International Journal of Design & Nature and Ecodynamics
Vol. 19, No. 1, February, 2024, pp. 267-273
Journal homepage: http://iieta.org/journals/ijdne

Avian Species Diversity in Oil Palm Plantations in Buol District, Central Sulawesi, Indonesia

Sitti Ramlah*, Moh. Ihsan, Yusran Yusran

Forestry Department, Forestry Faculty, Tadulako University, Palu 94118, Indonesia

Corresponding Author Email: sittiramlahuntad@gmail.com

https://doi.org/10.18280/ijdne.190129

Received: 7 December 2023
Revised: 16 January 2024
Accepted: 23 January 2024
Available online: 29 February 2024

Keywords:
avians, species diversity, palm oil plantation, endemic Sulawesi, Central Sulawesi

ABSTRACT

Indonesia is known as a country with a very high wealth of biodiversity, both at the ecosystem scale, however, Indonesia is also noted as a country that has an extraordinary vulnerability to the decline/loss of potential biodiversity. So far, scientific research on the impact on biodiversity, especially on avian species in oil palm development in Central Sulawesi province has never been carried out. This study aims to determine the diversity of bird species in oil palm plantation land cover, this is done because birds are one indicator of environmental quality. This research was conducted in oil palm plantations. Data were taken from 5-year and 15-year old oil palm land covers. The research was conducted from June to August 2023. Avian species inventory data collection was carried out using a combination method of strip transect and point observation and the help of other observation tools such as drones. Data analysis calculations using a laptop device and Microsoft Excel software. The results of this study found 177 individuals from 26 avian species belonging to 16 families, 3 avian species are endemic to Sulawesi. Avian species diversity in both 5-year-old and 15-year-old oil palm land covers was categorized as moderate (2.669 and 2.609), with high levels of evenness at 0.891 and 0.886, respectively. Avian species composition between the 5-year-old and 15-year-old oil palm land covers was relatively similar, as indicated by the 50% species similarity index. The high level of species similarity is due to the fact that both land covers have similar characteristics, namely both are dominated by oil palm plants. The presence of land covers close to the research site supports the presence of various avian species. Both land covers studied are adjacent to rice fields and water canals, which influence the increase in avian species diversity.

1. INTRODUCTION

Indonesia is known as a country with a very high wealth of biodiversity, both at the ecosystem, species and genetic scales that invite the attention and admiration of people around the world [1, 2]. However, Indonesia is also listed as a country that has an extraordinary vulnerability to the decline/loss of biodiversity potential (biodiversity loss). Among the many factors causing "biodiversity loss", one of which is the development of oil palm plantations, making Indonesia the largest palm oil producer in the world, has been considered as one of the determinant factors [3-5].

One of the alleged causes of biodiversity decline is the conversion of forests into oil palm plantations. As the area of independent oil palm plantations is increasing faster than large oil palm plantations, the expansion of independent oil palm plantations plays an important role in land cover change. Previous research shows that biodiversity is vulnerable to decline due to the opening of oil palm plantations. This raises concerns about the sustainability of biodiversity [6-10].

Given the importance of the contribution of oil palm plantations to the national economy through foreign exchange earnings that reached 240 trillion in 2016, employment of no less than 16.2 million people and other positive multiplier effects [11], the assumption or claim that oil palm plantations in Indonesia have resulted in a decrease in biodiversity needs to be studied quantitatively through accurate and valid scientific methodology. If left unchecked, it is feared that it will have a negative systemic impact on the progress of the Indonesian palm oil industry in the future, including an export ban on palm oil plantation products.

Buol District, in Central Sulawesi province, Indonesia, is one of the areas with productive oil palm plantations in Central Sulawesi (83,191 Ha) with a productivity of 14,015.32 tons/year [12]. So far, scientific research on the impact on biodiversity, especially on avian species, of oil palm development in Central Sulawesi province has not been conducted. These avians may represent some of the biodiversity affected by forest conversion to oil palm plantations. Avians also play an important role in the ecosystem as pollinators, water quality indicators, and predators. The presence of various avian species with their various roles can indicate good ecological stability in a location [13]. Therefore, this study aims to determine the diversity of avian species in the oil palm plantation land cover of Buol District, in Central Sulawesi Province, Indonesia.

2. MATERIAL AND METHODS

2.1 Time and study sites

This study was conducted in oil palm plantations, Buol District, Central Sulawesi, Indonesia. Data were collected on 5-year-old oil palm land covers and 15-year-old oil palm land covers (Figure 1). The research was conducted from June to August 2023.

