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# Bird diversity in three *Ficus* species in the Kuningan Lowland Forest, West Java, Indonesia

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**Abstract.** *Hendrayana Y, Sudiana E, Adhya I, Ismail AY. 2022. Bird diversity in three* Ficus *species in the Kuningan Lowland Forest, West Java, Indonesia. Biodiversitas 23: 2255-2261.* Frugivorous birds are an important group in tropical forests, as they promote a wide diversity of plant species and animal communities via tree seed dispersal. The presence of these avifauna depends on food, such as fruits provided by *Ficus* spp. This study examined the diversity of birds in three species of fruiting *Ficus* trees located in a secondary, natural lowland forest in Mount Tilu, Kuningan, West Java, Indonesia. Bird numbers in *Ficus benjamina* L., *Ficus sinuata* Thunb., and *Ficus kurzii* King were determined using the concentration count method. The data were analyzed using the Shannon–Wiener diversity index (H′), evenness index (E), and dominance index (Simpson's D). The results showed diversity index values of H′ = 2.255, E = 0.353, and D = 0.8342 for *F. benjamina*; H′ = 2.305, E = 0.5014, and D = 0.8376 for *F. sinuata*; and H′ = 2.305, E = 0.5014, and D = 0.8694 for *F. kurzii*. The bird species with the highest number of individuals was *Pycnonotus simplex* Lesson, 1839 (378 individuals, 20.8%), followed by *Megalaima australis* (Horsfield, 1821) (320, 17.7%), *Pericrocotus flammeus* (J.R.Forster, 1781) (203, 11.2%), *Dicaeum trigonostigma* (Scopoli, 1786) (116, 6.4%) and *Pycnonotus melanicterus* (Gmelin, 1789) (109, 6,01%). By (Horsfield, 1821) knowing the important role of ficus trees as a source of food for various species of birds, this information becomes important and can be used by forest managers to support biodiversity conservation, especially bird conservation.

**Keywords:** Avifauna, conservation, frugivorous, *Ficus* spp., Mount Tilu

## INTRODUCTION

Forest destruction in Southeast Asian tropical rainforests is mostly due to anthropogenic pressure and logging activity. Among its impacts is a decrease in biodiversity, including that of birds (Atikah et al. 2021), as their species diversity is largely determined by the composition of the landscape, especially forest cover (Li et al. 2019, 2020). Khan (2017), Shah and Sharma (2022), and Jones et al. (2021) found that forest cover greatly affects biodiversity. Then, Khamcha et al. (2014), Siri et al. (2019), and Rurangwa et al. (2021) demonstrated that forest landscapes influence not only bird species diversity but also their functional and phylogenetic diversity. Bird species diversity is also influenced by microclimate conditions and variable habitats (Rajpar and Zakaria 2011; Praptiwi et al. 2019).

Decreased diversity of bird species, especially frugivorous birds in forests, has consequences for the respective ecosystem as a whole (Farwig et al. 2017), given the important role of frugivorous birds (Schupp et al. 2017; Quitián et al. 2019) as seed dispersers for various types of plants (Imai et al. 2017; Li et al. 2019, 2020). In tropical forests, most tree species rely on birds for seed dispersal, and many birds use fruits as a food resource. Accordingly, plant-frugivore interactions affect population dynamics and persistence in ecological communities (Lavabre et al. 2016). These interactions often involve many bird species, resulting in of interacting plants and birds differing in their roles in determining network organization (Corlett 2017). Network organization reflects the structure of community interactions, which may impact both ecological and evolutionary dynamics. Species with a large influence on network organization may be particularly important for species persistence (Vidal et al. 2014). Thus, differences in frugivorous bird morphology and behavior shape plant seed distribution patterns. For instance, large-bodied birds are generally recognized as keystone species because they require more food than small birds (Marjakangas et al. 2020). Food type selection is also an important attribute for frugivorous birds that determines seed dispersal (Li et al. 2019; Tobias et al. 2020).

