>	1	1	1	+	LC	II	
Aegithalidae									
<i>Psaltria exilis</i> (Temminck, 1836)	Pygmy Tit	<i>Cerecet Jawa</i>	1	1	1	+	LC		J
Aegithinidae									
<i>Aegithina tiphia</i> (Linnaeus, 1758)	Common Iora	<i>Cipoh Kacat</i>		1			LC		
Alcedinidae									
<i>Alcedo meninting</i> (Horsfield, 1821)	Blue-eared Kingfisher	<i>Raja-udang Meninting</i>	1				LC		
<i>Halcyon cyanoventris</i> (Vieillot, 1818)	Javan Kingfisher	<i>Cekakak Jawa</i>	1	1			LC		J
<i>Todiramphus chloris</i> (Boddaert, 1783)	Collared Kingfisher	<i>Cekakak Sungai</i>	1	1			LC		
Apodidae									
<i>Apus affinis</i> (Gray, 1830)	Little Swift	<i>Kapinis Rumah</i>			1		LC		
<i>Apus nipalensis</i> (Hodgson, 1836)	House Swift	<i>Kapinis Rumah</i>	1	1			LC		
<i>Collocalia esculenta</i> (Linnaeus, 1758)	Glossy Swiftlet	<i>Walet Linci</i>	1	1	1		LC		
Ardeidae									
<i>Ixobrychus cinnamomeus</i> (Gmelin, 1789)	Cinnamon Bittern	<i>Bambangan Merah</i>	1				LC		
Artamidae									
<i>Artamus leucorhynchus</i> (Linnaeus, 1771)	Artamus Leucorhynchus	<i>Kekep Babi</i>	1	1	1		LC		
Bucerotidae									
<i>Rhyticeros undulatus</i> (Shaw, 1811)	Rhinoceros Hornbill	<i>Julang Emas</i>			1	+	VU	II	
Campephagidae									
<i>Coracina javensis</i> (Horsfield, 1821)	Large Cuckooshrike	<i>Kepudang-sungu Jawa</i>		1	1		LC		J,B
<i>Coracina larvata</i> (S. Müller, 1843)	Sunda Cuckooshrike	<i>Kepudang-sungu Gunung</i>		1			LC		
<i>Lalage fimbriata</i> (Temminck, 1824)	Lesser Cuckooshrike	<i>Kepudang-sungu Kecil</i>		1	1		LC		
<i>Pericrocotus cinnamomeus</i> (Linnaeus, 1766)	Small Minivet	<i>Sepah Kecil</i>			1		LC		
<i>Pericrocotus miniatus</i> (Temminck, 1822)	Sunda Minivet	<i>Sepah Gunung</i>	1		1		LC		S,J
Caprimulgidae									
<i>Caprimulgus pulchellus</i> (Salvadori, 1879)	Salvadori's Nightjar	<i>Cabak Gunung</i>			1		NT		J
Cettidae									
<i>Horornis vulcanius</i> (Blyth, 1870)	Sunda Bush-warbler	<i>Ceret Gunung</i>	1	1			LC		

Cisticolidae

<i>Cisticola juncidis</i> (Rafinesque, 1810)	Zitting Cisticola	<i>Cici Padi</i>	1	1		LC	
<i>Orthotomus ruficeps</i> (Lesson, 1830)	Ashy Tailorbird	<i>Cinene Kelabu</i>	1	1		LC	
<i>Orthotomus sepium</i> (Horsfield, 1821)	Olive-backed Tailorbird	<i>Cinene Jawa</i>	1		1	LC	J,B
<i>Orthotomus sutorius</i> (Pennant, 1769)	Common Tailorbird	<i>Cinene Pisang</i>	1	1	1	LC	J
<i>Prinia familiaris</i> (Horsfield, 1821)	Bar-winged Prinia	<i>Prenjak Jawa</i>	1	1		NT	S,J,B
<i>Prinia flaviventris</i> (Delessert, 1840)	Yellow-bellied Prinia	<i>Prenjak Rawa</i>	1			LC	

Chloropseidae

<i>Chloropsis cochinchinensis</i> (Gmelin, 1789)	Javan Leafbird	<i>Cica-daun Sayap-biru</i>			1	EN	
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Columbidae

