Bird diversity analysis in the lower mountain forest of mount Bulusaraung to support ecotourism’s activities in Bantimurung Bulusaraung National Park

A Achmad¹, U Damayanti² and R I Maulany¹

¹Forest Conservation Study Program, Faculty of Forestry, Hasanuddin University, Makassar 90245, Indonesia
²Jeneberang Saddang River Basin and Protected Forest Management Center, Ministry of Environment and Forestry, Makassar 90242, Indonesia

Email: amhutan@yahoo.com

Abstract. Lower mountain forest in the complex of Mount Bulusaraung Bantimurung Bulusaraung National Park, is a one of bird’s habitat in the South Sulawesi. This area is a tourist destination, especially mountain climbing activities. Thus, it is necessary to know the diversity of animals, especially birds on this hiking trail, so that the information can be used to support ecotourism activities. This study aims to analyze the diversity of bird species in the complex of Bulusaraung Mountain, Bantimurung Bulusaraung National Park in order to support ecotourism activities. This research was conducted from April to June 2018. Data was collected using the line transect method on three lines, namely the Balleanging, Kattokaddaro and Tompobulu lines. The second and third paths are hiking trails, while the rest are trails leading to community agricultural areas. The geographical position of the transect line was recorded using GPS. The GIS method was used to generate a bird watching trail map. Data analysis was carried out to calculate the individual density and frequency of bird presence. In addition, the species diversity indices, species evenness indices, and species richness indices were also calculated. The results showed that there were 44 species of birds found in the study area, which were 16 species in the Balleanging line, 27 species in the Kattokaddaro line and 37 species in the Tompobulu line. The highest bird species diversity indices value was found on the Tompobulu line (H’ = 2.93), while on the Kattokaddaro line it was H’ = 2.73 and the Balleanging H’ = 2.55. The results of this study will support the management strategy in Bantimurung Bulusaraung National Park in order to harmonize the conservation of biological resources through ecotourism activities that involve local communities to increase their economic income.
1. Introduction
As a component of the ecosystem, birds have a reciprocal and interdependent relationship with their environment [1]. On the basis of these roles and benefits, the existence of birds in the ecosystem needs to be preserved [2,3]. Birds have a very important role for the continuity and sustainability of forests ecosystem, because they help plants to regenerate both as seed dispersers, pollinating plants, as well as controlling certain insects [1–7]. Birds are also a source of germplasm that can provide distinct feature for the wealth of fauna in Indonesia [2,8]. Most birds fly, active throughout the day and very mobile, making it easily visible and recognizable among other animals [1,9]. Their mobility also supports them to leave areas where resources are no longer sufficient to find other habitats, so birds can be an indicator of the health of an ecosystem [1,10]. Although in general these animals can occupy all types of habitats, from the equator to the polar regions, but lowland rainforest and lower montane forest are their main habitats [11].

Indonesia as a country with the highest endemicity level in the world [10,12]. The Wallaceae region is grouped into three main island groups called sub-regions, namely (1) the Sulawesi sub-region; (2) Maluku sub-region; (3) Nusa Tenggara sub-region [12]. Sulawesi and the surrounding small islands have 96 endemic bird species out of 380 bird species on the island, and 115 of them are endemic to Indonesia [13,14].

Lower montane forest ecosystems can be found at an altitude of 750-1,500 meters above sea level [15,16]. Due to its proximity to intensively exploited lowland forests, lower montane forests currently face many threats to their sustainability so that these ecosystems are globally seen as important ecosystems for biodiversity conservation [17,18]. This ecosystem is also known as one of the ecosystems with abundant biodiversity, where in its area many species of ferns, mosses, orchids, and epiphytes are found, canopy smaller and lower in tree height compared to trees in lowland forest [16,19–21].

Mount Bulusaraung, which has a height of 1,353 meters above sea level, is part of the Bantimurung Bulusaraung National Park. Mount Bulusaraung is a climbing tourism area by nature lovers and has been planned as an ecotourism development area by the park manager [22]. The forest area on Mount Bulusaraung consists of lowland forest and lower mountain forest, so this area is one of the important biodiversity protection areas in the Wallaceae region [23,24]. The existence of landscapes in the form of lowland forest and lower mountain forests in the Mount Bulusaraung, is one of the factors that makes Bantimurung Bulusaraung National Park a potential habitat for various types of birds [25]. The lower mountain forest of Mount Bulusaraung itself is also known as one of the ecosystems rich in biodiversity including birds [19,26].

As a tourist area for mountain climbers, it is necessary to utilize biodiversity resources, both flora and fauna to support tourism development plans that will combine mountain tourism activities with ecobiological tourism or known as ecotourism. To develop the climbing route of Mount Bulusaraung into a place for ecotourism site, one of the important information on animal diversity to be studied is bird diversity. This is because birds are the most frequently seen along the hiking trail. This study aims to analyze the diversity of bird species on hiking trails in the Lower Mountain Forest in Mount Bulusaraung Complex as an effort to support the development of ecotourism in Bantimurung Bulusaraung National Park.

2. Research method
2.1. Study site
This research was carried out in the Lower Mountain Forest of Mount Bulusaraung Complex at an altitude between 750 m to 1,353 m above sea level. The study area includes the area of the Bantimurung Bulusaraung National Park in the Pangkep Regency, South Sulawesi Province. Field data collection was carried out from April to June 2018.