Among the most important tree species in the tropical forests of Southeast Asia is *Ficus* spp., because most members are keystone species. These trees inhabit tropical to subtropical zones (Lomáscolo et al. 2010). The *Ficus* genus includes five major species of dicotyledon plants that are always present in Indo-Australasian and neotropical tropical forests and lowland tropical rainforests (Daru et al. 2015). *Ficus* spp. is an important food source for frugivorous birds in the tropics, as their fruits provide a source of food after the fruiting seasons of other species end (Bleher et al. 2003). Some 990 bird species use *Ficus* spp. as a food source (Sreekar et al. 2010), including 42% of the bird species in Kalimantan, Indonesia (Atikah et al. 2021). *Ficus* trees are also a source of alternative food for most tropical frugivores and omnivorous tropical birds (Pandey et al. 2021). For example, Lambert and Marshall

(1991) recorded approximately 60 bird species feeding on figs in the Malaysian lowland rainforest where the *Ficus* crop was generally depleted in less than 1 week (Vollstädt et al. 2020).

Studies have shown that *Ficus* spp. are visited by various bird species. For example, *F. thonningii* in lowland tropical forests in Southern Africa was visited by 26 bird species, as it fruits year-round, even when the fruits of other tree species are scarce (Bleher et al. 2003). Moreover, Kurnianto et al. (2017) found that 33 of 46 recorded bird species were frugivorous and visited large *Ficus* trees in the Tengger Mountain in Malang, East Java, Indonesia. Meanwhile, Pradana et al. (2018) identified 29 species of frugivorous birds on *Ficus* trees. Frugivore diversity was shown to correlate with the diversity and abundance of forage trees (Sreekar et al. 2010; Caughlin et al. 2012; Kiros et al. 2018 ). In addition, frugivorous migratory birds choose stopover locations based on food availability (Wolfe et al. 2017). According to Sanitjan and Chen (2009), the diversity of frugivorous bird species visiting *Ficus* trees is influenced by tree and canopy size. In their study in the Ungaran Mountain, Central Java, Indonesia, Priyono et al. (2021) found that *F. involucrata* was the *Ficus* species most often visited by birds. Furthermore, *F. glaberrima*, *F. macrocarpa*, and *F. involucrata*, which have smaller fruits, were visited more often (681 visits) than *Ficus* species with medium-sized fruits, such as *F. villosa*, *F. drupacea*, and *F. padana* (392 visits); overall, more bird visits were made to *Ficus* spp. with smaller fruit sizes. Similarly, frugivorous bird diversity was shown to correlate strongly with *Ficus* fruit diversity (Zietsman et al. 2019).

The lowland forest of Mount Tilu, Indonesia, is a secondary natural forest with high plant diversity. Hendrayana et al. (2019) found 12 *Ficus* spp.: *F. sundaica*, *F. virens*, *F. calophylla*, *F. kurzii*, *F. benjamina*, *F. globosa*, *F. sinuate*, *F. variegata*, *F. glandulifera*, *F. copiosa*, *F. elastica*, and *F. ampelas*. This high diversity may account for the high diversity of frugivorous birds, but the role of individual *Ficus* spp. in providing food for different bird species is unknown. Therefore, the present study examined the diversity of bird species in three *Ficus* tree species in Indonesia. The results will assist in developing measures to support bird species conservation.

## MATERIALS AND METHODS

### Study area

This study was conducted from November 2020 to February 2021 in the forest of Mount Tilu, Indonesia (07°06′12.2″-07°07′48.1″ N, 108°41′47.7″-10°41′39.0″ E). This area lies within Cimara Village, Cibingbin District, and Jabranti Village, Karangkancana District, Kuningan West Java, Indonesia. Mount Tilu is covered by lowland secondary forest dominated by members of the Euphorbiaceae and Moraceae (Hendrayana et al. 2019). The study site covers an altitude of 600-900 m above sea level (Figure 1).

