

# Bird communities and vegetation composition in Nusa Penida, Bali, Indonesia

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**Abstract.** Sudaryanto FX, Hardini J, Kalih LATTWS, Asrori MM, Suana IW. 2019. Bird communities and vegetation composition in Nusa Penida, Bali, Indonesia. *Biodiversitas* 20: 3676-3683. A study on bird community and vegetation composition in Nusa Penida was carried out to determine its diversity, conservation status, and habitat as an effort to conserve and develop birdwatching ecotourism in Nusa Penida. The study was conducted in Tembeling forest and Ped agroforestry. By using the point count method, we found 80 species of birds: 70 species in Tembeling forest and 79 species in Ped agroforestry. Fourteen species of birds are protected by Indonesian law. According to the IUCN Red List of Threatened Species, four species are Critically Endangered and one species is classified as Near Threatened. We also found eight species of migratory birds. Diversity of birds in Nusa Penida was high. Individuals of each bird species was spread evenly, except *Hirundo rustica*, *Hirundo tahitica* and *Streptopelia chinensis* were dominant. Twenty-five species of trees were found in Tembeling, while in Ped were found 22 species. These vegetations were provided birds with good resources for foraging, resting, and nesting.

**Keywords:** Awig-awig, bird conservation, birdwatching ecotourism, migratory birds

## INTRODUCTION

Bali has a diverse landscape with its highest peak is Gunung Agung, 3,142 meters above sea level. Between the tallest mountain and the sea-sand areas, there are forests, flowing rivers, alluvial slopes and green rugs of crop fields. The forests of Bali stretch on the north western part of the island. The Bali Barat National Park is established to preserve the forests and their wildlife. Bali Starling *Leucopsar rothschildi* is an endemic bird of Bali found in this park. Besides Bali Starling which is the mascot of the Province of Bali, there are also 344 species of birds on this island, of which 190 are considered residents, 83 as regular visitors and 71 as vagrants (Mason 2011). One additional species, Greater Painted Snipe *Rostratula benghalensis*, is a new record for Bali that has not been recorded in Mason's checklist (Hermawan et al. 2013).

Nusa Penida is a small island located 20 km to the southeast of Bali. It has a limestone mountain with wooded grassland soil types whose water availability is very poor (Riany and Aunurohim 2013). Based on the Schmidt and Ferguson climate classification, Nusa Penida has an E climate type, with an average rainfall of 972 mm/year, and an average of 5.58 rainy days. The area of Nusa Penida is 20,284 ha, consisting of 1,000 ha of forest, most of which is agroforestry. The length of the coastline is 83.50 km (Pembkab Klungkung 2013). Nusa Penida is an ex-situ conservation area for Bali Starling recommended by Friends of National Parks Foundation (FNPF), a local NGO

of Bali. It was chosen as the center for rescue and release of Bali Starling because it has forest areas, agroforestry, and grasslands that can support the life of Bali Starling (Wirayudha 2008). In addition, community participation with its awig-awig (Balinese Common Law) has succeeded in protecting the existence of Bali Starling in Nusa Penida (Sudaryanto 2019). This is interesting for tourists to come to Nusa Penida (Agustina 2013). In 2018 the number of tourists who came to Nusa Penida was 350,000 people, and 80% are foreign tourists (Sudiarkajaya et al. 2018).

Habitat conditions generally have an effect on bird abundance and diversity (Partasasmita et al. 2017; Krisanti et al. 2017). To support the life of birds, it is necessary to have a single unit of habitat that can guarantee all the necessities of birdlife, such as food, resting and nesting places. We report here the bird diversity, conservation status, and bird habitat in Tembeling forest and Ped agroforestry as an effort to conserve and develop birdwatching ecotourism in Nusa Penida.

## MATERIALS AND METHODS

### Study area

The study lasted for three months (January to March 2019) in Tembeling forest and Ped agroforestry, Nusa Penida, Bali, Indonesia (Figure 1). Tembeling forest is located at an altitude of 200 to 250 meters above sea level (masl), and Ped agroforestry at an altitude of 0 to 130 m

asl. Agroforestry is a plantation that integrates timber tree management with commodity crops (van Noordwijk et al. 2004; Wulandari 2009). Large trees, such as *Syzygium cumini*, *Ficus benjamina*, and *Azadirachta indica* can be found in Ped agroforestry. In addition to these trees, there are coconut palms, cassava, corn, nuts, bushes, grasslands, and settlements (Ginantra et al. 2009). Tembeling forest is a natural forest that stores a lot of water on its soil favoring the growth of ferns or the like. Several species of large trees, including *Ficus glabella*, *Ficus benjamina*, *Acacia auriculiformis*, and *Lannea grandis* grow in this forest (Riany and Aunurohim 2013; Sudaryanto et al. 2015).