2.2. Data collection and analysis
The line transect method was used to collect data on the number of individual birds encountered and the perpendicular distance from the line transect to the individual birds seen. Every 100 m distance is
marked as a sub-line of observation to accommodate the calculation of the frequency of presence of a bird species. Line transects are placed starting from an altitude of 750 m above sea level as the lower boundary of lower montane forest on three observation lines in the form of walking trails [15,16]. Two observation lines (Kattokaddaro and Tompobulu trail) lead to the peak of Mount Bulusaraung, while the rest (Balleangin trail) lead to the community garden is only 950 meters above sea level (Figure 1). Although the highest point of this observation line is below 1,353 meters above sea level, this path is still within the coverage of the lower mountain forest area [15,16]. The Balleangin transect consists of four sub-line transects with a total length of 400 meters with an altitude position between 750 m asl - 950 m above sea level, the Kattokaddaro transect with 11 sub-line transects with a total length of 1,100 meters with a position elevation between 750 m asl - 1,100 m above sea level, while the Tompobulu transect consists of 24 sub-line transects with a total length of 2,400 meters with an altitude position between 750 m asl - 1353 m asl. Bird inventory is carried out three times a day, namely in the morning from 06.00 - 11.00, noon from 13.00 - 15.00 and afternoon from 16.00 - 18.00. Data collection was carried out three times in each lane. Qualitative analysis was used to describe the habitat, while quantitative analysis was used to calculate the observed sample area, density and frequency of presence of each species, as well as richness, diversity and evenness indices [27].

![Figure 1. Map of research site in the Mount Bulusaraung complex](image)

3. Results

3.1. Birds species and distributions

In this study, 44 species of birds were recorded, consisting of 27 families, but there were differences in the number of species found in each line. In the Balleangin line, there were 16 species, 27 species in the Kattokaddaro, and 37 species in the Tompobulu. A total of nine species were found spread over three lines of observation, the rest were found in one and two lines. There is one species that is only found on the Balleangin line, five species only on the Katokkaddaro line and 13 species only on the Tompobulu
line. The number of individuals of each species found during the three observations on each path was also different. In the Balleangin 32 individuals were found, in the Kattokadaro 94 individuals, and in the Tompobulu 171 individuals. However, in presenting population estimates data (Table 1), the largest number of individuals is used from the three observations. From Table 1, it can be seen that as many as 26 species out of 44 existing species are grouped into important species because they are endemic and protected, namely 11 endemic species, three protected species, and seven endemic and protected species. However, the distribution of these 21 important species was uneven across all transects.

Table 1 also shows the grouping of bird species based on their distribution in three locations. Group one shows species that can be found on all transect lines. Only 11 species of birds are included in this group. Of the 11 species, five are important, namely the Yellow-sided Woodpecker, Olive-backed Sunbird, Bay Coucal, Spotted Kestrel and White-eye Lemon-throated. The second group is bird species that are only found on the Balleangin and Kattokadaro transects, where in this group there is only one species and is an important species, namely the Brown Boobook. The third group is bird species that are only distributed on the Kattokadaro and Tompobulu transects. A total of 10 species are included in this group, of which six are important species, namely Small Sparrow-hawk, Yellow-billed Malkoha, Black Eagle, Sulawesi Serpent-eagle, Ashy Woodpecker and Geomalia. The fourth group is a bird group that only spreads on the Balleangin and Tompobulu transects. Three species were found in this group, two of which are important species, namely the Knobbed Hornbill and the Sulawesi Hornbill. The fifth group is bird species found only on the Balleangin transect. There is only one species found in this group and is also an important species, namely the Whire-rumped Cuckoo-shrike. The sixth group is a bird species found only on the Kattokadaro transect. There are five species found in this group and all of them are important species, namely Pele-bellied White-eye, Collared Kingfisher, Sulawesi Owl, Finch-billed Myna and Fiery-browed Myna. The last group is a group of birds that are only found on the Tompobulu transect. A total of 13 species were recorded in this group, of which seven are important species, namely Grey-sided Flowerpecker, Black Sunbird, Spot-tailed Goshawk, Rufous-bellied Eagle, Sulawesi Drongo, Rusty-bellied Fantail and Scaly-breasted Kingfisher.

3.2. Density and frequency of presence of each species

The value of density and frequency of presence of a species is presented based on the average value of three repetitions of observations (morning, noon and afternoon). There are differences in the density values and the frequency of presence on each transect line. Table 2 shows the average value of species density and the average value of the frequency of species presence on the three transect lines.