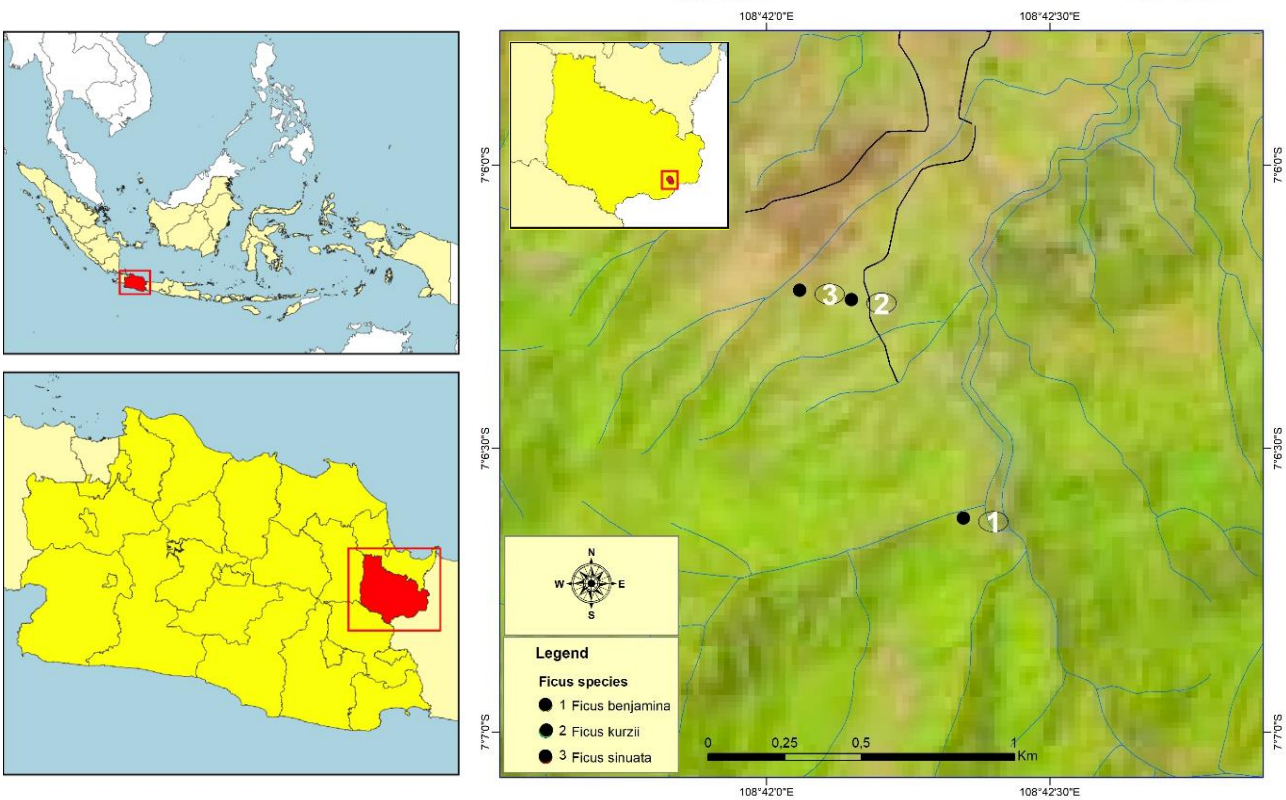


**Figure 1.** Map of the study area and sampling location in Kuningan lowland forest, West Java, Indonesia

**Procedures**

The tools used in this study included a binocular camera, timer, calculator, tally sheet and writing utensils, camera, and bird identification guide (MacKinnon et al. 2010). Observations were made using the concentration count method, which according to Lekipiou and Nanlohy (2018), can be applied to determine the population of birds in the wild whose lifestyle is concentrated in a specific place it can be observed silently by the observer. Within the study site, birds were observed in three *Ficus* spp.: *F. benjamina*, *F. sinuata*, and *F. kurzii*. The research was conducted from November 2020-February 2021, based on the fruiting season of 3 species of *Ficus*. Observations were made for 10 days of fruiting on three sample trees. Observations were made on each sample tree for 10 hours from 7.00 am to 5.00 pm, each hour, only observations were made for 30 minutes by counting the number of individuals and the number of bird species present. Each tree is observed by an observer trained as a bird watcher, so a total of 3 observers, at the time of observation, the observer's position is protected from the view of the observed birds. Each observer was provided with a camera, a bird identification book (MacKinnon et al. 2010), and a bird voice recorder. However, when the sampling took place, it generally rained at the location, so observations were only made until 15.00 in the afternoon. During the observation period, the bird species, and the number of individual birds, were recorded.