<i>Chalcophaps indica</i> (Linnaeus, 1758)	Grey-capped Emerald Dove	<i>Delimukan Zambrud</i>			1	LC	
<i>Ducula badia</i> (Raffles, 1822)	Mountain Imperial-pigeon	<i>Pergam Gunung</i>			1	LC	
<i>Macropygia emiliana</i> (Bonaparte, 1854)	Ruddy Cuckoo-dove	<i>Uncal Buau</i>		1	1	LC	
<i>Macropygia ruficeps</i> (Temminck, 1834)	Little Cuckoo-dove	<i>Uncal Koran</i>			1	LC	
<i>Macropygia unchall</i> (Wagler, 1827)	Barred Cuckoo-dove	<i>Uncal Loreng</i>			1	LC	
<i>Ptilinopus porphyreus</i> (Temminck, 1823)	Pink-headed Fruit-dove	<i>Walik Kepala ungu</i>			1	LC	S,J,B
<i>Spilopelia chinensis</i> (Scopoli, 1786)	Eastern Spotted Dove	<i>Tekukur Biasa</i>	1	1	1	LC	

Cuculidae

<i>Cacomantis merulinus</i> (Scopoli, 1786)	Plaintive Cuckoo	<i>Wiwik Kelabu</i>	1	1	1	LC	
<i>Cacomantis sepulcralis</i> (Vigors & Horsfield, 1826)	Brush Cuckoo	<i>Wiwik Uncuing</i>	1	1	1	LC	
<i>Centropus bengalensis</i> (Gmelin, 1788)	Lesser Coucal	<i>Bubut Alang-alang</i>	1		1	LC	
<i>Cuculus saturatus</i> (Blyth, 1843)	Oriental Cuckoo	<i>Kangkok Ranting</i>	1	1	1	LC	
<i>Phaenicophaeus curvirostris</i> (Shaw, 1810)	Chestnut-breasted Malkoha	<i>Kadalan Birah</i>	1			LC	
<i>Surniculius lugubris</i> (Horsfield, 1821)	Square-tailed Drongo-cuckoo	<i>Kedasi Hitam</i>	1	1		LC	
<i>Zanclostomus javanicus</i> (Horsfield, 1821)	Red-billed Malkoha	<i>Kadalan Kembang</i>			1	LC	

Dicaeidae

<i>Dicaeum concolor</i> (Jerdon, 1840)	Nilgiri Flowerpecker	<i>Cabai Polos</i>			1	LC	
<i>Dicaeum sanguinolentum</i> (Temminck, 1829)	Blood-breasted Flowerpecker	<i>Cabai Gunung</i>	1	1	1	LC	
<i>Dicaeum trigonostigma</i> (Scopoli, 1786)	Orange-bellied Flowerpecker	<i>Cabai Bunga-api</i>	1		1	LC	
<i>Dicaeum trochileum</i> (Sparman, 1789)	Scarlet-headed Flowerpecker	<i>Cabai Jawa</i>	1	1	1	LC	SKJB
<i>Prionochilus percussus</i> (Temminck & Laugier, 1826)	Crimson-breasted Flowerpecker	<i>Pentis Pelangi</i>			1	LC	

Dicruridae

<i>Dicrurus leucophaeus</i> (Vieillot, 1817)	Ashy Drong	<i>Srigunting Kelabu</i>	1	1	1	LC	
<i>Dicrurus macrocercus</i> (Vieillot, 1817)	Black Drong	<i>Srigunting Hitam</i>	1	1	1	LC	
<i>Dicrurus remifer</i> (Temminck, 1823)	Lesser Racquet-tailed Drongo	<i>Srigunting Bukit</i>			1	LC	

Estrildidae

<i>Erythrura hyperythra</i> (Reichenbach, 1863)	Tawny-breasted Parrotfinch	<i>Bondol Hijau-dada Merah</i>			1	LC	
<i>Erythrura prasina</i> (Sparman, 1788)	Pin-tailed Parrotfinch	<i>Bondol-hijau Binglis</i>			1	LC	
<i>Lonchura leucogastroides</i> (Horsfield & Moore, 1856)	Javan Munia	<i>Bondol Jawa</i>	1	1	1	LC	
<i>Lonchura maja</i> (Linnaeus, 1766)	White-headed Munia	<i>Bondol Haji</i>	1			LC	
<i>Lonchura punctulata</i> (Linnaeus, 1758)	Scaly-breasted Munia	<i>Bondol Peking</i>	1		1	LC	

