

Gorontalo

Journal Of Forestry Research

Volume 8 Nomor 2 Oktober 2025

P-ISSN 2614-2058 E-ISSN 2614-204X

ABUNDANCE AND CONSERVATION STATUS OF AVIFAUNA IN LIMBOTO LAKE, GORONTALO

Ernikawati*, Dian Puspaningrum, Sutan Zulham Panigoro

Universitas Gorontalo

*Email: ernikawatimikha@gmail.com

Received, 19th April 2025; Revised, 02nd September 2025;

Accepted, 23th September 2025

ABSTRACT

Avifauna is a type of wildlife that can be easily found in various locations and serves as an indicator of environmental quality. Avifauna plays roles such as seed dispersal, assisting pollination, preying on other animals, and so on. It holds significant importance in wetland ecosystems. One of the most crucial ecological functions of avifauna is as a bioindicator of wetland quality, closely related to its position in the food chain. This study aims to determine the number and types of avifauna, understand the abundance of avifauna species in the waters of Limboto Lake, and identify their conservation status. The research was conducted from January to March 2025. Observations were made using the Point Count method with three (3) randomly placed points. The results identified 13 bird species belonging to 6 orders and 7 families. The percentage of species per family was highest for Passeridae at 20%, while the percentage of individual birds per family was dominated by the Ardeidae family at 47.83%. The distribution of individual birds per order was highest for the order Passeriformes with 282 individuals, and lowest for the order Charadriiformes with 11 individuals. The highest avifauna abundance was the Eurasian tree sparrow (*Passer montanus*) at 20.52%, indicating high criteria, while the lowest relative abundance was the Greater crested tern (*Thalasseus bergii*) at 1.59% and the Purple heron (*Ardea purpurea*) at 1.30%. The diversity index (H') was 2.14%, indicating moderate abundance criteria; evenness (E) was 0.33%, indicating a stable species distribution index; and richness (Dmg) was 1.84%, classified as a low index.

Keywords: Avifauna; Abundance; Conservation_Status; Limboto_Lake.

INTRODUCTION

Avifauna refers to groups of wildlife found living and residing in aquatic areas such as swamps, marshes, mangrove forests, river estuaries, and coasts. Avifauna depends on the existence of wetlands for activities like foraging, nesting, loafing, and moulting. Another type, terrestrial birds, are not dependent on wetlands but sometimes utilize them for foraging and shelter (Zakaria & Rajpar, 2010). Ecologically, avifauna consists of bird species whose lives depend on the presence of wetlands (Maruapey et al., 2022). The presence of avifauna is an important indicator for assessing the quality and productivity of a wetland environment. Wetlands are crucial habitats for avifauna as breeding, nesting, and rearing grounds, foraging areas, water sources, shelter, and for predators (Jumilawaty, 2021).

Birds can act as controllers of pest insects, seed dispersers, and flower pollinators. Based on global bird diversity data, Indonesia ranks fourth on the list of the world's richest countries in terms of bird species, after Brazil, Colombia, and Peru, and first for endemics (Iskandar et al., 2021; Iswandaru et al., 2020). Birds are highly sensitive to environmental changes, making them suitable indicators of environmental change. This can be observed from changes in species diversity or population changes occurring annually in a location (Adelina et al., 2016). Besides

servicing as indicators of environmental change, birds also have ecological benefits, including roles in ecological processes such as balancing the food chain in ecosystems, assisting plant pollination, and acting as seed dispersal agents for various plants.

Limboto Lake in Gorontalo Regency is a freshwater swamp rich in biodiversity, both flora and fauna, including avifauna (waterbirds). Limboto Lake has many functions and benefits, including providing clean water, habitat for plants and animals, regulating hydrological functions, preventing natural disasters, stabilizing natural systems and processes, producing biological natural resources, generating energy, providing transportation, recreation and sports, fisheries resources, income generation, flood control, and serving as a means for research and education (Dauda et al., 2017).