2.2 Research methods

Avian species inventory data were collected in two land covers of oil palm plantations, namely 5 years and 15 years old (Figure 2), using a combination of strip transect and point observation methods and the help of other observation tools such as drones. Data analysis calculations using a laptop device and Microsoft Excel software.

The transect line used was 1 km long with a width of 100 m to the left and right per line (Figure 3). Observations were conducted in the morning (06:00-08:00 WITA) and afternoon (15:30-17:30 WITA) for 3 repetitions on different days (Wang and Finch 2002). Data recorded included time of encounter, avian species found, number of individuals of each species found and avian tracks in the form of sounds. In addition, for unknown avian species in the field, their morphological characteristics (feather color, beak shape, foot shape, crest shape, cockscomb shape, eye iris, wing shape, body size, voice, etc.) were recorded and identified based on a field guide to avians in the Wallaceae region, Sulawesi, Maluku and Nusa Tenggara [14].

2.3 Data analysis

Index of species diversity

Analysis to determine the diversity of avian species, the Shannon diversity index (H') was used [15] the diversity index is an index that serves to provide an overview of the composition of the ecosystem and its constituent communities and the stability of an ecosystem with the formula with the formula:

$$H' = -\sum_{I=1}^{S}(pi \ln pi)$$

The value of *pi* is obtained using the formula:

$$\text{Pi} = \frac{\text{number of individuals of the species}-i}{total\ individuals\ of\ all\ species}$$

where,

H' = Shannon Diversity Index
S = Number of species
pi = Proportion of individuals ke-i (n/N)
Ln = Log natural

Index of equitability or evenness

Analysis to determine the evenness of the species found in each community used the index of evenness (Index of Equitability or Evenness), which is the number of individuals of a species or the abundance of each species in a community, which serves to determine the evenness of each species in each community with the formula:

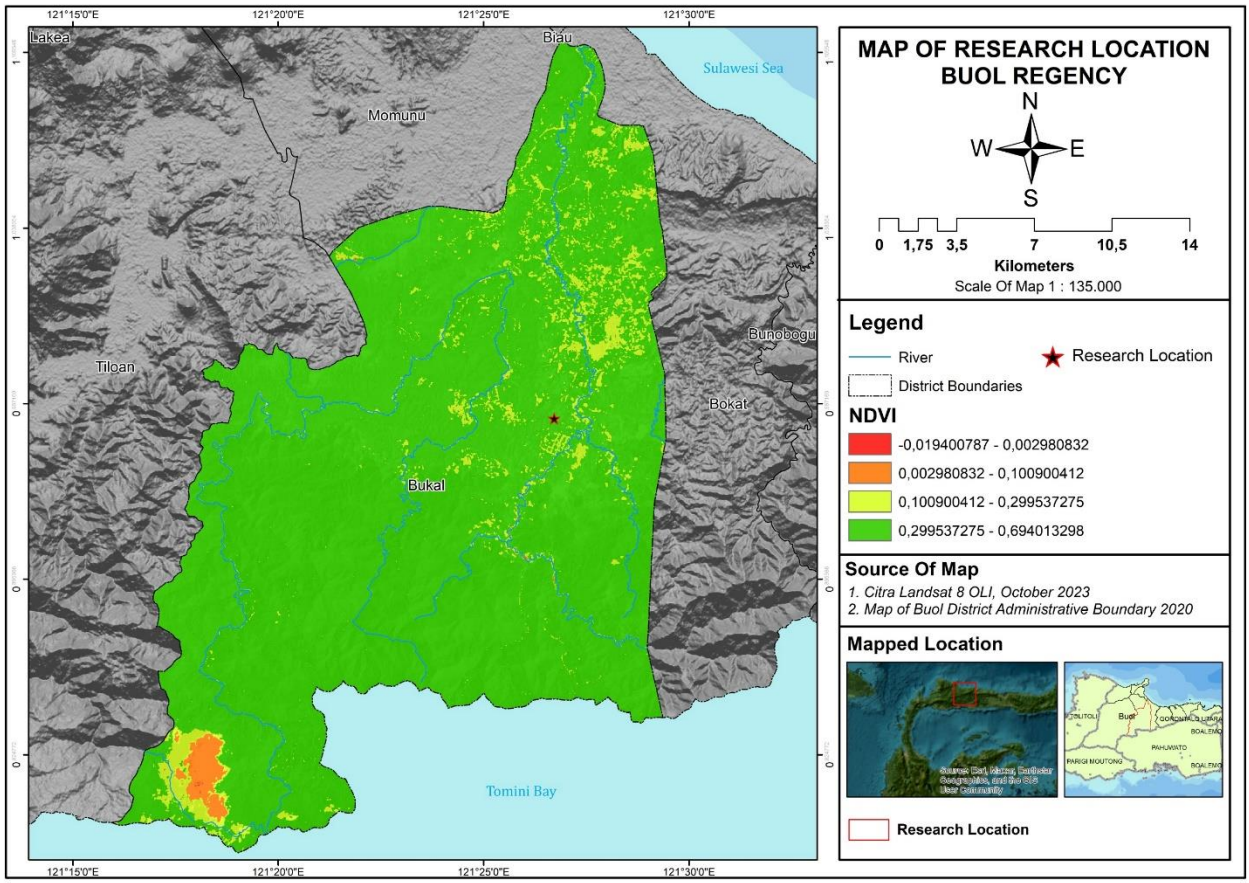

Figure 1. Map of research location

Figure 2. The general condition of oil palm plantation

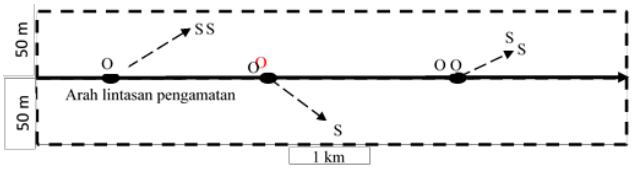

Figure 3. Transect lines used in avian observation in the field (average visibility for an observer at a given location); o (observer position); s (animal position)

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

where,
E = Evenness index
H' = Shannon Diversity Index
S = Number of species

Species Similarity Index (S)

To analyze the level of community similarity between land cover types in each oil palm plantation, a similarity index was used. The similarity index is used to determine the similarity of bird species found in different land covers. The calculation of the level of species similarity used is the Sorensen species similarity index [16]:

$$IS = \frac{2C}{A+B}$$

where,
IS: Similarity Index
A: Number of species at location A
B: Number of species at location B
C: Number of species present in both sites A and B

3. RESULTS AND DISCUSSIONS

3.1 Species composition

The total number of avian species found in the 5-year-old oil palm land cover and the 15-year-old oil palm land cover was 177 individuals from 26 avian species. All species belonged to 16 families. The family Rallidae was the family with the highest number of species, namely four species. In addition, the study site also found three Sulawesi endemic avian species, namely *Amaurornis isabellina, Spilornis rufipectus,* and *Dicaeum celebicum*. Compared to the results [17], who found 43 species of avians in oil palm plantations in Riau, the number of avian species found in this study was lower at only 26 species. Similarly, the results of research by study [18] found as many as 32 avian species belonging to 18 families in several variations of oil palm plantation land cover in North Mamuju District, West Sulawesi, Indonesia.

In the 5-year-old oil palm plantation land cover, there were 19 avian species with a total number of individuals of 98. This location is dominated by three species that have dominant populations, namely *hirundo tahitica, rice kareo*, and *forest crow*. In the 15-year-old oil palm plantation land cover, there were 22 avian species with a total of 79 individuals. This land cover was dominated by two species with dominant populations, namely *Hirundo tahitica* and *Gallirallus torquatus.*

3.2 Species diversity index and evenness index

Based on the results of data analysis, the species diversity index (H') and evenness index (E) in both land covers were relatively similar. In the 5-year-old oil palm land cover, the species diversity index reached 2.609 with an evenness of 0.886. While in the 15-year-old oil palm land cover, the diversity index reached 2.669 with an evenness index of 0.891. The evenness value is classified as a high evenness category based on the category [19].

The results showed that more avian species were found in 15-year-old oil palm plantations than in 5-year-old sawti plantations. This is thought to be related to the larger and denser structure of oil palm trees at 15 years of age. A study found that structural complexity in monoculture oil palm plantations increased by 25% after only three years of tree planting [20]. The structural complexity of oil palm plantations will impact the distribution and foraging behavior of avian communities in the context of vertical strata [21]. It also affects microclimate [22]. Vegetation can alter microclimate by blocking wind and shading the ground, resulting in cooler air temperatures. Since air temperature can significantly affect avian diversity, a higher diversity of avian species due to their microclimate will be more suitable for avian reproduction.