Eurylaimidae

<i>Eurylaimus javanicus</i> (Horsfield, 1821)	Javan Broadbill	<i>Sempur Hutan Rimba</i>			1	1	NT
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Falconidae								
<i>Falco moluccensis</i> (Bonaparte, 1850)	Spotted Kestrel	<i>Alap-alap Sapi</i>	1	1		+	LC	II
<i>Microhierax fringillarius</i> (Drapiez, 1824)	Black-thighed Falconet	<i>Alap-alap Capung</i>				+	LC	II
Hirundinidae								
<i>Cecropis daurica</i> (Linnaeus, 1771)	Red-rumped Swallow	<i>Layang-layang gua</i>		1	1		LC	
<i>Cecropis striolata</i> (Temminck & Schlegel, 1847)	Striated Swallow	<i>Layang-layang Loreng</i>	1				LC	
<i>Hirundo tahitica</i> (Gmelin, 1789)	Tahiti Swallow	<i>Layang-layang Batu</i>	1	1	1		LC	
Laniidae								
<i>Lanius schach</i> (Linnaeus, 1758)	Long-tailed Shrike	<i>Bentet Kelabu</i>	1	1	1		LC	
Leiotrichidae								
<i>Alcippe pyrrhoptera</i> (Bonaparte, 1850)	Javan Fulvetta	<i>Wergan Jawa</i>	1	1	1		LC	
<i>Laniellus albonotatus</i> (Lesson, 1832)	Spotted Crocias	<i>Cica Matahari</i>			1		NT	
Locustellidae								
<i>Megalurus palustris</i> (Horsfield, 1821)	Striated Grassbird	<i>Cica Koreng</i>	1	1	1		LC	
Megalaimidae								
<i>Megalaima armillaris</i> (Temminck, 1821)	Flame-fronted Barbet	<i>Takur Tohtor</i>	1	1	1		LC	
<i>Megalaima javensis</i> (Horsfield, 1821)	Black-banded Barbet	<i>Takur Tulung-tumpuk</i>	1		1		NT	
<i>Megalaima lineata</i> (Vieillot, 1816)	Lineated Barbet	<i>Takur Bultok</i>	1				LC	
<i>Psilopogon corvinus</i> (Temminck, 1831)	Brown-throated Barbet	<i>Takur Bututut</i>		1	1		LC	
Muscicapidae								
<i>Brachypteryx leucophris</i> (Temminck, 1828)	Lesser Shortwing	<i>Cingcoang Coklat</i>	1	1	1		LC	
<i>Cyornis unicolor</i> (Blyth, 1843)	Pale Blue-flycatcher	<i>Sikatan Biru-muda</i>		1	1		LC	
<i>Enicurus leschenaulti</i> (Vieillot, 1818)	White-crowned Forktail	<i>Meninting Besar</i>	1	1	1		LC	
<i>Enicurus velatus</i> (Temminck, 1822)	Sunda Forktail	<i>Meninting Kecil</i>			1		LC	
<i>Eumyias indigo</i> (Horsfield, 1821)	Indigo Flycatcher	<i>Sikatan Nion</i>		1	1		LC	
<i>Ficedula hyperythra</i> (Blyth, 1843)	Snowy-browed Flycatcher	<i>Sikatan Bodoh</i>	1	1	1		LC	
<i>Ficedula mugimaki</i> (Temminck, 1815)	Mugimaki Flycatcher	<i>Sikatan Mugimaki</i>		1			LC	
<i>Ficedula westermanni</i> (Sharpe, 1888)	Little Pied Flycatcher	<i>Sikatan Belang</i>	1	1	1		LC	
<i>Muscicapa dauurica</i> (Pallas, 1811)	Asian Brown Flycatcher	<i>Sikatan Bubik</i>	1	1	1		LC	
<i>Muscicapa sibirica</i> (Gmelin, 1789)	Dark-sided Flycatcher	<i>Sikatan Sisi-gelap</i>	1				LC	
<i>Myophonus glaucinus</i> (Temminck, 1823)	Javan Whistling-thrush	<i>Ciung Batu-kecil</i>		1	1		LC	
Nectariniidae								
<i>Aethopyga eximia</i> (Horsfield, 1821)	White-flanked Sunbird	<i>Burung Madu Gunung</i>	1	1	1		LC	
<i>Aethopyga siparaja</i> (Raffles, 1822)	Crimson Sunbird	<i>Burung-madu Sepah-raja</i>			1	+	LC	
<i>Arachnothera affinis</i> (Horsfield, 1821)	Streaky-breasted Spiderhunter	<i>Pijantung Gunung</i>			1		LC	
<i>Arachnothera longirostra</i> (Latham, 1790)	Little Spiderhunter	<i>Pijantung Kecil</i>	1	1	1		LC	
<i>Arachnothera robusta</i> (Muller & Schlegel, 1845)	Long-billed Spiderhunter	<i>Pijantung Besar</i>			1		LC	
<i>Chalcoparia singalensis</i> (Gmelin, 1789)	Ruby-cheeked Sunbird	<i>Burung Madu Belukar</i>			1		LC	
<i>Cinnyris jugularis</i> (Linnaeus, 1766)	Olive-backed Sunbird	<i>Burung Madu Sriganti</i>	1	1	1		LC	
Paridae								
<i>Parus major</i> (Linnaeus, 1758)	Great Tit	<i>Gelatik Batu</i>		1	1		LC	
Passeridae								
<i>Passer montanus</i> (Linnaeus, 1758)	Eurasian Tree Sparrow	<i>Burung-gereja Erasia</i>	1	1	1		LC	