The presence of avifauna in a location is an important indication of the quality and productivity of a wetland environment; therefore, data on the types and abundance of avifauna in their habitats are needed. To preserve the avifauna habitat in the waters of Limboto Lake, which is expected to help maintain environmental sustainability along with all its components, research is necessary to clearly reveal the number of species and abundance of avifauna that frequently utilize Limboto Lake waters as a habitat for foraging and other activities. The objectives of this research are to determine the number and types of avifauna in the waters of Limboto Lake, Gorontalo Regency, and to understand the species abundance of avifauna and their conservation status. Research on avifauna in Limboto Lake is important because this lake is one of the largest aquatic ecosystems in Gorontalo with strategic ecological functions, both as a natural habitat for local waterbirds and as a stopover site for migratory birds. However, the condition of Limboto Lake is under serious pressure due to sedimentation, land use change, and pollution, impacting the habitat quality for wildlife, including avifauna. Information regarding the number, types, abundance, and conservation status of birds in this area is essential as a scientific basis for planning, biodiversity conservation, sustainable water management, and efforts to preserve the lake's ecosystem functions.

RESEARCH METHODOLOGY

Time and Location

This research was conducted at Limboto Lake, Gorontalo Regency, from January to March 2025 (Figure 1). Administratively, Limboto Lake is located in Limboto District, Gorontalo Regency, Gorontalo Province. Geographically, it is located at coordinates 122° 42' 0.24" - 123° 03' 1.17" East Longitude and 00° 30' 2.035" - 00° 47' 0.49" North Latitude.

Materials and Tools

The tools used in this research included: GPS, binoculars, digital camera, and a watch for timekeeping. The materials used included a map of Limboto Lake and a field guidebook for bird species identification.