Oil palm plantations are a land cover formed by land cover change from mixed forest to monoculture land cover. Several previous studies have shown that monoculture habitats tend to have lower species diversity compared to mixed land covers or natural forests [23-25]. The results of this study are in line with these findings. The avian species diversity index in the two studied oil palm land covers showed that avian species diversity was in the medium category (Table 1). The number of species was relatively similar between the land covers of 5-year-old palms and 15-year-old palms, but the number of species was low. The low number of avian species inhabiting the oil palm land cover is thought to be caused by human intervention in the environment, such as routine harvesting and land clearing activities. The study [25] stated that in oil palm plantations, a decrease in avian species diversity occurs due to human intervention, especially in oil palm plantation management which involves clearing undergrowth and spraying weeds.

Table 1. Composition and diversity of avian species in land covers at the study site

Families	Species	Guild	Number of Avians		H'	
			Oil palm plantation			
			15-Years old	5-Years old	15-Years old	5-Years old
Rallidae	*Amaurornis isabellina*	Insektivora	1	5	0.055	0.152
	Amaurornis phoenicurus	Insektivora	1	13	0.055	0.268
	Gallirallus philippensis	Insektivora	-	2	-	0.079
	Gallirallus torquatus	Insektivora	9	5	0.247	0.152
Alcedinidae	*Alcedo meninting*	Piscivora	-	2	-	0.079
	Halcyon chloris	Piscivora	3	3	0.124	0.107
	Halcyon sancta	Piscivora	1	-	0.055	-
Ardeidae	*Ardea purpurea*	Piscivora	1	5	0.055	0.152
	Ardeola speciosa	Omnivora	4	-	0.151	-
	Bubulcus ibis	Omnivora	4	-	0.151	-
Columbidae	*Chalcophaps indica*	Frugivora	-	6	-	0.171
	Streptopelia chinensis	Granivora	6	-	0.196	-
	Streptopelia tranquebarica	Granivora	4	2	0.151	0.079
Accipitridae	*Haliastur indus*	Karnivora	1	1	0.055	0.047
	Spilornis rufipectus	Karnivora	1	1	0.055	0.047
Acanthizidae	*Gerygone sulphurea*	Insektivora	2	-	0.093	-
Apodidae	*Aerodramus vanikorensis*	Insektivora	4	9	0.151	0.219
Corvidae	*Corvus enca*	Omnivora	7	10	0.215	0.233
Cuculidae	*Eudynamis scolopacea*	Insektivora	-	2	-	0.079
Dicaeidae	*Dicaeum celebicum*	Frugivora	2	-	0.093	-
Estrildidae	*Lonchura malacca*	Granivora	8	7	0.232	0.189
Hirundinidae	*Hirundo tahitica*	Insektivora	15	19	0.315	0.318
Nectariniidae	*Cinnyris jugularis*	Nektarivora	2	2	0.093	0.079
Pycnonotidae	*Pycnonotus aurigaster*	Frugivora	-	2	-	0.079
Sturnidae	*Acridotheres javanicus*	Omnivora	3	-	0.124	-
Turnicidae	*Turnix suscitator*	Granivora	-	2	-	0.079
	Total Individuals		**79**	**98**	**-**	**-**
	Total Species		**20**	**19**	**-**	**-**
	Shannon Diversity Index (H')		**-**	**-**	**2.669**	**2.609**
	Evenness Index (E)		**-**	**-**	**0.891**	**0.886**

The land cover in this study is routinely cleared every two months; however, during the study, the understory was not cleared so it retained its function as an avian habitat. According to study [26], the presence of undergrowth in oil palm plantations is very important because it can provide shelter or nesting sites for avians as well as insect habitat. This understory also acts as a habitat for *Turnix suscitator* avians. However, routine clearing of the understory can result in plants that act as habitat for active avians on the ground becoming temporary habitats. This condition can affect the diversity of avian species, as stated in research [27], which states that high levels of human activity in oil palm plantation land management, such as maintenance and harvesting activities, can reduce the diversity of avian species [28].

In addition to human intervention factors, the monoculture structure of oil palm reduces habitat variation. This habitat is dominated by oil palm trees and shrubs on the plantation floor, resulting in less varied food sources for avian species. Although this study did not specifically examine avian food sources, the species composition illustrates the composition of avian guilds. Both land covers had the same number of guilds, with 7 categories. This guild composition is lower than the results of study [29] in primary forest, which recorded the number of guilds in 9 categories. The decrease in guild categories is one indication of a decrease in habitat quality. According to study [30], information on guilds can be used to identify changes in forest ecosystems, especially if the ecosystem or landscape has changed due to human activities. The poorer the habitat quality, the fewer the number of guilds.