### Sampling procedure

Bird sampling was carried out using point count method (Bibby et al. 2000). Observations were made from 06:00hr to 11:00hr, and from 15:00hr to 18:00hr, from January to March 2019. The number of points at each study site was 10, with 100 m distance between two points in Tembeling forest, and 200 m in Ped agroforestry. We made a difference in the distance between points at the two study sites because there were differences in the conditions of the study area, where in the Tembeling forest it had a slope of between 40% to 60%, while in Ped agroforestry was flat. Radius of observation in each point was 30 m, with an observation time of 15 minutes. During the study, it was 10 times visit for each point. Data recorded includes the bird species, the number of individuals of each bird species, and the activity of birds in the strata of canopy. Only birds that perch on the tree are recorded. Activity of birds on the tree was observed by scan sampling method with interval of 5 minutes (Martin and Bateson 2006). Identification of bird species was based on Mason and Jarvis (1994), MacKinnon et al. (2010) and Mason 2011.

To determine the habitat condition, vegetation analysis and habitat profile were made. We used a 20 m x 20 m quadrat plot to do vegetation sampling (Barbour et al.

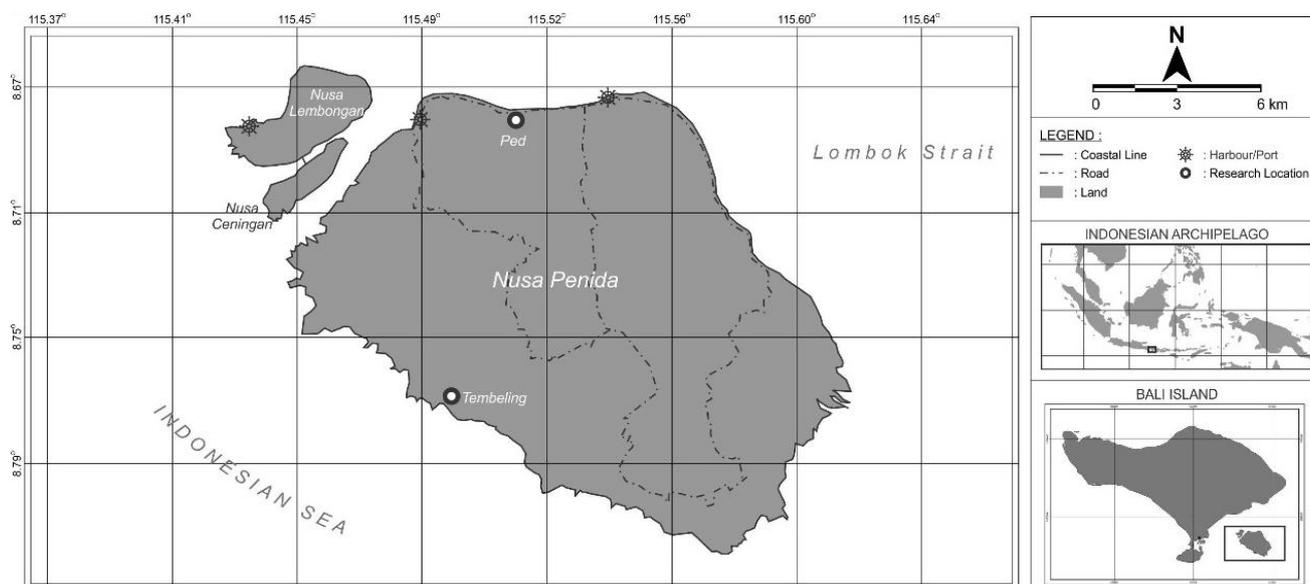
1987). On each quadrat plot, we were record and measure: number of individuals of each species, the total of tree height, the first branch height, canopy width, canopy length, canopy thick, tree diameter at breast height of researcher, the position of the tree (the distance to the x and y axis), then the vegetation profile is made. The conservation status of birds was based on Regulation of Ministry of Environment and Forestry (Permen LHK) Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018, and International Union for Conservation of Nature's Red List of Threatened Species.