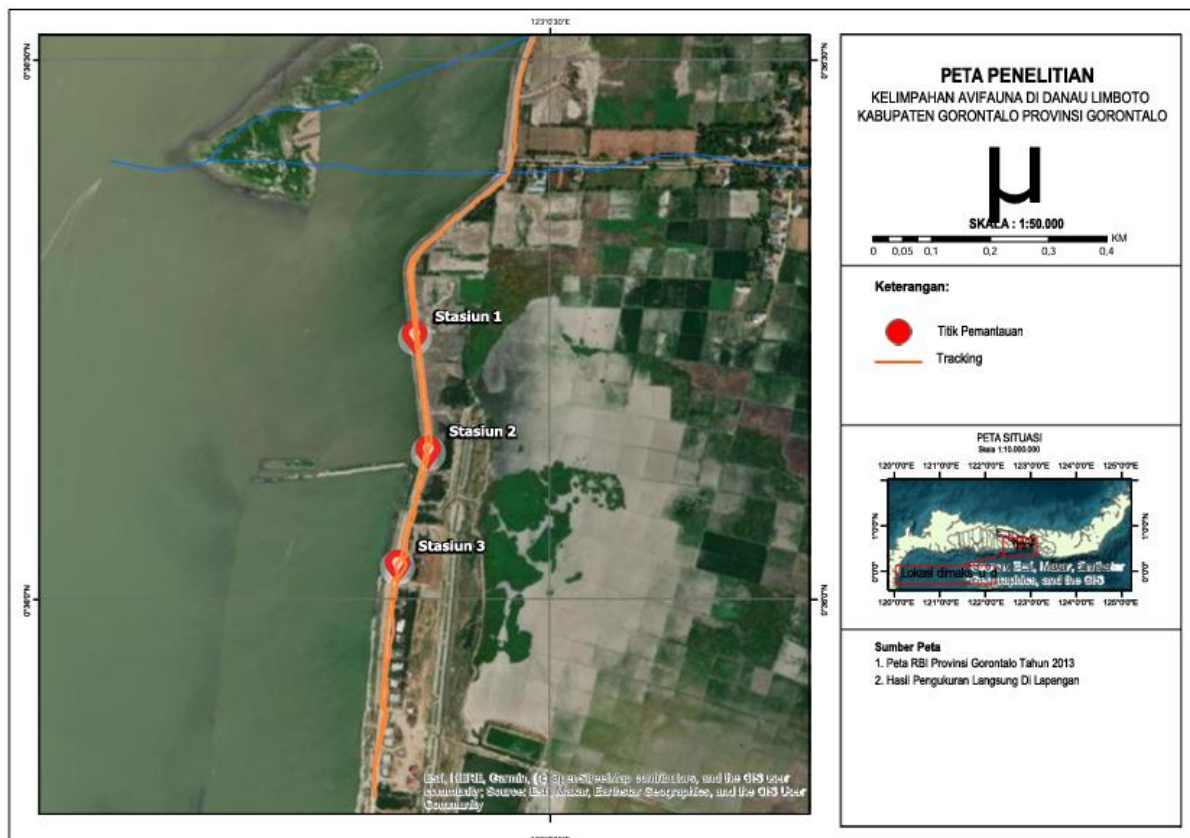


Figure 1. Research Location Map

Research Data Collection Method

Bird biodiversity data collection was conducted using the point count method. The method used in this research was a survey. The survey was carried out by determining observation points or stations (*Concentration Count*), a method of observation by placing several bird observation points in ideal positions for data collection and imaging of avifauna following the water flow (*river transect*) by walking along the lake. Observations were made at each observation station. Implementation involved standing at a specific point in the studied habitat and recording bird encounters within a certain time frame and specific area.

Observation points were spaced 200 meters apart with an observation radius as far as the eye could see (25 m), recording all birds detected within the visual radius for 2 hours. It took 15 minutes to walk to the next point. Thus, 3 repetitions were conducted. Repetition is important to clarify the research, broaden the scope of the research conclusions, and correct various errors in the research. Every direct bird encounter, including those flying, was recorded by species (Iswandaru et al., 2018), (Figure 2).

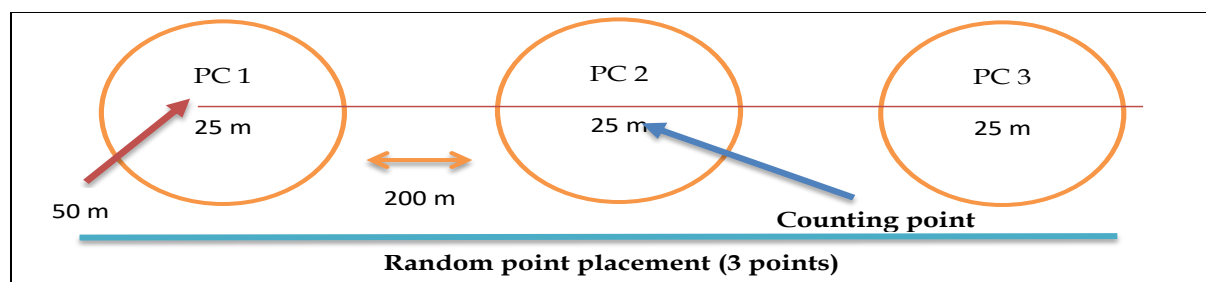


Figure 2. Bird Point Count Observation Design

Bird observations were conducted in the morning and evening between 06.00-08.00 WITA (Central Indonesia Time) and 16.00-18.00 WITA, during good weather (no heavy rain or strong wind) at predetermined observation points. Bird species observation was done by directly recording species and individual birds by sighting birds at the observation location, aided by a field guidebook for bird identification (MacKinnon et al., 2010). The bird data collected included the species and number of individual birds stopping and being active in the observation area. All bird species were recorded for the number of individuals and encounter time. The data collected were the bird species encountered, the number of individuals per species, and the transect length was adjusted to the lake's water area. Species and numbers of birds were recorded based on physical appearance during observation. To aid species identification, the field guides "Burung-Burung di Kawasan Wallacea" and Field Guide to the waterbirds of ASEAN were used (James et al., 2017; Kim et al., 2021).