The insectivorous guild category was the dominant guild category at the study site. The guild composition of the study site, dominated by insectivorous avians, suggests that insects are a commonly available resource. This guild category dominated in the 5-year-old oil palm land cover with seven species, and the population dominated more than half of the population at the site. In the 15-year-old oil palm land cover, although it is still the most dominant guild category in terms of number of species (5 species, and 23 individuals), there is a decrease in dominance. According to study [31], insects are abundant food species in nature, making them easily available to all avian species. In addition, oil palm plantations increase the number of insect species [32, 33]. Insectivorous avians are found in every land cover, with the highest number compared to avian species with other types of food [25]. Some of the avian species found in the study site are presented in Figure 4.

Amaurornis issabelina *Dicaeum celebicum*

Spilornis rufipectus *Halcyon chloris*

Figure 4. Some examples of avians found in the research site

In both land covers studied, the nectarivores category is the guild category that has the lowest number of species and the lowest number of individuals, namely one species and two individuals each in each land cover. This indicates that nectar is a limited food source. At the time of the study, plants that produce nectar were lacking. According to study [34], the number of individuals in a guild reflects the availability of resources that support it, while the number of species reflects the extent to which resources can be shared properly. These results are in line with research [25] that after habitat changes into homogeneous vegetation, nectar-eating avian species will also decrease or even not be found in oil palm plantations.

Homogeneous habitat conditions lead to limited habitat variation, which in turn leads to limited food resources. This makes it difficult for some avian species to find nesting, shelter or feeding grounds. However, the presence of other land covers adjacent to the study site supports the presence of various avian species there. Both land covers studied are adjacent to rice fields and water canals. This condition causes avians from the Ardeidae family to be found in both land covers, which are usually active in rice fields. The presence of various avian species and the relatively open habitat conditions also create a favorable environment for predatory avians. In this study, two predatory eagle species were identified, namely *Haliastur indus* and *Spilornis rufipectus*.

Both land covers studied were categorized as medium diversity, however the evenness of avian species in both land covers was classified as high evenness. This indicates a lack of dominating avian species. Factors such as limited food resources and habitat conditions that favor the presence of predators are thought to be the cause of the lack of dominant avian species. Two eagle species were recorded in both land covers. Eagles often top the food chain as apex predators that play an important role in controlling populations in ecosystems. The presence of eagles can be interpreted as an indication that the ecosystem below is relatively stable. The study [35] states that the evenness of avian species in a habitat can be characterized by the absence of dominating species. If each species has the same number of individuals, then species evenness in the community reaches a maximum value. Conversely, if the number of individuals in each species is significantly different, this may cause species evenness to reach a minimum value. A high evenness index in a habitat indicates that the habitat is more stable than a habitat that has a lower evenness index value [36].

Based on the results of the study, the value of the species similarity index between the 5-year-old oil palm land cover and the 15-year-old oil palm land cover reached 50%. The similarity index can be categorized as high [16]. The high level of species similarity is due to the fact that the two land covers have similar characteristics, namely both are dominated by oil palms, so the environmental conditions in them are similar. The study [37] explained that areas with similar environmental conditions tend to have similar communities. In addition, the high level of species similarity is also influenced by the proximity of the two land covers studied. This is in accordance with statement of study [38] that factor such as distance between adjacent habitats, similar vegetation composition, and other environmental factors also allow species similarities between the two habitats. Some factors that should be considered that affect avian species diversity are mainly related to the highly complex environmental conditions surrounding the presence of avian species, such as land use [39, 40], landscape structure [39], and other environmental factors, landscape structure [41, 42] habitat gradients [42, 43] roads [44] and human disturbance [45, 46].

These results are consistent with previous studies which found that avian species evenness was lowest in cultivated lands and highest in natural habitats such as national conservation areas [47]. It was further explained that river corridors in freshwater wetlands have higher species richness in valley areas [48]. In study [49], some important characteristics of avian species abundance include sedge area, water area, reed area, patch density, and distance to people. Therefore, landscape structure and disturbance due to human activities may affect the results of this study and should be considered and clarified in future research.

4. CONCLUSIONS

The diversity of avian species in 5-year-old oil palm and 15-year-old oil palm land cover is moderate, meaning that in general avians can still live in oil palm land cover and use oil palm plantations as habitat, with a high level of evenness in both. Avian species composition between the 5-year-old oil palm and 15-year-old oil palm land covers was relatively similar, as indicated by the results of the species similarity index. The high level of species similarity is due to the similar characteristics of both land covers, which are both dominated by oil palm. The presence of these land covers close to the study site supports the presence of various avian species there. Both land covers studied are adjacent to rice fields and water canals, which influence the increase in avian species diversity.