Pellorneidae									
<i>Malacocincla sepiaria</i> (Horsfield, 1821)	Horsfield's Babbler	<i>Pelanduk Semak</i>	1	1					LC
<i>Napothera epilepidota</i> (Temminck, 1827)	Eyebrowed Wren-babbler	<i>Berencet Berkening</i>	1	1	1				LC
<i>Trichastoma pyrrogenys</i> (Temminck, 1827)	Temminck's Babbler	<i>Pelanduk Bukit</i>	1						LC
Phasianidae									
<i>Arborophila javanica</i> (Gmelin, 1789)	Chestnut-bellied Partridge	<i>Puyuh-gonggong Jawa</i>	1	1	1				LC
<i>Coturnix chinensis</i> (Linnaeus, 1766)	Asian Blue Quail	<i>Puyuh Batu</i>	1		1				LC
<i>Gallus gallus</i> (Linnaeus, 1758)	Red Junglefowl	<i>Ayam-hutan Merah</i>			1				LC
Phylloscopidae									
<i>Phylloscopus grammiceps</i> (Strickland, 1849)	Javan Warbler	<i>Cikrak Muda</i>	1	1	1				LC
<i>Phylloscopus trivirgatus</i> (Strickland, 1849)	Mountain Warbler	<i>Cikrak Daun</i>	1	1	1				LC
Picidae									
<i>Chrysocolaptes validus</i> (Temminck, 1825)	Orange-backed Woodpecker	<i>Pelatuk Kundang</i>			1	1			LC
<i>Chrysophlegma mentale</i> (Temminck, 1825)	Javan Yellownappe	<i>Pelatuk Kumis-kelabu</i>			1	1			NT
<i>Dendrocopos macei</i> (Vieillot, 1818)	Fulvous-breasted Woodpecker	<i>Caladi Ulam</i>	1	1	1				LC
<i>Dendrocopos moluccensis</i> (Gmelin, 1788)	Sunda Pygmy Woodpecker	<i>Caladi Tilik</i>	1						LC
<i>Sasia abnormis</i> (Temminck, 1825)	Rufous Piculet	<i>Tukik Tikus</i>				1			LC
Podargidae									
<i>Batrachostomus javensis</i> (Horsfield, 1821)	Horsfield's Frogmouth	<i>Paruh-kodok Jawa</i>	1	1	1				LC
Psittacidae									
<i>Loriculus pusillus</i> (Gray, 1859)	Yellow-throated Parrot	<i>Serindit Jawa</i>			1	1	+		NT II
Pnoepyidae									
<i>Pnoepyga pusilla</i> (Hodgson, 1845)	Pygmy Cupwing	<i>Berencet Kerdil</i>	1	1	1				LC
Pycnonotidae									
<i>Alophoixus bres</i> (Lesson, 1832)	Brown-cheeked Bulbul	<i>Empuloh Janggut</i>				1			LC
<i>Iole viridescens</i> (Blyth, 1845)	Olive Bulbul	<i>Brinji Gunung</i>				1			LC
<i>Pycnonotus aurigaster</i> (Vieillot, 1818)	Sooty-headed Bulbul	<i>Cucak Kutilang</i>	1	1	1				LC
<i>Pycnonotus bimaculatus</i> (Horsfield, 1821)	Orange-spotted Bulbul	<i>Cucak Gunung</i>			1	1			NT
<i>Pycnonotus goiavier</i> (Scopoli, 1786)	Yellow-vented Bulbul	<i>Merbah Cerukcuk</i>	1	1	1				LC
Rallidae									
<i>Amaurornis phoenicurus</i> (Pennant, 1769)	White-breasted Waterhen	<i>Kareo Padi</i>	1	1					LC
Scotocercidae									
<i>Phyllergates cuculatus</i> (Temminck, 1836)	Mountain Tailorbird	<i>Cinenen Gunung</i>	1	1	1				LC
<i>Tesia superciliaris</i> (Bonaparte, 1850)	Javan Tesia	<i>Tesia Jawa</i>	1	1	1				LC
Stenostiridae									
<i>Culicicapa ceylonensis</i> (Swainson, 1820)	Grey-headed Canary-flycatcher	<i>Sikatan Kepala-abu</i>	1	1	1				LC
Rhipiduridae									
<i>Rhipidura phoenicura</i> (Müller, 1843)	Rufous-tailed Fantail	<i>Kipasan Ekor-merah</i>	1	1					LC
Sittidae									
<i>Sitta azurea</i> (Lesson, 1830)	Blue Nuthatch	<i>Munguk Loreng</i>	1	1	1				LC
<i>Sitta frontalis</i> (Swainson, 1820)	Velvet-fronted Nuthatch	<i>Munguk Beledu</i>				1			LC
Strigidae									
<i>Otus angelinae</i> (Finsch, 1912)	Javan Scops-owl	<i>Celepuk Jawa</i>				1	+		VU II
<i>Otus lempiji</i> (Horsfield, 1821)	Sunda Scops-owl	<i>Celepuk Reban</i>	1		1				LC II