Table 1. Identified bird species will be grouped based on IUCN (Convention On International Trade In Endangered Species Of Wild Fauna And Flora)

IUCN	CITES	Permen LHK No.106
Not Evaluated (NE)	Apendiks I,II dan III	Protected (Dilindungi =D)
Data Deficent (DD)		Not Protected (Tidak Dilindungi =TD)
Least Concern (LC)		
Near Threatened (NT)		
Near Threatened (NT)		
Vulnerable (VU)		
Endangered (EN)		
Critically Endangered (CE)		
Extinct in the Wild (EW)		
Extinct (EX)		

Source: Conservation status, IUCN 2020

Data Analysis

Number and types of avifauna, research data will be tabulated based on number, species, status, and relationship with habitat preference, then interpreted and presented in tables, graphs, and figures.

Avifauna abundance, was used to determine the density of individuals in an ecosystem. Relative abundance was calculated based on the formula (Sriyanto, 2013):

$$D_i = \frac{n_i}{N_i} \times 100\%$$

D_i = relative abundance (%); n_i = number of individuals of each species;
 N = total number of individuals.

Based on the number of bird species found in the field, the relative abundance category can be determined into five classes: Dominant: > 8%; Abundant: 2.1 - 8%; Frequent: 1.1 - 2%; Occasional: 0.1 - 1%; Rare: < 0.1%.

Conservation Status of Avifauna Species, the determination of species conservation status refers to the Indonesian Bird List Number 2 of 2007 and IUCN, 2020.

RESULTS AND DISCUSSION

Number of Avifauna Species

The results of the avifauna study found 13 species, classified into six (6) orders, seven (7) families, with a total of 692 individual birds. The bird species found were quite diverse, with various characteristics differing for each species (Table 2). The

number of bird species can serve as an indicator of an ecosystem's existence because birds can influence presence or distribution in Limboto Lake. The high diversity of avifauna species in the lake is caused by a combination of habitat diversity, resource availability, differing ecological adaptations among species, and the lake's function as a global migration route. This diversity is not only important for ecosystem balance but also serves as an indicator of aquatic environmental health (Maclean et al., 2011). The population and density of birds in a particular habitat are influenced by biological factors, including vegetation and other elements, as well as environmental factors, including water, temperature, air, and sunlight (Maulidya et al., 2021). Lakes significantly enhance avifauna life activities as they can be locations for shelter, foraging, and breeding/nesting (Sari et al., 2022). This aligns with the statement by (McKinney et al., 2011) that lakes significantly enhance avifauna life activities because freshwater ecosystems provide abundant resources, including food availability (fish, invertebrates, aquatic plants), nesting habitats, and shelter areas. Lake waters also serve as important "stopover sites" for migratory birds needing rest and foraging spots during long journeys. Riparian and marsh vegetation around the lake increases habitat heterogeneity, supporting diversity of bird trophic guilds such as piscivores, insectivores, to granivores (Wetlands International, 2020). Furthermore, stable water supply and high primary productivity in lake ecosystems create optimal conditions for the sustainability of avifauna populations, both resident and migrant (Keddy, 2010).

Table 2. Avifauna Species of Limboto Lake

NO	Ordo	Famili	Spesies
1	Anseriformes	Anatidae	Wandering Whistling-Duck (<i>Dendrocygna arcuata</i>)
2	Ciconiiformes	Anatidae	Little Egret (<i>Egretta garzetta</i>)
3		Anatidae	Pacific Reef-Heron (<i>Egretta sacra</i>)
4		Anatidae	Purple Heron (<i>Ardea purpurea</i>)
5	Charadriiformes	Sternidae	Greater Crested Tern (<i>Thalasseus bergii</i>)
6	Gruiformes	Rallidae	Purple Swamphen (<i>Porphyria porphyria</i>)
7		Rallidae	Barred Rail (<i>Gallirallus torquatus</i>)
8	Pelecaniformes	Ardeidae	Great Egret (<i>Ardea alba</i>)
9		Ardeidae	Intermediate Egret (<i>Ardea intermedia</i>)
10		Ardeidae	Javan Pond-Heron (<i>Ardeola speciosa</i>)
11	Passeriformes	Estrildidae	Chestnut Munia (<i>Lonchura atricapilla</i>)
12		Oriolidae	Brown Oriole (<i>Oriolus szalayi</i>)
13		Passeridae	Eurasian Tree Sparrow (<i>Passer montanus</i>)