**Sampling method**

Sampling location selection using the purposive method, namely determining the sampling location based on the existing ficus tree species. Based on the presence of figs trees, three sampling locations were found, namely *F. benjamina*, *F. sinuata*, and *F. kurzii*.

**Description of the three studied *Ficus* species**

1. *Ficus benjamina*, concentrated at 7°6′37.35″ S and 108°42′20.86″ E, is a tall tree with a typical height of 15 m and a diameter of 100 cm. It bears fruit 2 to 4 times a year (Corlett 1984). The trees in this study were located at the border between forest and rice fields in a valley and close to a river (Figure 2).
2. *Ficus sinuata*, concentrated at 7°6′13.27″ S and 108°42′3.5″ E, has a typical height of 13 m and diameter of 60 cm and bears fruit three times a year. The trees in this study were located along the border between a production forest and a protected forest (Figure 3)
3. *Ficus kurzii*, which is located at a geographical position of 7°6'13.27"S and 108°42'3.5"E. Habitus is a tall tree up to more than 30 meters. Coarse leaves arranged in a spiral, elliptical to oval. Paired fruits appear in the axils of the leaves, 1-2 cm in diameter, dark red, purple or black (Mulyani et al. 2021) (Figure 4).

**Data analysis**

The total diversity of the birds visiting the three investigated *Ficus* species was analyzed using the Shannon-Wiener index (H′), an indicator of the relationship between species richness and species abundance at a given location. The index is calculated as follows (Magurran 2004):

$$H' = -\sum P_i Ln P_i$$

Where $P_i$ is the number of birds per species divided by the total number of species.

The evenness index (E) is used to determine the evenness of the number of individuals that make up a community. It is calculated from H′ as follows (Magurran 2004):

$$E' = \frac{H'}{\ln(S)}$$

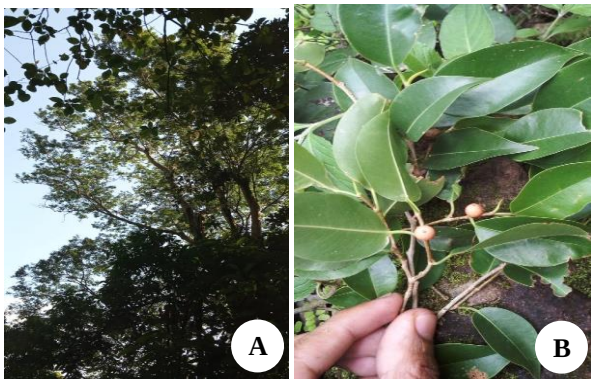


**Figure 2.** *Ficus benjamina*: A. Tree, B. Fruit


**Figure 3.** *Ficus sinuata*: A. Tree, B. Fruit


**Figure 4.** *Ficus kurzii*: A. tree, B. fruit

Simpson's dominance index (D) ranges from 0 to 1, where a smaller value indicates that there is no dominant species and a larger value indicates the dominance of a species (Odum 1993):

$$D = \Sigma (ni/N)^2$$

Where ni is the number of individuals per species and N is the number of individuals of all species.

Differences in bird diversity among the three *Ficus* species were calculated based on the beta-diversity, as expressed by the Morisita-Horn similarity index.

## RESULTS AND DISCUSSION

### Bird diversity among *Ficus* species

During 30 days of observation of the three *Ficus* species, 1,811 birds belonging to 21 families and 43 species were recorded (Table 1). The values of H′, E, and D were 2.255, 0.353, and 0.8342 at *F. benjamina*, 2.305, 0.5014, and 0.8376 at *F. sinuata*, and 2.305, 0.5014, and 0.8694 at *F. Kurzii* respectively The largest number of birds were found at *F. benjamina* (28 species), followed by *F. sinuata* (20 species) and *F. kurzii* (19 species). This finding agrees with other studies of bird diversity in *Ficus* trees. For instance, in their study of 12 *Ficus* species in Nigeria, Daru et al. (2015) identified 48 bird species, with 12-48 species visiting each tree species. Meanwhile, in the Tengger Mountains of East Java, (Kurnianto et al. 2017) reported 46 bird species visiting one *Ficus* tree species. Rahayuningsih et al. (2020) and Priyono et al. (2021) studied bird diversity by surveying *Ficus* trees based on fruit size in the Ungaran Mountain, Central Java, Indonesia, and recorded 29 bird species from 16 families. In urban areas, *Ficus* trees provided foraging and nesting sites for 12 bird species (Pradana et al. (2018). Factors driving the usage of a particular *Ficus* species might include tree density and fruit phenology, color, nutritional value, and size (Bleher et al. 2003; Gagetti et al. 2016). Differences in the number of visiting bird species may be due to differences in tree habitus, fruit shape, and fruit color. Almanaz-Núñez et al. (2021) suggested that tree structure, fruit color, and fruit size affect the presence of frugivorous bird species in trees in the forests of Mexico. In Southeast Asia, frugivorous bird diversity was influenced by fruit size and tenderness, with more types of fruits consumed by birds with larger body sizes than by small birds (Imai et al. 2017).