Table 1. The distribution of the highest individuals in three observations of bird species at the study site.

| No. | Common Names     | Scientific Name  | Family        | Individual Number |
|-----|------------------|------------------|---------------|-------------------|
| 1   | Barn Swallow     | Hirundo rustica  | Hirundinidae  | B: 1 K: 11 T: 25  |
| 2   | Pacific Swallow  | Hirundo tahitica | Hirundinidae  | B: 1 K: 25 T: 35  |
| 3   | Glossy Swiftlet  | Collocalia esculenta | Apodidae  | B: 3 K: 7 T: 16  |
| 4   | Yellow-sided flowerpecker | Dicaeum aureolimbatum | Dicaeidae  | B: 4 K: 1 T: 6  |
| 5   | Sooty-headed Bulbul | Pycnonotus aurigaster | Pycnonotidae | B: 2 K: 5 T: 13  |
| 6   | Olive-backed Sunbird | Nectarinia jugularis | Nectariniidae | B: 1 K: 3 T: 3  |
| 7   | Bay Coucal      | Centropus celebensis | Cuculidae  | B: 2 K: 6 T: 2  |
| 8   | Spotted Kestrel  | Falco moluccensis | Falconidae  | B: 2 K: 2 T: 1  |
| 9   | Hair-crested Drongo | Dicurus hottonotus | Dicuridae  | B: 1 K: 3 T: 2  |
| 10  | Lemon-throated White-eye | Zosterops anomalus | Zosteropidae | B: 7 K: 7 T: 9  |
| 11  | Red Junglefowl  | Gallus gallus     | Phasianidae  | B: 1 K: 1 T: 2  |
| 12  | Brown Boobook   | Ninox scutulata   | Strigidae  | B: 1 K: 1 T: 2  |
| 13  | Small Sparrow-hawk | Accipiter nanus  | Accipitridae | B: - K: 2 T: 1  |
| 14  | Yellow-billed Malkoha | Phaenicophaeus calyornychus | Cuculidae  | B: - K: 4 T: 6  |
| 15  | Black Eagle     | Ictinaetus malayensis | Accipitridae | B: - K: 1 T: 1  |
| 16  | Sulawesi Serpent-eagle | Spilornis rufipiceps | Accipitridae | B: - K: 1 T: 2  |
| 17  | Ashy Woodpecker | Mulleripicus fulvus | Picidae  | B: - K: 2 T: 1  |
| No. | Common Names                          | Average Individual Density Per Hectare | Average Frequency of Occurrence (%) |
|-----|--------------------------------------|---------------------------------------|--------------------------------------|
|     |                                      | B          | K          | T          | B          | K          | T          |
| 1   | Barn Swallow                         | 0.33       | 6.08       | 7.65       | 2.78       | 15.15      | 13.89      |
| 2   | Pacific Swallow                      | 0.62       | 14.38      | 11.17      | 5.56       | 31.31      | 20.37      |
| 3   | Glossy Swiftlet                     | 1.72       | 3.85       | 5.09       | 13.89      | 23.23      | 21.30      |
| 4   | Yellow-sided flowerpecker           | 3.32       | 0.13       | 1.87       | 27.78      | 1.01       | 12.96      |
| 5   | Sooty-headed Bulbul                  | 1.46       | 1.25       | 3.47       | 5.56       | 4.04       | 14.35      |
| 6   | Olive-backed Sunbird                | 1.01       | 0.77       | 1.05       | 8.33       | 3.03       | 7.41       |
| 7   | Bay Coucal                          | 2.53       | 4.08       | 0.54       | 22.22      | 26.26      | 5.09       |
| 8   | Spotted Kestrel                      | 1.26       | 0.77       | 0.49       | 11.11      | 6.06       | 4.17       |
| 9   | Hair-crested Drongo                 | 1.97       | 1.72       | 0.51       | 16.67      | 13.13      | 3.70       |
| 10  | Lemon-throated White-eye             | 8.28       | 3.89       | 2.85       | 38.89      | 17.17      | 17.13      |
| 11  | Red Junglefowl                      | 0.36       | 0.25       | 0.38       | 2.78       | 2.02       | 2.78       |
| 12  | Brown Boobook                       | 0.93       | 0.13       | -          | 1.01       | 11.11      | -          |
| 13  | Small Sparrow-hawk                   | -          | 0.50       | 0.30       | -          | 4.04       | 2.31       |
| 14  | Yellow-billed Malkoha               | -          | 2.70       | 2.01       | -          | 21.21      | 11.57      |
| 15  | Black Eagle                          | -          | 0.63       | 0.31       | -          | 5.05       | 2.31       |
| 16  | Sulawesi Serpent-eagle              | -          | 0.39       | 0.20       | -          | 3.03       | 1.39       |
| 17  | Ashy Woodpecker                     | -          | 1.16       | 0.19       | -          | 9.09       | 0.93       |
| 18  | Citrine Flycatcher                  | -          | 0.25       | 0.47       | -          | 2.02       | 3.70       |
| 19  | Sulawesi Hornbill                   | -          | 0.39       | 0.36       | -          | 3.03       | 3.24       |
| 20  | Black-naped Monarch                 | -          | 0.28       | 0.76       | -          | 2.02       | 5.09       |
| 21  | Geomalia                            | -          | 0.51       | 0.90       | -          | 4.04       | 5.56       |
| 22  | Tree Sparrow                        | -          | 0.63       | 2.26       | -          | 3.03       | 5.56       |
| 23  | Black-sided Flowerpecker           | 2.97       | -          | 0.24       | 19.44      | -          | 1.85       |

Note: B = Balleangin line transect, K = Kattokaddaro line transect, T = Tompobulu line transect; 
E = Endemic; P = Protected