Source: Primary research data analysis, 2025

Percentage of Bird Species per Family

The Ardeidae family had the highest percentage at 50% (Note: 7 species listed in table, but family count in text suggests 4 species from other families: Anatidae (1), Laridae/Sternidae (1), Rallidae (2), Estrildidae (1), Oriolidae (1), Passeridae (1) = 7 families total. The 50% likely refers to proportion of species within Ardeidae vs. all others). Four species belong to the Ardeidae family: Wandering Whistling-Duck (*Dendrocygna arcuata*), Little Egret (*Egretta garzetta*), Pacific Reef-Heron (*Egretta*

sacra), Purple Heron (*Ardea purpurea*), Great Egret (*Ardea alba*), Intermediate Egret (*Ardea intermedia*), and Javan Pond-Heron (*Ardeola speciosa*). Meanwhile, the families with the lowest percentage were Laridae/Sternidae and Oriolidae, each with a percentage of 2% (one species each). One species from Laridae/Sternidae is the Greater Crested Tern (*Thalasseus bergii*), and one species from Oriolidae is the Brown Oriole (*Oriolus szalayii*). For clarity, see (Figure 3) below.

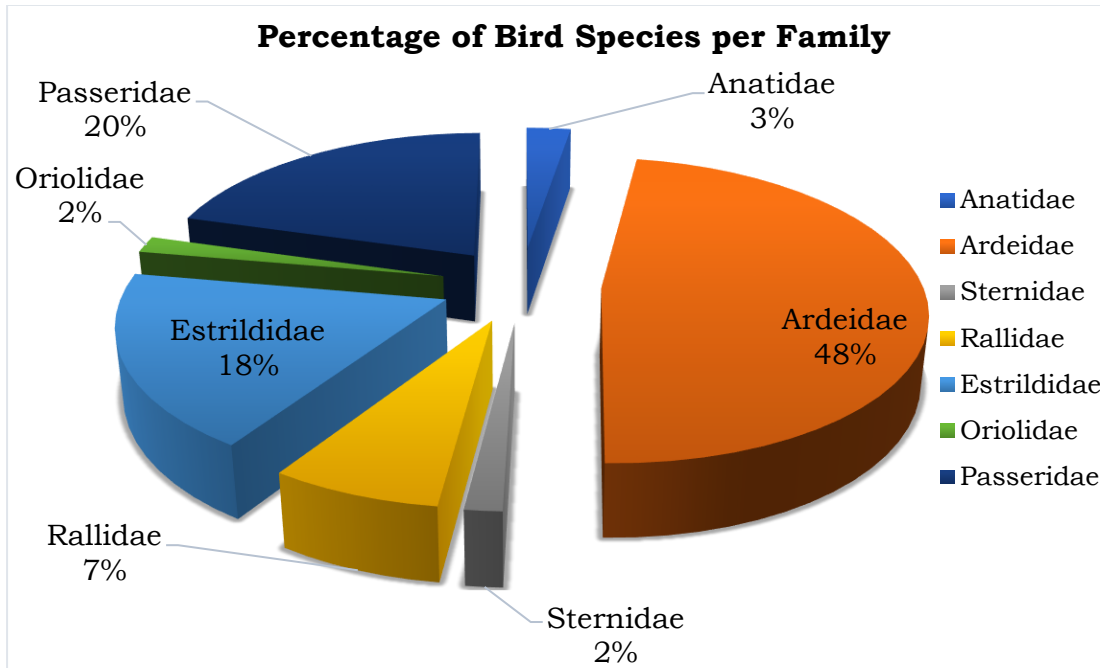


Figure 3. Percentage of Bird Species per Family

Based on the number of species, the Ardeidae family has the highest number of species at 48%, or 331 individuals, which generally prefer the waters along the lake. This aligns with the statement by Nugroho et al. (2013) that the Ardeidae family dominates lake waters, as this family is more commonly found in lakes in general and consists of birds that feed on small fish and insects.