### Data analysis

Diversity of bird and plant was performed using Shannon-Wiener Diversity Index ( $H'$ ):  $H' = -\sum_{i=1}^s pi \ln pi$ , where ' $pi$ ' is proportional abundance. If  $H' < 1.5$  the diversity is categorized as low, values of 1.5 to 3.5 are categorized as moderate, and values  $> 3.5$  indicate high diversity (Magurran 1988).

Distribution of birds in their habitat was determined using Index of Evenness ( $E$ ):  $E = H'/\ln S$ , where ' $S$ ' is the total number of species in the samples. When ' $E$ ' approaches 0 (zero), the species of bird is not too diverse, and there is dominance of certain species. On the contrary, when ' $E$ ' approaches 1 (one), the number of individuals among species is not too different, and there is no dominance of certain species (Ludwig and Reynolds 1988).

Dominance of bird species in each study site, was calculated using the formula:  $Di = (ni/N) \times 100\%$ , where ' $ni$ ' is the number of individual species- $i$ , and ' $N$ ' is the total number of individuals. Criteria for determining the level of dominance are as follows:  $Di = 0$  to 2% indicated non-dominant species, 2 to 5% showed sub-dominant species, and  $> 5\%$  was categorized as dominant species (Dewi et al. 2007).



**Figure 1.** Map showing locations of two study sites, Tembeling forest and Ped agroforestry, Nusa Penida, Bali, Indonesia

Similarities of bird and plant communities in the two study sites were calculated using the Similarity Index (SI):  $SI = 2J/(a + b)$ , where 'J' is the number of species that exist in both study sites, 'a' is the number of species at study site 'a', and 'b' is the number of species at study site 'b'. SI less than 50% indicated low similarity between two habitats, 50% to 75% showed moderate, and more than 75% was categorized high (Setiadi 2004).

The use of habitat (Ft) by birds to perform various activities, such as foraging, perching/resting, and nesting was calculated with the formula:  $Ft = (St/Sp) \times 100\%$ , where 'St' is the number of bird species that use habitat or vegetation, 'Sp' is the total number of bird species present at the study site (Dewi et al. 2007; Paskal et al. 2015).

Analysis of the importance of trees in Tembeling forest and Ped agroforestry using an Index of Importance Value (IIV):  $IIV = RD_i + RFi + RC_i$ .  $RD_i$  (Relative Density) is a comparison between the number of individuals of species-i ( $N_i$ ) and the number of all individuals ( $\Sigma N$ ).  $RF_i$  (Relative Frequency) is a comparison between frequency of species-i ( $F_i$ ) and total frequency of all species ( $\Sigma F$ ).  $RC_i$  (Relative Cover) is a comparison between the area of species-i cover area ( $C_i$ ) and the total coverage area for all species ( $\Sigma C$ ) (English et al. 1994).

## RESULTS AND DISCUSSION

### Diversity of birds

During the study, we found 1,185 individuals of birds from 39 families, 61 genera and 80 species (Table 1). In Tembeling forest there were 36 families, 56 genera and 70 species, while in Ped agroforestry we found 38 families, 60 genera and 79 species. Among these species of birds, 14 species are protected by Permen LHK Republic of Indonesia No. P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018, and 66 species not protected. Based on IUCN Red List of Threatened Species, 1 species (*Numenius arquata*) is categorized as Near Threatened, 4 species (*Cacatua sulphurea*, *Fregata andrewsi*, *Acridotheres tertius*, and *Leucopsar rothschildi*) as Critically Endangered, and 75 species of Least Concern.

Bird diversity (H') in Tembeling forest was 3.75, with an Evenness Index (E) of 0.89. This means that the diversity of bird species was high. The number of individuals of each bird species was not too different, although there were some dominant bird species (Table 1), such as *Hirundo rustica* ( $Di = 6.20$ ), *Streptopelia chinensis* ( $Di = 5.60$ ), and *Hirundo tahitica* ( $Di = 5.20$ ). The diversity of birds in Ped agroforestry was higher than in Tembeling forest, with  $H' = 3.82$ , and an Evenness Index of 0.88. Similar to Tembeling forest, in Ped agroforestry, individuals of each bird species were almost evenly distributed, except *Hirundo tahitica* ( $Di = 5.99$ ) and *Streptopelia chinensis* ( $Di = 5.63$ ) which were classified as dominant (Table 1). The Similarity Index (SI) between Tembeling forest and Ped agroforestry based on bird species was 0.93. This means that the composition of bird species in the two habitats was almost the same.

### Profile and diversity of tree vegetation

Observation of vegetation profile was carried out to determine the function and utilization of habitat for birds. The profile of tree vegetation in Tembeling forest and Ped agroforestry presented in Figure 2. Tree vegetation was slightly denser in Tembeling forest than Ped agroforestry, but canopy cover was denser in Ped agroforestry, it was due to more tree branches.