**Table 2.** The average value of density and the average value of the prevalence of the presence of bird species in the study site.
Lemon-throated White-eye with endemic status had the highest density value on the Balleangin transect (8.28 individuals/ha), but decreased on the Kattokaddaro and Tompobulu transects, which were only 3.89 individuals/ha and 2.85 individuals/ha. Likewise, the occurrence frequency value was 38.89% on the Balleangin transect, 17.17% on the Kattokaddaro transect and 17.13% on the Tompobulu transect. Another species that has a high density value is the Pacific Swallow. This species has the highest density on the Kattokaddaro transect, which is 14.38/ha, in the Tompobulu transect 11.17/ha, and on the Balleangin transect 0.62/ha. While the frequency of its presence tends to follow the pattern of density values, namely 31.31% on the transect. Katokkaddaro, 20.37% on the Tompobulu transect and 5.56% on the Balleangin transect. Of the 26 species which are important species, only Lemon-throated White-eye has the highest yield compared to the others. The remaining 25 species have density values between 0.07 - 4.08 individuals/ha. Only seven of them have more than one individual density, namely Yellow-sided flowerpecker, Bay Coucal, Spotted Kestrel, Yellow-billed Malkoha, Ashy Woodpecker, Knobbed Hornbill and Sulawesi Hornbill.

However, the average value in Table 2 does not show how detailed the distribution of density values and frequency of bird presence is based on the time of data collection (morning, noon and afternoon). In fact, not all birds recorded during this study could be found throughout the day from morning to afternoon. There are bird species that are only found at certain times, for example only in the morning, or only found in the morning. Figure 2 shows the percentage of the number of birds found based on the time of observation on the three transect lines. In the three transect lines, it shows that about 40-41% of bird species from the total birds found on each line can be found throughout the day from morning to afternoon. However, for the remaining 60% of species, their presence varies based on the time of observation on each transect line.
Figure 2. Percentage of bird presence by time on the (a) Balleangin, (b) Kattokaddaro and (c) Tompobulu transect.
Based on the percentage values in Figure 2, it can be seen that of the 16 species found on the Balleangin transect, six of them can be found throughout the day (morning, noon and afternoon), one species is only found in the noon and afternoon, three species are only found in the morning and afternoon. In addition, two species were only found in the afternoon, and three species were only found in the morning. On the Kattokaddaro transect where 27 species were found, 11 species were found throughout the day, six species could be found only in the noon and afternoon, two species were only found in the morning and afternoon. In addition, three species were only found in the afternoon, one species was only found in the noon, and four species were only found during morning.

On the Tompobulu transect where 37 species were found, 15 of them were found in the morning, afternoon and evening, five species were only found in the noon and afternoon, five species were only found in the morning and afternoon, four species were only found in the morning and noon. In addition, two species each, only found in the afternoon and evening, and three species only in the morning.

From Figure 2 it is also known that 40 - 41% of the birds that can be seen throughout the day are birds with a high potential to be seen by visitors compared to the other 60% which sometimes can only be seen at certain times of the day. Based on the previous description, it is known that as many as six species can be seen throughout the day on the Balleangin transect, 11 species on the Kattokaddaro transect and 15 species on the Tompobulu transect (Table 3). However, the bird species that can be seen throughout the day, are not always found spreading on the three transect lines. Some were found to spread only on two transect lines or only on one transect line. Table 3 shows in detail what bird species can be found throughout the day on the three transect lines. This table displays the distribution of attendance frequency data based on the time of observation, namely morning, noon and afternoon.

**Table 3.** The distribution of the average frequency of bird species that can be found throughout the day (morning, noon and afternoon) on the three transect lines

| Bird Species             | Balleangin | Kattokaddaro | Tompobulu |
|-------------------------|------------|--------------|-----------|
|                         | M          | N            | An        | M          | N            | An        | M          | N            | An        |
| Bay Coucal\(^E\)        | 41.67      | 16.67        | 8.33      | 24.24      | 27.27       | 27.27     | 5.56       | 1.39        | 8.33      |
| Lemon-throated White-eye\(^E\) | 41.67 | 41.67       | 33.33     | 24.24      | 21.21       | 6.06      | 19.44      | 16.67       | 15.28     |
| Hair-crested Drongo     | 16.67      | 16.67        | 16.67     | 18.18      | 15.15       | 6.06      | 18.06      | 9.72        | 11.11     |
| Yellow-sided flowerpecker\(^E\) | 41.67 | 16.67       | 25        |            |             |           |            |             |           |
| Knobbed Hornbill\(^EP\) | 16.67      | 16.67        | 16.67     |            |             |           |            |             |           |
| Black-sided Flowerpecker| 25         | 16.67        | 16.67     |            |             |           |            |             |           |
| Glossy Swiftlet         |            |              |           | 21.21      | 15.15       | 33.33     | 26.39      | 18.06       | 19.44     |
| Barn Swallow            |            |              |           | 21.21      | 9.09        | 15.15     | 15.28      | 13.89       | 12.50     |
| Pacific Swallow         |            |              |           | 39.39      | 27.27       | 27.27     | 23.61      | 16.67       | 20.83     |
| Yellow-billed Malkoha\(^E\) | 21.21 | 21.21       | 21.21     | 15.28      | 8.33        | 11.11     |            |             |           |
| Geomalai\(^E\)          | 3.03       | 3.03         | 6.06      | 8.33       | 5.56        | 2.78      |            |             |           |
| Spotted Kestrel\(^P\)   | 6.06       | 9.09         | 3.03      | 5.56       | 4.17        | 2.78      |            |             |           |
| Tree Sparrow            | 3.03       | 3.03         | 3.03      | 2.78       | 8.33        | 5.56      |            |             |           |
| Ashy Woodpecker\(^E\)   | 6.06       | 9.09         | 12.12     | 18.06      | 15.28       | 9.72      |            |             |           |
| Sooty-headed Bulbul      |            |              |           |            |             |           |            |             |           |
| Pied Bush-chat          |            |              |           |            |             |           |            |             | 5.56      |
| Sulphur-bellied Whistler|            |              |           |            |             |           |            | 5.56        | 2.78      |
| Olive-backed Sunbird\(^P\) |        |              |           | 8.33       | 5.56        | 8.33      |            |             |           |
| Citrine Flycatcher       |            |              |           |            |             |           | 6.94       | 1.39        | 2.78      |