Sturnidae							
<i>Aplonis panayensis</i> (Scopoli, 1786)	Asian Glossy Starling	<i>Perling Kumbang</i>	1				LC
Timaliidae							
<i>Cyanoderma melanothorax</i> (Temminck, 1823)	Crescent-chested Babbler	<i>Tepus Pipi-perak</i>	1	1	1		LC
<i>Stachyris thoracica</i> (Temminck, 1821)	White-bibbed Babbler	<i>Tepus Leher Putih</i>			1		LC
Turdidae							
<i>Cochoa azurea</i> (Temminck, 1824)	Javan Cochoa	<i>Ciung-mungkal Jawa</i>	1	1	1	+	VU
<i>Geokichla sibirica</i> (Pallas, 1776)	Siberian Thrush	<i>Anis Siberia</i>		1			LC
Turnicidae							
<i>Turnix suscitator</i> (Gmelin, 1789)	Barred Buttonquai	<i>Gemak Loreng</i>	1		1		LC
Vangidae							
<i>Hemipus hirundinaceus</i> (Temminck, 1822)	Black-winged Flycatcher-shrike	<i>Jingjing Batu</i>	1	1	1		LC
Vireonidae							
<i>Pteruthius aenobarbus</i> (Temminck, 1836)	Chestnut-fronted Shrike-babbler	<i>Ciu Kunyit</i>	1	1	1		LC
<i>Pteruthius flaviscapis</i> (Temminck, 1836)	Pied Shrike-babbler	<i>Ciu Besar</i>	1	1	1		LC
Zosteropidae							
<i>Heleia javanica</i> (Horsfield, 1821)	Javan Grey-throated White-eye	<i>Opior Jawa</i>		1	1	+	LC
<i>Zosterops japonicus</i> (Temminck & Schlegel, 1845)	Mountain White-eye	<i>Kacamata Gunung</i>			1		LC
<i>Zosterops palpebrosus</i> (Temminck, 1824)	Oriental White-eye	<i>Kacamata Biasa</i>	1	1	1		LC
		Total	82	80	105	14	11