ACKNOWLEDGMENT

The author would like to thank the Rector of Tadulako University for this Excellent Research Fund through the Faculty DIPA, Postgraduate, PSDKU Tojo Una-Una and University, The Ministry of Education and Culture, Tadulako University, No. 208209/UN.28/PL/2023 April 11, 2023.

REFERENCES

[1] Maryanto, I., Noerdjito, M., Partomihardjo, T. (2012) Ekologi Gunung Slamet: Geologi, Klimatologi, Biodiversitas, Dan Dinamika Sosial. Lembaga Ilmu Pengetahuan Indonesia.

[2] Suhartini, L. (2016). Perbandingan Persepsi Petani Dan Bukan Petani Sawit Terhadap Kebun Kelapa Sawit Swadaya. Institut Pertanian Bogor, Bogor.

[3] Juliprijanto, W., Prasetyanto, P.K., Setiawan, A.D. (2022). Analysis of determinants of palm oil exports in Indonesia. INOVASI, 18: 88-95. https://doi.org/10.30872/jinv.v18i0.11242

[4] Raharja, S., Papilo, P., Massijaya, M.Y., Asrol, M., Darmawan, M.A. (2020). Institutional strengthening model of oil palm independent smallholder in Riau and Jambi Provinces, Indonesia. Heliyon, 6(5): e03875. https://doi.org/10.1016/j.heliyon.2020.e03875

[5] Masitah, T.H., Setiawan, M., Indiastuti, R., Wardhana, A. (2023). Determinants of the palm oil industry productivity in Indonesia. Cogent Economics & Finance, 11(1): 2154002. https://doi.org/10.1080/23322039.2022.2154002