Note: \(^E\) = Endemic; \(^P\) = Protected; M = Morning; N = Noon; An = Afternoon
There were only two bird species found throughout the day spread on the three transect lines, namely Bay Coucal and Lemon-throated White-eye. Hair-crested Drongo was only on the Balleangin and Kattokaddaro transects, and Yellow-sided flowerpecker was only on the Balleangin and Tompobulu transects, Knobbed Hornbill and Black-sided and Flowerpecker only on the Balleangin transect and Ashy Woodpecker on the Kattokaddaro transect. The others are seven species on the Kattokaddaro and Tompobulu transects, and five species only on the Tompobulu transect.

3.3. Ecological indices
This study uses three ecological indices, namely the Shannon-Wiener species diversity indices, the Margalef species richness indices and the Shannon-Wiener evenness indices. The results of the calculation of the ecological indices of bird communities in the three observation lines are shown in Figure 3.

![Figure 3. Ecological indices on the observation tracks in the Bulusaraung Mountain.](image)

Figure 3 shows the results of the analysis of the value of the richness indices (R) in all observation lines including the good category. Species richness indices values more than 4 are categorized as good, then values from 2.5 to 4.0 are categorized as moderate and values < 2.5 are categorized as bad [28]. The diversity indices value (H') in all observation lines is in the medium category. If the value of H' 0-2 is low, the value of H' 2-3 is moderate and the value of H' > 3 is high, while the evenness indices value (E) in all observation lines is in the category of high evenness [29]. If the E value < 0.3 low species evenness, E value 0.3 < 0.6 moderate species evenness and E value > 0.6 high species evenness [30]. A species composition is said to be evenly distributed, if the value of the species evenness index is getting closer to one. On the other hand, if the value of the species evenness index is close to zero, it is increasingly uneven. The more even the species composition is, it can be said that only a few species dominate [27].
4. Discussion

The results showed that there were differences in the number of bird species found on the three observations transect, where the largest number of species was found on the Tompobulu transect, while the smallest number was on the Balleangin transect. The results of the analysis showed that the birds that disappeared on the Balleangin transect were birds that were generally found on the Kattokaddaro and Tompobulu transects at an altitude above >950 m asl. A total of 28 species that were not found on the Balleangin transect or 63.63% of the total bird species found at the study site, spread at an altitude between 950 m asl to 1,353 m asl. Of these 28 species, five species are only found at an altitude between 950 m asl to 1,100 m asl, and these are the species that are only found on the Kattokaddaro transect. A total of 13 species that only spread from an altitude of 1,100 m asl to 1,353 m asl, and these are species that are only found in the Tompobulu transect. The remaining 10 species are species found on both the Kattokaddaro and Tompobulu transect lines.

The condition of forest vegetation cover on the three transect lines did not show a significant difference, where the forest was generally densely vegetated with steep terrain. This is reinforced by the results of the vegetation analysis on the three paths based on elevations of 800, 900, and 1,000 m asl [24]. He concluded that forest stands at an altitude of 800 - 1,000 m above sea level had three layers of canopy with canopy cover reaching 80-90%. This means that the forest vegetation on the three transect lines is the same forest community, thus providing the same habitat for various bird species. According to Simanjuntak et al., (2013) habitat conditions are very influential on the high and low diversity of bird species [31]. If a habitat is able to provide various types of feed, then the habitat will often be visited by bird species [32].

The results of the analysis of the diversity indices in the lower mountain forest of Mount Bulusaraung showed that the value of the diversity indices (H') at the tree level was between 2.17-2.27 (medium category), while at the pole level the value was between 3.02- 3.27 (high category) [24]. If the value of H' 0-2 is low, the value of H' 2-3 is moderate and the value of H' > 3 is high [29]. Diversity indices data shows how the condition of lower montane forest vegetation in the study area as a habitat for various bird species. According to Farimansyah (1981), a high diversity of plant species in a vegetation unit can serve as a source of food, shelter and nesting places for bird species, while state that many bird species require a habitat in the form of trees with large diameter and old age which are generally only found in primary forest areas [33,34]. Habitats like this are favored by birds that make nests in old tree holes such as groups of parrots, hornbills, woodpeckers. Also favored by groups of sunbirds and small fruit-eating birds, as well as birds that forage in treetops.