Note: Conservation Status: RI: Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P 106 on Protected Plant and Animal Species; IUCN: International Union for Conservation of Nature, LC: *Least Concern*, NT: *Near Threatened*, VU: *Vulnerable*, EN: *Endangered*, CITES: Convention on International Trade in Endangered Species, I: *Appendix I*, *Appendix II*, *Appendix III*; Locations: KMJ: Kamojang, DRJ: Darajat, GS: Gunung Salak. Endemic: J: Java Island, B: Bali Island, K: Kalimantan Island, S: Sumatera, Sw: Sulawesi Island.

Other species found in natural forests were *Pericrocotus miniatus*, *Tesia superciliaris*, *Ficedula westermanni*, *Sitta azurea*, *Culicicapa ceylonensis*, *Rhipidura phoenicura*, *Alcippe pyrrhoptera*, *Psaltria exilis*, *Cyanoderma melanothorax*, and *Hemipus hirundinaceus*. Certain species can only be found in natural forests such as *Coracina javensis* and *Chrysophlegma mentale*. It is possible that these two species can be found in other ecosystems such as in lakes or riparians, as long as they still have natural stands and have relatively the same environmental conditions.

Woodpeckers such as *Chrysocolaptes validus* were often found in pristine natural forests with old vegetation stands. It is because this species often forages on the trunks of old trees with many insects. In addition, these old trees can be used as nesting sites. The existence of this species is an indication that this habitat still has the carrying capacity for this species to find food and nest.

The structural heterogeneity and high diversity of plant species provide niches for many species of birds, and therefore can support a great number of bird species sharing the same habitat. The diversity of vegetation is an important factor affecting bird species diversity in the secondary forests (Erniwati et al. 2016).

Water habitats

Species found around pond area were *Dicaeum concolor*, *Prionochilus percussus*, *Cyornis unicolor* and *Psilopogon corvinus*. This location had puddles, which were used by birds to cool their body. Other birds found in riparian were *Pnoepyga pusilla*, *Ficedula westermanni*, *Alcippe pyrrhoptera*, *Dicrurus leucophaeus*, *Culicicapa ceylonensis*, *Tesia superciliaris*, and *Myophonus glaucinus*.

Species found around lake were *Caprimulgus pulchellus*, *Otus angelinae* and *Batrachostomus javensis*. The presence of these species around lake is likely due to the presence of frogs, toads, and small mammals as their foods. Species that can be found around river area were *Lonchura leucogastroides*, *Pycnonotus bimaculatus*, *Aethopyga eximia*, *Pteruthius aenobarbus*, *Brachypteryx leucophrys*, *Ficedula westermanni*, and *Pnoepyga pusilla*. Species recorded in swampy areas were *Lonchura leucogastroides*, *Todiramphus chloris*, *Megalurus palustris*, and *Nectarina jugularis*.

The combination of natural forest and open habitat

Species that occupied open habitats directly adjacent to natural forests were *Erythrura hyperythra*, *Ptilinopus porphyreus*, *Caprimulgus pulchellus*, *Phaenicophaeus curvirostris*, *Zanclotomus javanicus*, *Dicrurus macrocercus*, *Enicurus velatus*, *Muscicapa dauica*, and *Batcocomis durica*. Species that often used forest edge were *Pericrocotus cinnamomeus* and *Pericrocotus miniatus*. The species that inhabited other open habitats, such as shrubs, were *Orthotomus ruficeps* and *Orthotomus sepium*. Other species that often found in open and disturbed habitats were *Spilopelia chinensis*, *Centropus bengalensis*, *Surniculus lugubris*, *Lonchura*

leucogastroides, *Lonchura punctulata*, *Hirundo tahitica*, *Megalurus palustris*, *Pycnonotus aurigaster*, *Pycnonotus goiavier*, and *Turnix suscitator*.