In terms of species count, three families have a relatively low number of species: the Oriolidae family, represented by the Brown Oriole (*Oriolus szalayii*) at 2% or 12 individuals; the Sternidae family, represented by the Greater Crested Tern (*Thalasseus bergii*) at 2% or 11 individuals; and the Anatidae family, represented by the Wandering Whistling Duck (*Dendrocygna arcuata*) at 3% or 18 individuals. These species can be categorized as rare visitors to the lake or are only found in specific locations such as rice fields, swamps, mangroves, or other wetland areas. However, these families are also often observed gliding in the air over forested areas (Warmetan et al., 2015). The low presence of the Oriolidae and Sternidae families during the study may be attributed to the end of the fruit harvest season, resulting in fewer sightings of grain-eating bird species (Kartikasari et al., 2024).

The number of species from the Oriolidae and Sternidae families is relatively lower in lake ecosystems because these families have different habitat preferences compared to freshwater conditions. Oriolidae birds are generally arboreal insectivores and frugivores, relying more on forests and tree vegetation rather than open water areas (Del Hoyo et al., 2019). Meanwhile, Sternidae birds are more commonly found in coastal ecosystems, estuaries, and small islands due to the greater abundance of fish in these habitats compared to lakes (Burger & Gochfeld, 2020). Therefore, lakes are not the primary habitat supporting the ecological needs of these two families, making their presence more limited compared to other families such as Ardeidae, which highly depend on aquatic ecosystems.

Percentage of Total Avifauna Individuals per Family

The research results show that the percentage of total avifauna individuals per family is as follows: the Ardeidae family had the highest number of individuals at 331, representing a percentage of 47.83%. This was followed by the Passeridae family with 142 individuals (20.52%), and the Estrildidae family with 128 individuals (18.5%). In contrast, the families with the smallest percentages were the Rallidae family (7.23%), the Anatidae family with 18 individuals (2.60%), followed by the Oriolidae family with 12 individuals (1.73%), and the Sternidae family with 11 individuals (1.59%). For further clarity, please refer to (Figure 4).