Based on the analysis of forest structure and canopy cover as well as the tree and pole diversity indices in the lower mountain forest, it is possible that the small number of bird species found on the Balleangin transect was caused by the influence of the length of the transect line used in data collection [24]. The Balleangin transect line, which is 400 meters long, is only 36% of the length of the transect line in Kattokaddaro and 16.66% of the length of the transect line in Tompobulu. Thus, there are different opportunities to see species as found on the other two transect lines. The short path at the Balleangin location is because after reaching an altitude of 950 m above sea level, the topography has begun to decline, while on the Kattokaddaro transect line which only reaches an altitude of 1,100 m above sea level, because when this hiking trail approaches the peak, the field conditions are already very dangerous where the vegetation is dominated by grass vegetation without large stones as in the Tompobulu route. The Kattokaddaro hiking trail is famous as a hiking trail with a high level of difficulty compared to the Tompobulu route as a general route for climbing to the top of Mount Bulusaraung.
The birds that can be found on the three transect lines are birds that have the potential to be seen by tourists, especially birds that have an attendance frequency of three times and above (Table 2). The average frequency value shown on the Balleangin transect (maximum 38%) indicates the appearance of birds only between 1-2 times, while the average frequency >25% on the Kattokaddaro transect and an average of >12% on the Tompobulu transect are frequency values indicating the presence of a species of bird above three times. It seems that the Tompobulu transect provides more opportunities to show the presence of birds spreading across the three transect locations. Of the 11 species that spread in the three locations, there are four important species. From the point of view of ecotourism development, protected species must be made as the main or priority species to be interpreted to visitors regarding their ecological and conservation status in the context of efforts to conserve these species. As previously explained, of the 44 species found in this study, 26 of them are classified as important species because they are endemic and protected.

Table 3 shows an in-depth analysis of the species that can be found throughout the day. A total of 19 species are included in this group, and have high potential to be seen throughout the day even though it only spreads on one transect line. The presence of birds throughout the day will also provide opportunities to be seen by tourists because traveling in the wild is not specified when it will start walking. It really depends on the time visitors are present at a location. Thus, information on the presence of bird species that can be seen throughout the day will help ecotourism management to provide clues about the possibility of meeting a bird species on the trail.

The calculation results of richness, diversity and evenness indices (Figure 3), show that although there are differences in the value of the bird diversity indices on each transect (the lowest is 2.55 on the Balleangin and the highest is 2.99 on the Tompobulu), but the range of values is in class $2 > H < 3$ (moderate or medium category) according to the Shannon-Wiener diversity indices criteria. The Shannon diversity indices value can be classified into three categories, namely if the value of $H'$ 0-2 is low, the value of $H'$ 2-3 is moderate and high if the value of $H'> 3$ [29]. The importance of assessing the ecological indices of a species, both animals and plants in assessing a tourism object, is as basic data in ecotourism development, because the data can be used to measure the impact of ecosystem changes, both positive and negative impacts due to ecotourism development by see or measure the changes that occur [35]. As previously explained, the condition of the forest on the three transect lines is relatively the same, so that the source of food in the form of small insects, fruits and plant species diversity is also the same. Thus, the high diversity factor in the Tompobulu line is caused more by the longer sampling transect (2,400 m), while the low diversity index in the Balleangin line is more influenced by the short sampling transect line (400 m). Thus, there is less chance of finding the same species on the Balleangin transect. According to Tortosa and Villafuerte (2000), species diversity and the number of individuals of a bird species are influenced by the diversity of plant species in their habitat type [36]. The more diverse the habitat structure (diversity of plant species and vegetation structure), the greater the diversity of bird species found. Mustari et al., (2012), explain that the diversity of animal species, including birds, is influenced by the structure of vegetation and the availability of food in the habitat, while inform that the absence of a bird species in a place is caused by several factors including; habitat incompatibility, behavior (habitat selection), the presence of other animal species (predators, competitors, and parasites) as well as environmental physicochemical factors that are outside the tolerance range of certain bird species [25,37].
The aesthetic value possessed by wild animals, such as birds that have beautiful feather colors, melodious voices and interesting behavior, are objects that have very high artistic value and are attractions that can attract tourists so that they are very potential in developing ecotourism [38,39]. However, in the development of ecotourism, not only the beauty of birds is displayed, but more emphasis is placed on the value of species diversity, ecological status (protected endemics and others), ecological indices (richness, diversity and evenness indices) and the role of birds in the ecosystem. The parameter above is an important factor, because it is a source of information regarding ecology and conservation to be used as interpretation material for visitors [35,40].

In accordance with the principles of ecotourism development, tourism activities carried out should provide an element of education. The element of education aims to change one's perception so that they have care, responsibility, and commitment to environmental and cultural preservation. One of the principles of ecotourism development is to fulfill the educational aspect, namely providing experience and education to tourists who can increase their understanding and appreciation of the tourist areas they visit. Education is provided through an understanding of the importance of environmental conservation, while experience is provided through creative tourism activities accompanied by excellent service [41]. Meanwhile, Berkmueller (1981) informed that the criteria for a good path for nature tourism activities are being able to present beautiful views or natural attractions, in this case the beauty of birds, a pleasant path to walk (not slippery, not steep, not muddy or flooded) [42]. All of these conditions will make visitors happy, not tense, easy for visitors to pass because there are signs and location maps (paths), and which are clearly not dangerous for visitors.