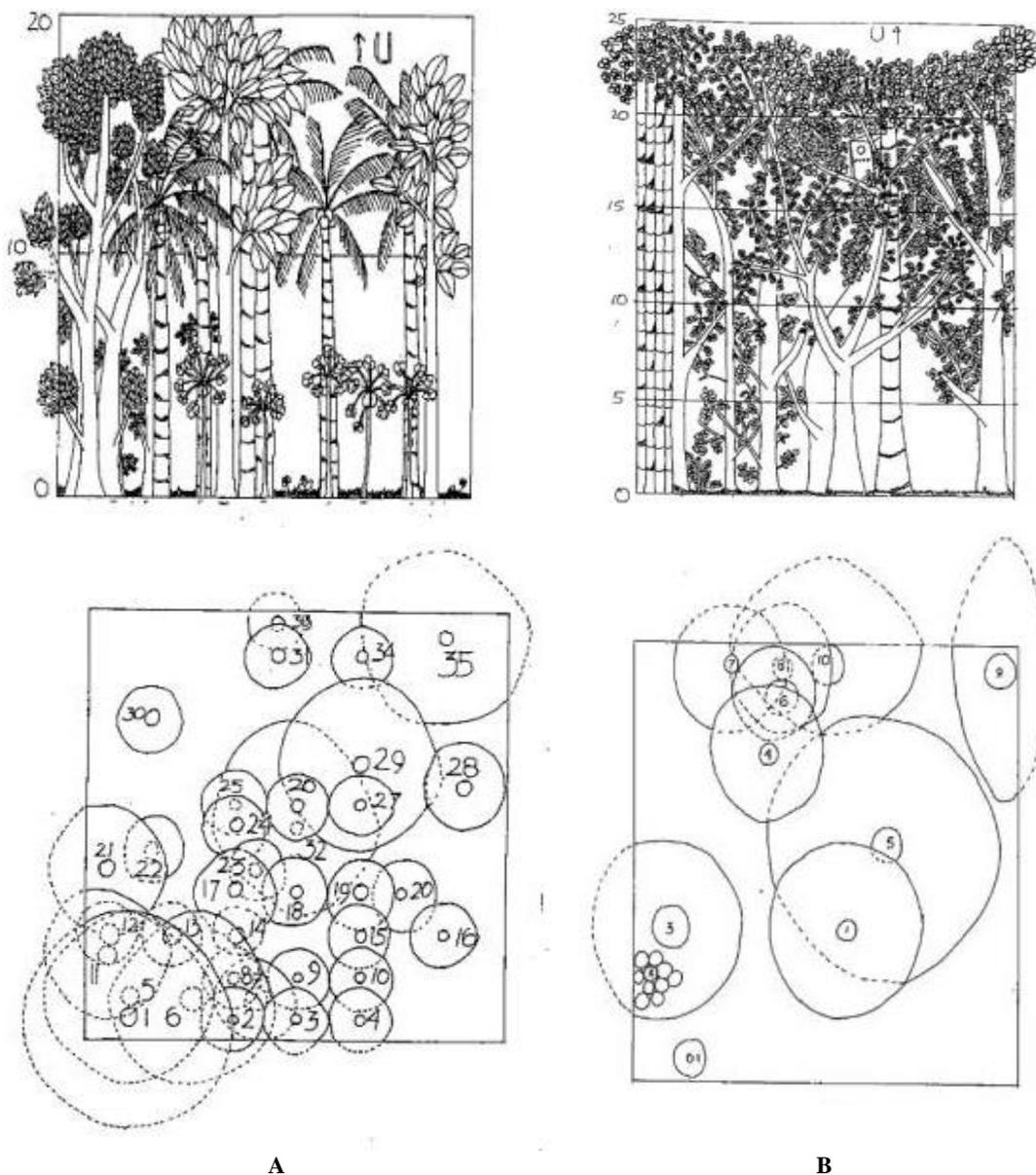
We found 25 species of trees in Tembeling forest, with a Diversity Index (H') of 2.62. The dominant species were *Swietenia macrophylla* with Index of Important Value (IIV) of 389.08%, *Azadirachta indica* (IIV = 167.61%), *Albizia saman* (IIV = 145.26%), *Tectona grandis* (IIV = 150.37%), and *Ficus glabella* (IIV = 124.06%). In Ped agroforestry, there were 22 species of trees with a Diversity Index of 2.69. *Ficus glabella* was a dominant tree species with IIV of 80.33%, followed by *Mangifera indica* (IIV = 60.62%), *Muntingia calabura* (IIV = 34.42%), *Albizia saman* (IIV = 26.88%), and *Tectona grandis* (IIV = 24.74%). The level of similarity between Tembeling forest and Ped agroforestry based on tree species was 0.81, and indicates that the composition of tree species in the two habitats was almost the same. Table 2 presents the use of trees by birds in these two study sites.