### Bird species composition

Of the 22 bird families identified, nine were represented by more than one species. The family with the most species was Pycnonotidae (six species), followed by Dicaeidae, Columbidae, and Nectariniidae (four species each), Megalaimidae, Campephagidae, and Cuculidae (three species each), and Sylviidae and Dicruridae (two species each); other families consisted of only one species each. The six Pycnonotidae species were *Pycnonotus simplex*, *P. melanicterus*, *P. brunneus*, *P. aurigaster*, *P. atriceps*, and *P. plumosus*; six species were found on *F. benjamina*, five on *F. sinuata*, and four on *F. kurzii*. This distribution reflects the features of the Pycnonotidae family, which consists of generalist frugivorous birds with a flexible feeding behavior that allows them to eat fruits from a broad range of plants (Li et al. 2019, 2020). Members of the Pycnonotidae are an important component of tropical rainforest ecosystems and often exhibit differences associated with vegetation structure and composition. They are ecologically diverse and occupy a wide array of habitats. Corlett (2017) and Shakya and Sheldon (2017) showed that Pycnonotidae is an important frugivorous family in forest areas in Southeast Asia, as these birds disperse a wide variety of forest plant seeds.

Bird species depend on vegetation structure and composition (e.g., trees, shrubs, and herbs) as well as food resources for their survival and reproduction, and are sensitive to habitat alterations (Azman et al. 2011; Rajpar and Zakaria 2011; Khan 2017; Siri et al. 2019; Shah and Sharma 2022) Family Columbidae consists of 4 species found, this species belongs to the category of species that eat fruit and seeds, so it is easily found on figs trees (Adang, et al. 2008), Family Megalaimidae with 3 species, namely: *Megalaima australis*, *M. javensis* and *M. armillaris*. According to Chang et al. (2012), Asian barbets are primarily frugivorous, feeding on a variety of tree fruits and playing an important role in seed dispersal, which accounts for their frequent detection on *Ficus* trees (Rajpar and Zakaria 2011; Trounov and Vasilieva 2014; Rahayuningsih et al. 2020).

### Discussion

Of the 44 bird species found in *Ficus* trees, four occurred in all three species, 13 only in *F. benjamina* and *F. sinuata* ($I_{SM}$ = 0.332), six only in *F. benjamina* and *F. kurzii* ($I_{SM}$ = 0.3442), and four only in *F. sinuata* and *F. kurzii* ($I_{SM}$ = 0.1918). Nine species were unique to *F. benjamina*, six to F. *sinuata*, and nine to *F. kurzii*. These differences may result from different vegetation structures or habitat types around the trees (Imai et al. 2017; Kurnia et al. 2021). Chen (2018) showed that the habitat of trees providing food for birds affects the diversity of bird species visiting the trees, and forage trees surrounded by shrubs tend to have a higher bird species diversity than forage trees in secondary forests. In their study of former tea plantations in West Java, (Partasasmita et al. 2017) recorded a higher number of bird species in food-providing trees located adjacent to shrubs. Furthermore, the diversity of tree species in a habitat will also affect the diversity of visiting bird species (Ayat and Tata 2015; Rohman et al. 2020). In this study, *F. benjamina* trees were located on the border between forest and paddy fields such that the trees served as a perching place for birds to either look for food or rest. Similarly, *F. sinuata* trees were located at the border between the production forest and secondary forest.