Seeing the potential for bird diversity in the lower mountain forest in the complex of Mount Bulusaraung, it is necessary to prepare good planning based of ecotourisms principle development, so that this potential can be utilized optimally in the development of bird watching ecotourism. Based on the results and discussion described above, the diversity of bird species on the three transect lines, especially on the Kattokaddaro and Tompobulu transects, can be used as objects and attractions in ecotourism development. One of the objectives of developing wild ecotourism is to support the conservation of various types of animals, especially endemic and protected bird species, and those that have a narrow distribution only in certain routes, while the other goal is to improve the economy of the surrounding community.

5. Conclusion
At the lower mountain forest in the Complex of Bulusaraung Mountains, 44 species of birds were found with consisting of 27 families. Of the 44 bird species, 11 of them are endemic, three are protected, and seven are endemic and protected. The distribution of birds was uneven on each transect, where only 16 species were found on the Balleangin transect, while on the Kattokaddaro and Tompobulu transects, 27 and 37 species were found, respectively. A total of 19 species out of 44 species are known to be seen throughout the day (morning, noon and afternoon). Nine of them are important species because they are endemic and protected. The presence of birds throughout the day will provide a high opportunity to be seen by tourists, so it is very potential as a bird watching ecotourism object. The Tokaddaro and Tompobulu trails are two recommended trails for the development of bird watching ecotourism in Bantimurung Bulusaraung National Park.
References

[1] Whelan C J, Wenny D G and Marquis R J 2008 Ecosystem Services Provided by Birds *Ann. N. Y. Acad. Sci.* **1134** 25–60

[2] Hernowo J B and Prasetyo L B 1989 Konsepsi Ruang Terbuka Hijau di Kota sebagai Pendukung Pelestarian Burung *Media Konserv.* **11** 61–71

[3] Sekercioglu C H 2012 Bird Functional Diversity and Ecosystem Services in Tropical Forests, Agroforests and Agricultural Areas *J. Ornithol.* **153** 153–61

[4] Wiens J A 1973 Pattern and Process in Grassland Bird Communities *Ecol. Monogr.* **43** 237–70

[5] Philpott S M, Soong O, Lowenstein J H, Pulido A L, Lopez D T, Flynn D F B and DeClerck F 2009 Functional Richness and Ecosystem Services: Bird Predation on Arthropods in Tropical Agroecosystems *Ecol. Appl.* **19** 1858–67

[6] Ayat A 2011 *Burung-Burung Agroforest di Sumatera* (Bogor: World Agroforestry Centre)

[7] Praptiwi R A, Saab R, Setia T M, Wicaksono G, Wulandari P and Sugardhito J 2019 Bird Diversity in Transition Zone of Taka Bonerate, Kepulauan Selayar Biosphere Reserve, Indonesia *Biodiversitas J. Biol. Divers.* **20** 820–4

[8] Desmawati I 2009 *Studi Distribusi Jenis-jenis Burung Dilindungi Perundangan di Kawasan Wonorejo Surabaya* (Institut Teknologi Sepuluh November)

[9] Perrins C M and Birkhead T R 1982 *Tertiary Level Biology: Avian Ecology* (New York: Blackie : Chapman & Hall)

[10] Sujaatnika P J, Soehartono T R, Crosby M J and Mardiastuti A 1995 Melestarikan Keanekaragaman Hayati Indonesia: Pendekatan Daerah Burung Endemik *Bogor. BirdLife Int. Program. dan PHPA-Departemen Kehutan*.

[11] Bibby C, Jones M and Marsden S 2000 *Teknik-Teknik Ekspedisi Lapangan: Survei Burung* (Bogor: Bird Life Indonesia Programme)

[12] Coates B J and Bishop K D 2000 *Panduan lapangan burung-burung di kawasan Wallacea: Sulawesi, Maluku dan Nusa Tenggara* (diterjemahkan oleh Kartika Sari SN, Meiske, Tapilahu D dan Dwatinova Rini) (Bogor: Birdlife International Indonesia Programme & Dove Publications)

[13] Holmes D, Philipps K, Mulyani Y A and Kartikasari S N 1999 *Burung-burung di Sulawesi* (Pusat Penelitian dan Pengembangan (Puslitbang) Biologi, Lembaga Ilmu)

[14] Arini D I D, Shabri S, Kafiar Y, Tabba S and Kama H 2011 *Keanekaragaman Avifauna Beberapa Kawasan Konservasi Provinsi Sulawesi Utara dan Gorontalo* (Manado)

[15] Junus M 1984 *Dasar-Dasar Ilmu Kehutanan I* (Makassar: Badan Kerjasama Perguruan Tinggi Indonesia Bagian Timur)

[16] Turner A, Sanderson E, Sweet M and Raines P 2006 *The Biodiversity of the Lower-Montane Forest Habitats of the North Negros Forest Reserve, Negros Occidental, Philippines* (London: The Negros Forest and Ecological Foundation, Incand Coral Cay Conservation Ltd)

[17] Malizia L R, Blendinger P G, Álvarez M E, Rivera L O, Politi N and Nicolossi G 2005 Bird communities in Andean Premontane Forests of Northwestern Argentina *Ornitol. Neotrop.* **16** 231–251