**Table 1.** Species diversity, dominant species of birds and their conservation status in Tembeling and Ped, Nusa Penida, Bali, Indonesia from January to March 2019

Common name	Scientific name	Dominance (Di)		Conservation status	
		Tembeling (%)	Ped (%)	Permen	IUCN
Javan Myna	<i>Acridotheres javanicus</i>	1.00	0.88	NP	LC
Common Myna	<i>Acridotheres tertius</i>	1.40	1.23	P	CR
Common lora	<i>Aegithina tiphia</i>	2.60	2.99	NP	LC
White Breasted Waterhen	<i>Amaurornis phoenicurus</i>	3.80	2.64	NP	LC
Brown Throated Sunbird	<i>Anthreptes malacensis</i>	0.20	0.18	NP	LC
Little Swift	<i>Apus affinis</i>	3.40	2.11	NP	LC
Little Spiderhunter	<i>Arachnothera longirostra</i>	0.20	0.18	NP	LC
White Breasted Woodswallow	<i>Artamus leucorhynchus</i>	0.60	0.53	NP	LC
Yellow Crested Cockatoo	<i>Cacatua sulphurea</i>	0.60	0.00	P	CR
Plaintive Cucko	<i>Cacomantis merulinus</i>	1.00	2.99	NP	LC
Lesser Coucal	<i>Centropus bengalensis</i>	0.60	0.53	NP	LC
Common Emerald Dove	<i>Chalcophaps indica</i>	0.60	0.53	NP	LC
Olive Backed Sunbird	<i>Cinnyris jugularis</i>	4.80	3.35	NP	LC
Edible Nest Swiftlet	<i>Collocalia fucifaga</i>	2.60	2.64	NP	LC