[6] Dodson, A., Spencer, E., Johnston, D. (2021). The State of Palm Oil Company Reporting on Biodiversity. Spott. London: Zoological Society of London.
[7] Jaroenkietkajorn, U., Gheewala, S.H., Scherer, L. (2021). Species loss from land use of oil palm plantations in Thailand. Ecological Indicators, 133: 108444. https://doi.org/10.1016/j.ecolind.2021.108444
[8] Vijay, V., Pimm, S.L., Jenkins, C.N., Smith, S.J. (2016). The impacts of oil palm on recent deforestation and biodiversity loss. PloS One, 11(7): e0159668. https://doi.org/10.1371/journal.pone.0159668
[9] Masyithoh, G. (2017). Perbandingan keanekaragaman jenis mamalia dan burung antara perkebunan sawit besar dengan kebun sawit swadaya. Doctoral dissertation, Bogor Agricultural University.
[10] Tapia, J.F.D., Doliente, S.S., Samsatli, S. (2021). How much land is available for sustainable palm oil? Land Use Policy, 102: 105187. https://doi.org/10.1016/j.landusepol.2020.105187
[11] Bappenas: Oil palm industry absorbs 16.2 million workers. Https://Korindonews.Com/Bappenas-Oil-Palm-Industry-Absorbs-16-2-Million-Workers/, accessed on Feb. 15, 2024.
[12] Kabupaten buol 2017. https://buolkab.bps.go.id/publication/2017/08/16/c3305154e9d92ebbb5394e0a/kabupaten-buol-dalam-angka-2017.html, accessed on Feb, 22, 2024.
[13] Kwatrina, R.T., Santosa, Y., Bismark, M., Santoso, N. (2018). Ecological impacts of oil-palm plantation on butterfly and bird species diversity. Jurnal Manajemen Hutan Tropika, 24(1): 23-31.
[14] Coates, B.J., Bishop, K.D., Gardner, D. (2000). Panduan Lapang Burung-burung di Kawasan Wallacea (Sulawesi, Maluku dan Nusa Tenggara). Bird Life International Indonesia Programme. Bogor.
[15] Ludwig, J.A., Reynolds, J.F. (1988). Statistical Ecology: A Primer in Methods and Computing. Wiley-Interscience Pub., New York.
[16] Magurran, A.E. (1988). Ecological Diversity and Its Measurement. New Jersey (US): Harper and Row Publisher.
[17] Erniwati, E., Zuhud, E.A.M., Santosa, Y., Anas, I. (2016). The value of secondary forest patches for bird conservation in palm oil landscapes of Riau, Sumatra. Biodiversitas Journal of Biological Diversity, 17(2): 791-798. https://doi.org/10.13057/biodiv/d170256
[18] Ramlah, S., Santosa, Y., Santoso, N., Rushayati, S.B. (2021). The variation of bird diversity in various oil palm land cover in North Mamuju, West Sulawesi, Indonesia. Biodiversitas Journal of Biological Diversity, 22(7): 3068-3074. https://doi.org/10.13057/biodiv/d220761
[19] Brower, J.E., Zar, J.H., Von Ende, C.N. (1998). Field and Laboratory Methods for General Ecology. Boston: WCB McGraw-Hill.
[20] Zemp, D.C., Ehbrecht, M., Seidel, D., Ammer, C., Craven, D., Erkelenz, J., Irawand B., Sundawatie., Hölscherc D., Kreft, H. (2019). Mixed-species tree plantings enhance structural complexity in oil palm plantations. Agriculture, Ecosystems & Environment, 283: 106564.
[21] Imron, M.A., Tantaryzard, M., Satria, R.A., Maulana, I., Pudyatmoko, S. (2018). Understory avian community in a teak forest of Cepu, Central Java. Journal of Tropical Forest Science, 30(4): 509-518. https://doi.org/10.26525/fs2018.30.4.509518
[22] Donfack, L.S., Röll, A., Ellsäßer, F., Ehbrecht, M., Irawan, B., Hölscher, D., Knol A., Kreft H., Siahaan E.D., Sundawati L., Stiegler C., Zemp, D.C. (2021). Microclimate and land surface temperature in a biodiversity enriched oil palm plantation. Forest Ecology and Management, 497: 119480. https://doi.org/10.1016/j.foreco.2021.119480
[23] Azhar, B., Puan, C.L., Zakaria, M., Hassan, N., Arif, M. (2014). Effects of monoculture and polyculture practices in oil palm smallholdings on tropical farmland birds. Basic and Applied Ecology, 15(4): 336-346. https://doi.org/10.1016/j.baae.2014.06.001
[24] Widodo, W. (2010). Studi keanekaan jenis burung dan habitatnya di lereng timur hutan Pegunungan Slamet, Purbalingga, Jawa Tengah. None, 12(2): 218050.
[25] Hastaril, B., Soendjoto, M.A. (2015). Studi variasi tingkat keanekaragaman jenis burung pada berbagai tipe habitat di areal konservasi perkebunan sawit PT. MSM, Wilmar Plantation, Kalteng. Daun, 2(1): 1-11. https://doi.org/10.33084/daun.v2i1.167
[26] Utari, W.D. (2000). Keanekaragaman jenis burung pada beberapa tipe habitat di areal hutan tanaman industri pt riau andalan pulp dann paper dan perkebunan kelapa sawit pt duta palma nusantara group propinsi dati i riau. Institut Pertanian Bogor, Bogor.
[27] Utami, C.Y. (2018). Pendugaan kehilangan dan perolehan keanekaragaman jenis burung sebagai akibat perkebunan kelapa sawit: Studi kasus di kebun KJNP, Provinsi Riau. Insititut Pertanian Bogor, Bogor.
[28] de Albuquerque, F.S., Bateman, H.L., Boehme, C., Allen, D.C., Cayuela, L. (2021). Variation in temperature, precipitation, and vegetation greenness drive changes in seasonal variation of avian diversity in an urban desert landscape. Land, 10(5): 480. https://doi.org/10.3390/land10050480
[29] Imanuddin. (2009). Komunitas Burung Di Bawah Tajuk Pada Hutan Primer Dan Hutan Sekunder Di Taman Nasional Bukit Barisan Selatan. Ipb University, Bogor.
[30] Mardiastuti, A. (2015). Ekologi Satwa Pada Lanskap Yang Didominasi Manusia. PT Penerbit IPB Press.
[31] Darmawan, M.P. (2006). Keanekaragaman Jenis Burung Pada Beberapa Tipe Habitat Di Hutan Lindung Gunung Lumut, Kalimantan Timur. Jurusan Konservasi Sumberdaya Hutan, Fakultas Kehutanan, Bogor.
[32] Riley, S.O., Dery, S.K., Afreh-Nuamah, K., Agyei-Dwarko, D., Ayizannon, R.G. (2022). Pollinators of oil palm and relationship to fruitset and yield in two fruit forms in Ghana. OCL, 29: 17. https://doi.org/10.1051/ocl/2022009
[33] Armando, R. (2016). Pengaruh kondisi habitat kelapa sawit (Elaeis guineensis JACQ.) terhadap artropoda dan hama tikus. Doctoral dissertation, Bogor Agricultural University.
[34] Wong, M. (1986). Trophic organization of understory birds in a Malaysian dipterocarp forest. The Auk, 103(1): 100-116. https://doi.org/10.1093/auk/103.1.100
[35] Santosa, Y. (1995). Teknik Pengukuran Keanekaragaman Satwaliar. Jurusan Konservasi Sumberdaya Hutan, Fakultas Kehutanan, Institut Pertanian Bogor.
[36] Rahayuningsih, M., Oqtafiana, R., Priyono, B. (2012). Keanekaragaman jenis kupu-kupu superfamili papilionoidae di dukuh banyuwindu desa limbangan