**Table 1.** Bird species richness and the total number of the individual at three *Ficus* species

| Family | Species | Local Name | *Ficus benjamina* | *Ficus sinuata* | *Ficus kurzii* | Total | Feeding guilds |
|---|---|---|---|---|---|---|---|
| Pycnonotidae | *Pycnonotus simplex* | Merbah corok-corok | 279 | 28 | 71 | 378 | Frugivore, Insectivore |
| | *Pycnonotus atriceps* | Cucak kuricang | 22 | - | 6 | 28 | Frugivore, Insectivore |
| | *Pycnonotus melanicterus* | Cucak kuning | 108 | 1 | - | 109 | Frugivore, Insectivore |
| | *Pycnonotus brunneus* | Merbah mata-merah | 49 | 6 | 2 | 57 | Frugivore, Insectivore |
| | *Pycnonotus aurigaster* | Cucak kutilang | 27 | 18 | - | 45 | Frugivore, Insectivore |
| | *Pycnonotus plumosus* | Merbah belukar | 9 | - | 1 | 10 | Frugivore, Insectivore |
| Dicaeidae | *Dicaeum trigonostigma* | Cabai bunga-api | 50 | 32 | 34 | 116 | Frugivore |
| | *Dicaeum concolor* | Cabai polos | 11 | - | 33 | 44 | Frugivore |
| | *Prionochilus percussus* | Pentis pelangi | 1 | - | - | 1 | Frugivore |
| | *Dicaeum trochileum* | Cabai jawa | - | 1 | - | 1 | Frugivore |
| Columbidae | *Macropygia emiliana* | Uncal buau | 4 | 1 | - | 5 | Grainivore |
| | *Treron griseicauda* | Punai pengantin | 3 | - | - | 3 | Frugivore |
| | *Streptopelia tranquebarica* | Tekukur merah | 2 | - | - | 2 | Grainivore |
| | *Treron vernans* | Punai gading | - | 76 | - | 76 | Frugivore |
| Nectariniidae | *Aethopyga siparaja* | Burung-madu sepah-raja | 7 | - | - | 7 | Nectarivore |
| | *Aethopyga mystacalis* | Burung-madu jawa | 2 | - | - | 2 | Nectarivore |
| | *Nectarinia jugularis* | Burung-madu sriganti | - | - | 12 | 12 | Nectarivore |
| | *Arachnothera affini* | Pijantung gunung | - | - | 6 | 6 | Nectarivore |
| Megalaimidae | *Megalaima australis* | Takur tenggeret | 80 | 240 | - | 320 | Frugivore |
| | *Megalaima javensis* | Takur tulung-tumpuk | 2 | - | 22 | 24 | Frugivore |
| | *Megalaima armillaris* | Takur tohtor | 24 | 49 | - | 73 | Frugivore |
| Campephagidae | *Pericrocotus flammeus* | Sepah hutan | 97 | 35 | 71 | 203 | Insectivore |
| | *Hemipus hirundinaceus* | Punai gading | 32 | 19 | - | 51 | Insectivore |
| | *Tephrodornis gularis* | Jinjing petulak | 1 | - | - | 1 | Insectivore |
| Cuculidae | *Phaenicophaeus javanicus* | Kadalan kembang | - | 14 | - | 14 | Insectivore |
| | *Phaenicophaeus curvirostris* | Kedalan birah | 3 | - | - | 3 | Insectivore |
| | *Surniculus lugubris* | Kedasi hitam | - | 6 | - | 6 | Insectivore |
| Sylviidae | *Orthotomus ruficeps* | Cinenen kelabu | 4 | - | - | 4 | Insectivore |
| | *Orthotomus sutorius* | Cinenen pisang | 2 | - | - | 2 | Insectivore |
| Dicruridae | *Dicrurus leucophaeus* | Srigunting kelabu | 1 | - | 14 | 15 | Insectivore |
| | *Dicrurus macrocercus* | Srigunting hitam | 3 | 54 | - | 57 | Insectivore |
| Pellorneidae | *Turdinus sepiaria* | Pelanduk semak | - | - | 16 | 16 | Insectivore |
| Aegithinidae | *Aegithina tiphia* | Cipoh kacat | 3 | 34 | - | 37 | Grainivore |
| Monarchidae | *Hypothymis azurea* | Kehicap ranting | 1 | 2 | - | 3 | Insectivore |
| Zosteropidae | *Zosterops flavus* | Kacamata jawa | - | 30 | - | 30 | Frugivore, Insectivore |
| Psittacidae | *Loriculus pusillus* | Serindit jawa | - | 27 | 3 | 30 | Insectivore |
| Accipitridae | *Spilornis cheela* | Elang-ular bido | - | 9 | - | 9 | Carnivore |
| Timaliidae | *Mixornis flavicollis* | Ciung-air jawa | - | - | 24 | 24 | Insectivore |
| Halcyonidae | *Halcyon cyanoventris* | Cekakak jawa | - | - | 6 | 6 | Insectivore |
| Estrildidae | *Lonchura leucogastroides* | Bondol jawa | - | - | 5 | 5 | Grainivore |
| Eurylaimidae | *Eurylamus javanivus* | Sempur-hujan raja | - | - | 1 | 1 | Frugivore |
| Meropidae | *Merops leschenaultia* | Kirik-kirik senja | - | - | 1 | 1 | Insectivore |
| Pittidae | *Pitta guajana* | Paok pancawarna | - | - | 1 | 1 | Insectivore |
| | | Taxa_S | 28 | 20 | 19 | | |
| | | Individuals | 827 | 682 | 329 | | |
| | | Shannon_H | 2,255 | 2,305 | 2,328 | | |
| | | Evenness_e^H/S | 0,353 | 0,5014 | 0,5399 | | |
| | | Simpson_1-D | 0,8342 | 0,8376 | 0,8694 | | |