Glossy Swiftlet	<i>Collocalia esculenta</i>	3.80	2.29	NP	LC
Black Nest Swiftlet	<i>Collocalia maxima</i>	3.20	1.94	NP	LC
Oriental Magpie Robin	<i>Copsychus saularis</i>	0.20	0.88	NP	LC
Large Billed Crow	<i>Corvus macrorhynchos</i>	0.60	1.23	NP	LC
Asian Palm Swift	<i>Cypsiurus balasiensis</i>	1.40	1.23	NP	LC
Asian House Martin	<i>Delichon dasypus</i>	0.20	0.18	NP	LC
Fulvous Breasted Woodpecker	<i>Dendrocopos macei</i>	0.80	0.70	NP	LC
Red Chested Flowerpecker	<i>Dicaeum maugei</i>	1.80	1.58	NP	LC
Scarlet headed Flowerpecker	<i>Dicaeum trochileum</i>	1.20	1.06	NP	LC
Hair Crested Drongo	<i>Dicrurus hottentottus</i>	0.40	0.35	NP	LC
Black Drongo	<i>Dicrurus macrocercus</i>	1.40	1.23	NP	LC
Green Imperial Pigeon	<i>Ducula aenea</i>	2.20	2.82	NP	LC
Pied Imperial Pigeon	<i>Ducula bicolor</i>	1.20	0.53	NP	LC
Pacific Reef Heron	<i>Egretta sacra</i>	0.00	0.18	NP	LC
Spotted Kestrel	<i>Falco moluccensis</i>	0.20	0.18	P	LC
Christmas Frigatebird	<i>Fregata andrewsi*</i>	0.00	0.18	P	CR
Lesser Frigatebird	<i>Fregata ariel*</i>	0.00	0.18	NP	LC
Red Junglefowl	<i>Gallus gallus</i>	0.60	0.35	NP	LC
Green Junglefowl	<i>Gallus varius</i>	0.80	0.70	NP	LC
Zebra Dove	<i>Geopelia striata</i>	0.80	2.82	NP	LC
Golden Bellied Gerygone	<i>Gerygone sulphurea</i>	0.20	0.18	NP	LC
Common Hill Myna	<i>Gracula religiosa</i>	0.00	0.18	P	LC
White Bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	0.40	0.35	P	LC
Brahminy Kite	<i>Haliastur indus</i>	0.60	0.35	P	LC
Black Winged Flycatcher Shrike	<i>Hemipus hirundinaceus</i>	1.80	1.06	NP	LC
Barn Swallow	<i>Hirundo rustica*</i>	6.20	4.05	NP	LC
Pacific Swallow	<i>Hirundo tahitica</i>	5.20	5.99	NP	LC
Black Naped Monarch	<i>Hypothymis azurea</i>	0.40	0.35	NP	LC
Black Eagle	<i>Ictinaetus malaiensis</i>	0.20	0.18	P	LC
White Shouldered Triller	<i>Lalage sueurii</i>	1.20	1.58	NP	LC
Bali Starling	<i>Leucopsar rothschildi</i>	0.00	4.23	P	CR
Indonesian Honeyeater	<i>Lichmera limbata</i>	0.60	0.53	NP	LC
Long billed Dowitcher	<i>Limnodromus scolopaceus*</i>	0.20	0.18	P	LC
Javan Munia	<i>Lonchura leucogastroides</i>	0.20	1.06	NP	LC
Black Faced Munia	<i>Lonchura molucca</i>	0.20	0.18	NP	LC
Scaly Breasted Munia	<i>Lonchura punctulata</i>	2.60	3.17	NP	LC
Mees's White Eye	<i>Lophozosterops javanicus</i>	0.20	0.18	NP	LC
Chestnut Headed Bee Eater	<i>Merops leschenaultii</i>	3.00	2.99	NP	LC
Blue Tailed Bee Eater	<i>Merops philippinus</i>	4.20	4.05	NP	LC
Eurasian Curlew	<i>Numenius arquata*</i>	0.00	0.18	P	NT
Whimbrel	<i>Numenius phaeopus*</i>	0.00	0.18	P	LC
Black Naped Oriole	<i>Oriolus chinensis</i>	1.80	0.88	NP	LC
Olive Backed Tailorbird	<i>Orthotomus sepium</i>	0.20	0.18	NP	LC
Mangrove Whistler	<i>Pachycephala grisola</i>	0.20	0.18	NP	LC
Cinereous Tit	<i>Parus major</i>	3.40	2.46	NP	LC
Eurasian Tree Sparrow	<i>Passer montanus</i>	1.00	0.18	NP	LC
White Tailed Tropicbird	<i>Phaethon lepturus</i>	0.20	0.18	P	LC
Mountain Leaf Warbler	<i>Phylloscopus trivirgatus</i>	0.20	0.18	NP	LC
Bar Winged Prinia	<i>Prinia familiaris</i>	0.20	0.18	NP	LC
Black Naped Fruit Dove	<i>Ptilinopus melanospila</i>	1.20	1.06	NP	LC
Sooty Headed Bulbul	<i>Pycnonotus aurigaster</i>	3.40	3.35	NP	LC
Yellow Vented Bulbul	<i>Pycnonotus goavier</i>	4.20	4.05	NP	LC
Malaysian Pied Fantail	<i>Rhipidura javanica</i>	1.80	1.58	NP	LC
Crested Serpent Eagle	<i>Spilornis cheela</i>	0.40	0.35	P	LC
Little Tern	<i>Sterna albifrons*</i>	0.00	0.18	NP	LC
Bridled Tern	<i>Sterna anaethetus*</i>	0.00	0.18	NP	LC
Island Collared Dove	<i>Streptopelia bitorquata</i>	0.60	2.46	NP	LC
Spotted Dove	<i>Streptopelia chinensis</i>	5.60	5.63	NP	LC
Collared Kingfisher	<i>Todiramphus chloris</i>	1.80	2.11	NP	LC
Sacred Kingfisher	<i>Todirhamphus sanctus</i>	0.40	0.35	NP	LC
Pink Naped Green Pigeon	<i>Treron vernans</i>	1.00	0.88	NP	LC
Common Sandpiper	<i>Tringa hypoleucos</i>	0.00	0.18	NP	LC
Barred Buttonquail	<i>Turnix suscitator</i>	0.20	0.18	NP	LC
Lemon Bellied White Eye	<i>Zosterops chloris</i>	0.20	0.18	NP	LC
Mountain White Eye	<i>Zosterops montanus</i>	0.20	0.18	NP	LC
Oriental White Eye	<i>Zosterops palpebrosus</i>	0.20	0.18	NP	LC

Note: P = protected; NP = not protected; LC = Least Concern; NT = Near Threatened; CR = Critically Endangered; \* = migratory birds; Permen = Conservation status based on Regulation of Minister of Environment and Forestry Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018; IUCN = Conservation status according to the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species.