Tea plantation

Specifically, in Gunung Salak, there were tea plantations with remnants of natural vegetation and a part of the tea plantations that directly adjacent to natural forests. Due to this unique landscape, there was also a uniqueness of avifauna that lived there in which some species were they that commonly found in natural habitats while others were they that often found in open or disturbed habitats.

The species commonly found in natural habitats and found in this location were *Psaltria exilis* and *Loriculus pusillus*. *Psaltria exilis* were found in natural areas directly adjacent to tea plantations, while *Loriculus pusillus* were found in forest edge areas and areas where natural stands were still present. *Loriculus pusillus* is an avifauna that often uses tall tree canopies to fly from one tree to another. *Loriculus pusillus* was observed to fly from natural spotting stands in the middle of a tea garden. This is partly due to the presence of natural stands that were in a period of fruiting, so it became an attraction for the species of fruit-eating avifauna. In this case, the importance of habitat for avifauna species can be seen, i.e. although it was located between disturbed habitats, but if it can still provide carrying capacity, the site will certainly continue to be utilized by *Loriculus pusillus* for its survival.

Crater

Specifically, in Darajat, there was a unique habitat which is a crater. This crater still had the availability of feed and nesting locations for certain types of avifauna. One species found was a small fruit-eating bird with fairly small distribution, *Macropygia emiliana*, which was found in natural stands directly adjacent to the crater area. Other species found around the crater were *Lanius schach*, *Pnoepyga pusilla*, *Aethopyga eximia*, *Dicaeum sanguinolentum*, *Dicaeum trochileum*, *Halcyon cyanoventris*, *Todiramphus chloris*, and *Psaltria exilis*.

Species that have low adaptability will be vulnerable to disturbance and can suffer population decline. Usually, species that have low adaptability tend to have specific types of feed and other habitat needs. Because of the importance of the birds role, bird species and the sensitivity of their presence to habitat needs to be monitored as an evaluation of habitat quality.

In the current era of development, an indicator is needed to assess the effect of development or to assess the quality of an area. This assessment is important because it can provide an overview of an event or change in the environment and how to reduce the negative impact of a change. According to Young et al. (2013), the development of biological criteria using bird communities has become an important approach now for monitoring and assessing environmental quality.



Figure 2. Some birds that found in geothermal power plant areas: A. *Dicrurus leucophaeus*, B. *Dendrocopos moluccensis*, C. *Dicaeum sanguinolentum*, D. *Megalurus palustris*, E. *Hirundo tahitica*, F. *Falco moluccensis*. Photographs by Syahrasf

According to Mariappan et al. (2013), the high diversity of birds is related to the more diverse plant species, which provide more choices for food preference, nesting and breeding places for birds. For example, tea agroforest arranged by shrubs, some clusters, and near the stream, is highly favorable by birds, but only if there are not many human activities. Wolf et al. (2012) said that vegetation structure of habitat is important and determines how many species could live in it. Vegetation cover is an important component of habitat and along with the surrounding landscape and management history might influence the composition of the breeding bird species.

In conclusion, based on the result of this study in three geothermal power plant areas in West Java, we conclude that the diversity of bird species is different from one location to others and it is affected by the type of vegetation. Gunung Salak had the highest diversity of bird species than any other locations with 105 species from 43 families. Species that were always found in all three locations were 49 species, including one species with Vulnerable status while the others had Least Concern status. There were two species with Endangered (EN) which only found in Gunung Salak. A total of 11 species were endemic species in which five were endemic in Java.

The presence of some birds was an indicator of ecosystem condition and functioning, including indicator of food chain, quality of water, quality of natural habitat, condition of riparian habitat, and the condition of open or disturbed habitat. Some birds were also associated with particular habitats, such as natural forests, riparians, a combination of natural forests and open habitats, tea plantations, and craters.

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