kecamatan limbangan kabupaten kendal. Indonesian Journal of Mathematics and Natural Sciences, 35(1): 11-20. https://doi.org/10.15294/ijmns.v35i1.2092

[37] Hubbell, S.P. Foster, R.B. (1986). Biology, chance and history and the structure of tropical rain forest tree communities. In: Community Ecology, Harper and Row, New York, pp. 314-329.

[38] Keindeigh, S.C. (1980). Ecology with Special Reference to Animal and Men. New Delhi (IN): Prentice Hall of India Private Limited.

[39] Dallimer, M., Marini, L., Skinner, A.M., Hanley, N., Armsworth, P.R., Gaston, K.J. (2010). Agricultural land-use in the surrounding landscape affects moorland bird diversity. Agriculture, Ecosystems & Environment, 139(4): 578-583. https://doi.org/10.1016/j.agee.2010.09.019

[40] Brambilla, M., Falco, R., Negri, I. (2012). A spatially explicit assessment of within-season changes in environmental suitability for farmland birds along an altitudinal gradient. Animal Conservation, 15(6): 638-647. https://doi.org/10.1111/j.1469-1795.2012.00561.x

[41] Banks-Leite, C., Ewers, R.M., Kapos, V., Martensen, A.C., Metzger, J.P. (2011). Comparing species and measures of landscape structure as indicators of conservation importance. Journal of Applied Ecology, 48(3): 706-714. https://doi.org/10.1111/j.1365-2664.2011.01966.x

[42] Ortega-Álvarez, R., Lindig-Cisneros, R., MacGregor-Fors, I., Renton, K., Schondube, J.E. (2013). Avian community responses to restoration efforts in a complex volcanic landscape. Ecological Engineering, 53: 275-283. https://doi.org/10.1016/j.ecoleng.2012.12.058

[43] MacGregor-Fors, I., Blanco-García, A., Lindig-Cisneros, R. (2010). Bird community shifts related to different forest restoration efforts: A case study from a managed habitat matrix in Mexico. Ecological Engineering, 36(10): 1492-1496. https://doi.org/10.1016/j.ecoleng.2010.06.001

[44] Rao, S., Koli, V.K. (2017). Edge effect of busy high traffic roads on the nest site selection of birds inside the city area: Guild response. Transportation Research Part D: Transport and Environment, 51: 94-101. https://doi.org/10.1016/j.trd.2016.12.013

[45] Mbiba, M., Mazhude, C., Fabricius, C., Fritz, H., Muvengwi, J. (2021). Bird species assemblages differ, while functional richness is maintained across an urban landscape. Landscape and Urban Planning, 212: 104094. https://doi.org/10.1016/j.landurbplan.2021.104094

[46] Cui, B., Yang, Q., Yang, Z., Zhang, K. (2009). Evaluating the ecological performance of wetland restoration in the Yellow River Delta, China. Ecological Engineering, 35(7): 1090-1103. https://doi.org/10.1016/j.ecoleng.2009.03.022

[47] Mzendah, C.M., Mashapa, C., Magadza, C.H.D., Gandiwa, E., Kativu, S. (2015). Bird species diversity across a gradient of land use in southern Gonarezhou National Park and adjacent areas, Zimbabwe. Journal of Animal & Plant Sciences, 25(5): 1322-1328.

[48] Stagoll, K., Manning, A.D., Knight, E., Fischer, J., Lindenmayer, D.B. (2010). Using bird–habitat relationships to inform urban planning. Landscape and Urban Planning, 98(1): 13-25. https://doi.org/10.1016/j.landurbplan.2010.07.006

[49] Yuan, Y., Zeng, G., Liang, J., Li, X., Li, Z., Zhang, C., Huang L., Lai X., Lu L., Wu H., Yu, X. (2014). Effects of landscape structure, habitat and human disturbance on birds: A case study in East Dongting Lake wetland. Ecological Engineering, 67: 67-75. https://doi.org/10.1016/j.ecoleng.2014.03.012