**Figure 2.** Tree vegetation profile in: A) Tembeling forest: *Ficus glabella* (1, 15, 11, 12, 21), *Muntingia calabura* (8-10, 14-16); *Cocos nucifera* (6, 31); *Tectona grandis* (7, 28); *Gliricidia sepium* (13, 22); *Mangifera indica* (23, 24); B) Ped agroforestry: *Albizia saman* (1-3); *Dendrocalamus asper* (2); *Ficus glabella* (4, 8, 9); *Cocos nucifera* (5); *Syzygium aqueum* (6); *Swietenia macrophylla* (7); *Ficus rumphii* (10); *Ziziphus mauritintia* (11).

## Discussion

The diversity of bird species in Ped agroforestry and Tembeling forest was high. In general, the abundance and diversity of birds were directly related to the condition of their habitat (Partasmita et al. 2017; Krisanti et al. 2017). This means that Tembeling forest and Ped agroforestry can support the lives of birds for foraging, resting, and nesting. Almost all (93%) the tree species found in both habitats provide a source of food for the birds.

*Ficus glabella* was most widely used by birds, among other trees. Trees that can provide the resources needed by various bird species, enable each stratum of the canopy to be used by certain bird species (Rahayuningsih and

Nugroho 2013; Partasmita et al. 2017). *Ficus glabella* produces fruit that is a source of food for birds, and has many branches that make it a good place for resting and nesting. *Leucopsar rothschildi*, *Acridotheres tertius*, and *Acridotheres javanicus* often used *Ficus glabella* for food, resting, and nesting. Other trees also widely used by birds were *Ficus benjamina*, *Albizia saman*, and *Muntingia calabura*. In addition to these trees, shrubs and herbs that produce nectar, fruits and seeds, such as *Datura metel*, *Lantana camara*, *Temeda arguens*, *Hoplismenus* sp., *Axonopus* sp., *Eragrostis* sp., *Kylinga monocephala*, and *Chloris barbata* were also sources of food for Bali Starling in Ped agroforestry (Ginantra et al. 2009).

**Table 2.** Tree vegetation utilization and function for birds in Tembeling forest and Ped agroforestry, Nusa Penida, Bali, Indonesia from January to March 2019

Common name	Scientific name	Utilization		Function
		Tembeling (%)	Ped (%)	
Earleaf acacia	<i>Acacia auriculiformis</i>	5.71	0	R,F
Rain tree	<i>Albizia saman</i>	18.57	13.92	R,F
Soursop	<i>Annona muricata</i>	0	11.39	R,F
Queensland-cherry	<i>Antides mabunius</i>	12.86	20.25	F
Jackfruit	<i>Artocarpus heterophyllus</i>	8.57	16.46	R,F,N
Neem	<i>Azadirachta indica</i>	10.00	11.39	R,F
Cananga tree	<i>Cananga odorata</i>	7.14	13.92	R,F
Coconut tree	<i>Cocos nucifera</i>	5.71	8.86	R
Giant bamboo	<i>Dendrocalamus asper</i>	2.86	2.53	R
Ficus tree	<i>Ficus benjamina</i>	24.29	30.38	R,F,N
White fig	<i>Ficus glabella</i>	38.57	45.57	R,F,N
Jackson fig	<i>Ficus rumphii</i>	2.86	7.59	R,F,N
Indian plum	<i>Flacourtia rukam</i>	2.86	0	R,F
Quickstick	<i>Gliricidia sepium</i>	10.00	17.72	R,F
Beechwood	<i>Gmelina arborea</i>	2.86	2.53	R,F
Giant crepe-myrtle	<i>Lagerstroemia speciosa</i>	8.57	0	R,F
Indian ash tree	<i>Lannea grandis</i>	10.00	0	R,F
Mango	<i>Mangifera indica</i>	5.71	11.39	R,F,N
Indian mulberry	<i>Morinda citrifolia</i>	4.29	10.13	R,F
Kerson fruit	<i>Muntingia calabura</i>	5.71	20.25	R,F
Indian sandalwood	<i>Santalum album</i>	0	2.53	R,F
Walik ukun	<i>Schoutenia ovata</i>	5.71	0	R,F
African tulip tree	<i>Spathodea campanulata</i>	0	5.06	R,F
Mahogany	<i>Swietenia macrophylla</i>	8.57	16.46	R,F
Watery rose apple	<i>Syzygium aqueum</i>	0	2.53	R,F
Tamarind	<i>Tamarindus indica</i>	5.71	0	R,F
Teak	<i>Tectona grandis</i>	5.71	8.86	R,F
Chinese mahogany	<i>Toona sinensis</i>	4.29	0	R,F,N
Jujube	<i>Ziziphus mauritiana</i>	2.86	3.79	R,F