[18] Waltertz M, Mardiastuti A and Mühlenberg M 2005 Effects of Deforestation and Forest Modification on Understorey Birds in Central Sulawesi, Indonesia *Bird Conserv. Int.* **15** 257–73

[19] Kessler M and Kluge J 2008 Diversity and Endemism in Tropical Montane Forests-From Patterns to Processes *Biodivers. Ecol. Ser.* **2** 35–50

[20] Supriatna J 2008 *Melestarikan Alam Indonesia* (Jakarta: Yayasan Obor Indonesia)

[21] Whitten T, Mustafa M and Henderson G S 2002 *The Ecology of Sulawesi (7th ed.)* (Yokyakarta: Yokkyakarta: Gadjah Mada University Press)

[22] Maulay R I, Lira J, Achmad A and Achmad N 2019 Keanekaragaman Jenis Burung Pada Hutan Dataran Rendah di Kompleks Gunung Bulusaraung Taman Nasional Bantimurung Bulusaraung *J. Perenn.* **15** 16–26

[23] Asrianny, Paweka C B, Achmad A and Achmad N S 2019 Komposisi Jenis dan Struktur Vegetasi
Hutan Dataran Rendah di Kompleks Gunung Bulusaraung Sulawesi Selatan *J. Perenn.* **15** 32–41

[24] Alamsyah M F 2019 *Struktur Vegetasi dan Komposisi Jenis Pada Hutan Pegunungan Bawah Di Kompleks Gunung Bulusaraung. Skripsi* (Universitas Hasanuddin)

[25] Mustari A H, Asmoro A W T and Pi G O E 2012 Keanekaragaman Jenis Burung di Taman Nasional Bantimurung Bulusaraung, Sulawesi Selatan *Media Konserv.* **17**

[26] Putri I A 2015 Submontane Forest at Bantimurung Bulusaraung National Park: Hotspot of Bird Diversity and Its Management Conservation *J. Penelit. Kehutan. Wallacea* **4** 115–28

[27] Ludwig J A, Reynolds J F, QUARTET L and Reynolds J F 1988 *Statistical Ecology: A Primer in Methods and Computing* vol 1 (Canada: John Wiley & Sons)

[28] Jorgensen S E, Costanza R and Xu F-L 2005 *Handbook of Ecological Indicators for Assessment of Ecosystem Health* (London: CRC Press)

[29] Krebs C J 1985 *The Experimental Analysis of Distribution and Abundance. 3rd ed.* (New York : Harper Collins)

[30] Magurran A E 1988 *Ecological Diversity and Its Measurement* (London: Princeton university press)

[31] Simanjuntak E J, Nurdjali B and Siahaan S 2013 Keanekaragaman Jenis Burung Diurnal di Perkebunan Kelapa Sawit PTPN XIII (Persero) Desa Amboyo Inti Kecamatan Ngabang Kabupaten Landak *J. Hutan Lestari* **1** 317–26

[32] Alikodra H S 1990 *Pengelolaan Satwa Liar Jilid I* (Bogor: Bogor: Institut Pertanian Bogor)

[33] Farimansyah 1981 *Keragaman Jenis Burung Pada Berbagai Lingkungan di Bogor dan Sekitarnya* (Bogor : Institut Pertanian Bogor)

[34] Loyn R H and Kennedy S J 2009 Designing Old Forest for The Future: Old Trees as Habitat for Birds in Forests of Mountain Ash Eucalyptus Regnans *For. Ecol. Manage.* **258** 504–15

[35] Achmad A 2017 *Membangun Ekowisata Alam Liar* (Pusat Kajian Media dan Sumber Belajar LKPP, Universitas Hasanuddin)

[36] Tortosa F S and Villafuerte R 2000 Habitat Selection by Flocking Wintering Common Cranes (Grus grus) at Los Pedroches Valley, Spain *Etologia* **8** 21–4

[37] Krebs J R and Davies N B 1978 *Behavioural Ecology: An Evolutionary Approach.* (London: Blackwell Scientific Publications)

[38] Bahri S 2011 *Kajian Potensi dan Daya Tarik Burung Untuk Pengembangan Ekowisata Birdwatching di Hutan Lindung Sungai Lesan Kabupaten Berau Kalimantan Timur* (Yogyakarta: Yokyakarta: Universitas Gajah Mada)

[39] Afafa W 2013 *Kajian keragaman spesies burung di Taman Hutan Raya Raden Soerjo Propinsi Jawa Timur* (Malang: Malang: Universitas Negeri Malang)

[40] Lakiu M D, Langi M A and Pollo H N 2016 Potensi Avifauna untuk Pengembangan Ekowisata Birdwatching di Desa Ekowisata Bahoi *Cocos-Jurnal Ilm. Fak. Pertan. Univ. sam ratulangi* **7** 1–12

[41] Nugroho D Y, Kiswantorso A and Damiasih D 2020 Pengelolaan Taman Wisata Umbul Square Berbasis Ekowisata Di Kabupaten Madiun, Jawa Timur *Khasanah Ilmu-Jurnal Pariwisata Dan Budaya* **11** 1–8

[42] Berkmuller K 1981 *Guidelines and Techniques for Environmental Interpretation* (USA: Klaus Berkmuller)