As shown by Bleher et al. (2003), Kurnianto et al. (2017), and (Pradana et al. 2018), the birds found in the three types of *Ficus* trees belonged to different feeding guilds, with insectivores accounting for 17 species, frugivorous–insectivorous birds for eight species, frugivores for nine species, granivores for five species, for four species, and carnivores for one species. The larger number of insectivorous birds compared to other feeding guilds can be explained because most of these birds are bush birds. Moreover, insects are much more abundant than other food types and are readily found in various parts of plants, such that insects commonly serve as the main food or as an alternative when the availability of other food sources is reduced (Partasasmita et al. 2009). *Ficus* spp. is inhabited by insects recognized as both pests and pollinators. In their study of insects on *F. benjamina* trees in Xishuangbanna, China, Yang et al. (2008) found 65 species belonging to 40 genera and 23 families. According to Mifsud et al. (2012), some insects are found in *Ficus* trees and use *Ficus* trees as their main food source throughout their adult development.

Based on the abundance data, only five bird species were dominant in the three investigated *Ficus* species. This result was confirmed by the D values of 0.8342 in *F. benjamina*, 0.8376 in *F. sinuata*, and 0.8694 in *F. kurzii*. Of the 44 bird species we detected, the species with the highest number of individuals was *P. simplex* (378 individuals, 20.8%), followed by *M. australis* (322, 17.7%), *Pericrocotus flammeus* (203, 11.2%), *Dicaeum trigonostigma* (116, 6.4%) and *P. melanicterus* (109, 6.01%). Fourteen species accounted for 1-6%, and 23 for < 1%. Most of the dominant species were found in *F. benjamina*, except for *D. trigonostigma*, which was highly dominant in *F. sinuata*. The results of this study may be due to the bird's preference for tree heights and surrounding habitats. However, the results of this study differ from those of Azman et al. (2011), which found that the number of dominant species was higher in forest habitats than in paddy fields, as well as the number of unique species, i.e., species occupying only one tree. Therefore, the results of this study are very important for designing bird conservation in an area. Bird conservation in a forest area can be based on ficus trees' diversity and variations in fruiting time. Forest managers can use the method of planting *Ficus* trees with different species as intermediaries in the managed forest area.

In conclusion, our study showed that three *Ficus* species supported 43 bird species, and different bird species favored each tree species. Therefore, conservation managers can use the results of this study to enact measures to increase bird diversity in the Mount Tilu protected forest area of Indonesia.

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