Abbreviations: R = resting, F = foraging, N = nesting

Similarity of bird communities in Ped agroforestry with those in Tembeling forest was high (93%). The only difference lies in the presence of shorebirds, given that Ped's agroforestry is located near flat beaches with large tidal areas. On the other hand, Tembeling forest is located on a higher place with steep beaches and big waves, so that no shorebirds were found in this area. The shorebirds such as *Limnodromus scolopaceus*, *Numenius arquata*, *Numenius phaeopus*, *Sterna albifrons*, *Sterna anaethetus*, *Fregata ariel*, *Fregata andrewsi*, and *Hirundo rustica* are generally seasonal migratory birds. These birds usually use tidal areas for foraging. The presence of migratory birds on Nusa Penida adds to the importance of the island as a bird conservation area.

During the study, Yellow-crested Cockatoo *Cacatua sulphurea* was found only in Tembeling forest, which is protected by Permen LHK Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018 and categorized as Critically Endangered by IUCN Red List of Threatened Species. *Cacatua sulphurea* is endemic to Indonesia, the sub-species *C. s. parvula* is distributed from Nusa Penida eastwards through the Lesser Sunda chain of islands from Lombok to Alor, and Timor (Setiawan 1996). The existence of this bird in Tembeling forest is due to the presence of large trees with height between 10 to 25 m,

which are used for nesting. The big trees, among others, were: *Swietenia macrophylla*, *Ficus glabella* and *Toona sinensis*. During the survey in Nusa Penida, Setiawan (1996) noted 27 species of trees for foraging and nesting of this bird, including *Sterculia foetida*, *Ceiba petandra*, *Tamarindus indica*, and *Cocos nucifera*. In Komodo National Park, Imansyah et al. (2005) reported that this bird used large and tall trees between 7 to 20 m for nesting, such as *Sterculia oblongata*, *Corypha utan*, and *Borassus flabellifer*.

Twenty four Bali Starling *Leucopsar rothschildii* were found in Ped agroforestry. The bird is protected by Permen LHK Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018, and listed in the Critically Endangered category by IUCN Red List of Threatened Species. Bali Starling was present in Ped agroforestry after it was released by the Friends of National Park Foundation in 2005 (Sudaryanto et al. 2018). *Gracula religiosa* was also found in Ped agroforestry. This bird is protected by Permen LHK Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018 and categorized as Least Concern by IUCN Red List of Threatened Species. It is suspected that the bird escaped from its owner's cage, because its natural distribution only reached Bali Island (MacKinnon et al. 2010; Mason 2011).

All villages in Nusa Penida own and implement awig-awig that protect birds. For example, awig-awig of Ped Village (Suklaa 1987), regulates the prohibition of bird hunting, especially Bali Starling. One of the sanctions in awig-awig is paying financial fines and social sanctions for people who catch, sell, and shoot birds. This also applies to migrants who are not Hindus. Although in Nusa Penida there is an Islamic Village, namely Toyapakeh, which does not have awig-awig, their residents also obey the awig-awig of surrounding villages. Until now, there have never been residents who violated this awig-awig (Wirayudha 2007; Sudaryanto et al. 2019). The existence of awig-awig that protects all animals, especially birds, ensures the conservation of birds in Nusa Penida to be successful (Sudaryanto et al. 2019). Since formal law often fails to prevent bird hunting, awig-awig has a strategic position to conserve birds in Nusa Penida. The high diversity of birds, as well as the unique local communities in protecting birds enable Nusa Penida to be developed as a birdwatching ecotourism area.

To conclude, in Nusa Penida, there were 80 species of birds, consisting of 70 species in Tembeling forest and 79 species in Ped agroforestry. Some of these birds are protected under Permen LHK Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018 of 2018, and have Near Threatened and Critically Endangered status according to IUCN Red List of Threatened Species. The habitat in Nusa Penida is very supportive of birdlife because it can provide resources for birds for foraging, resting, and nesting. The presence of migratory birds, the conservation status, and the unique local custom to protect birds are strong reasons to propose Nusa Penida as a bird conservation area and for birdwatching ecotourism in the future.

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