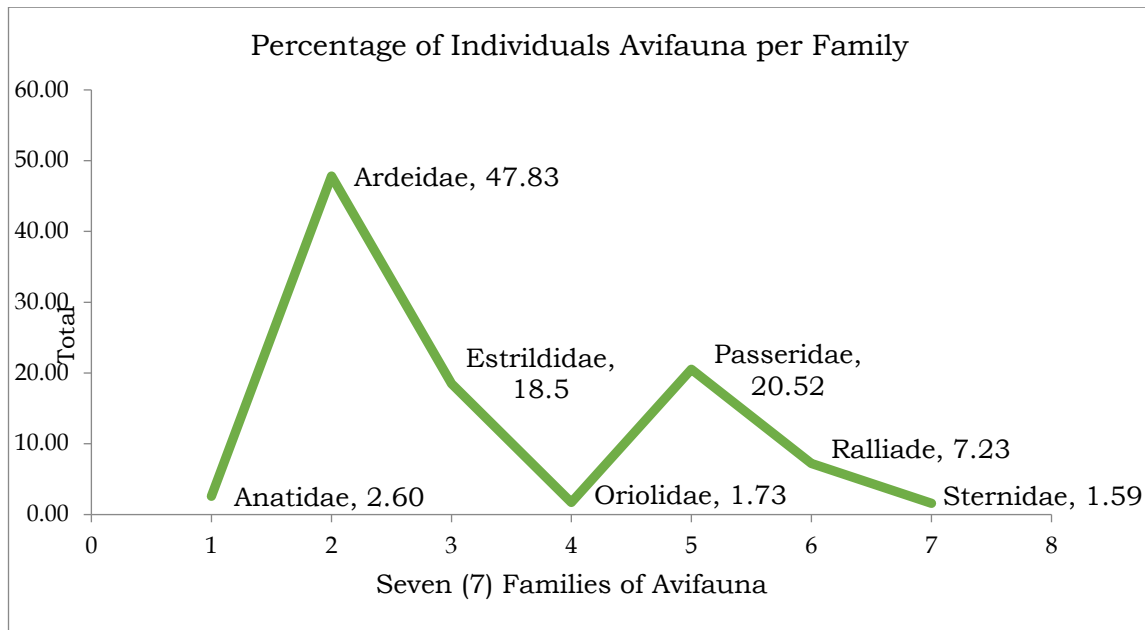


Figure 4. Percentage of Total Bird Individuals per Family

Figure 4 shows that the Ardeidae family was found to have the highest number of individuals. This can be attributed to the dominance of this family, which is likely influenced by the lake habitat, its swampy nature, and the presence of water pools that support a diverse range of fish, frogs, and other animals commonly preyed upon by these birds.

Ecologically, the lake provides an ecosystem that suits the needs of Ardeidae, such as shallow waters, marshes, and areas with aquatic vegetation. Ardeidae are known as opportunistic predators that feed on small fish, amphibians, crustaceans, and even aquatic insects (Kushlan & Hancock, 2005). Conditions of lake siltation and eutrophication actually create an ideal habitat for Ardeidae by increasing the availability of small fish and other aquatic organisms in shallow areas (Sukmantoro et al., 2007). Consequently, the number of Ardeidae individuals is higher compared to other bird families that rely more on stable aquatic habitat quality.

This pattern of Ardeidae dominance is also consistently observed. This aligns with the statement by Harianto et al. (2016) that birds with characteristic long legs, such as the Purple Heron (*Ardea purpurea*), Great Egret (*Ardea alba*), Intermediate Egret (*Egretta intermedia*), and Pacific Reef-Heron (*Egretta sacra*), are avifauna species that can stalk crustaceans, fish, frogs, and reptiles. The Ardeidae family dominates waterbird communities because extensive shallow waters provide an abundant food source (Suhardiman, 2016). Furthermore, Ardeidae are found in significant numbers, especially in lake edge areas with swamp vegetation, and they become the dominant group due to the abundance of small fish in the shallow waters (Manembu et al., 2019; Pattiselanno & Arobaya, 2013).

Thus, the dominance of Ardeidae in Limboto Lake, as well as in other lakes, indicates that this family has a high ecological adaptability and effective foraging strategies in

shallow water habitats. The main factors supporting the high number of Ardeidae individuals are a combination of habitat conditions (shallow and inundated waters), high food availability, and the opportunistic nature of these birds in utilizing changes in the aquatic ecosystem.

Distribution of Total Avifauna Individuals per Order

Research results show the distribution of individual birds per order as follows: Passeriformes with 282 individuals, followed by Pelecaniformes with 186 individuals, Ciconiiformes with 145 individuals, Gruiformes with 50 individuals, Anseriformes with 18 individuals, and Charadriiformes with 11 individuals (Figure 5).

Avifauna utilize mudflats as areas for foraging and drinking. Among the avifauna orders identified is Order Ciconiiformes Species from this order include the Little Egret (*Egretta garzetta*), Pacific Reef-Heron (*Egretta sacra*), and Purple Heron (*Ardea purpurea*). Others is Order Anseriformes, a species from this order is the Wandering Whistling Duck (*Dendrocygna arcuata*).

The uneven distribution of individual birds across the lake ecosystem has the potential to cause significant ecological impacts. Birds are a key component of the lake's food web, functioning as predators, seed-eaters, pollinators, and seed dispersers. An imbalance in the distribution of individuals can disrupt ecosystem dynamics. For example, it may lead to an increase in the population of certain organisms due to reduced predation pressure or, conversely, a decrease in the regeneration of aquatic vegetation due to a decline in seed-dispersing agents (Whelan et al., 2008).

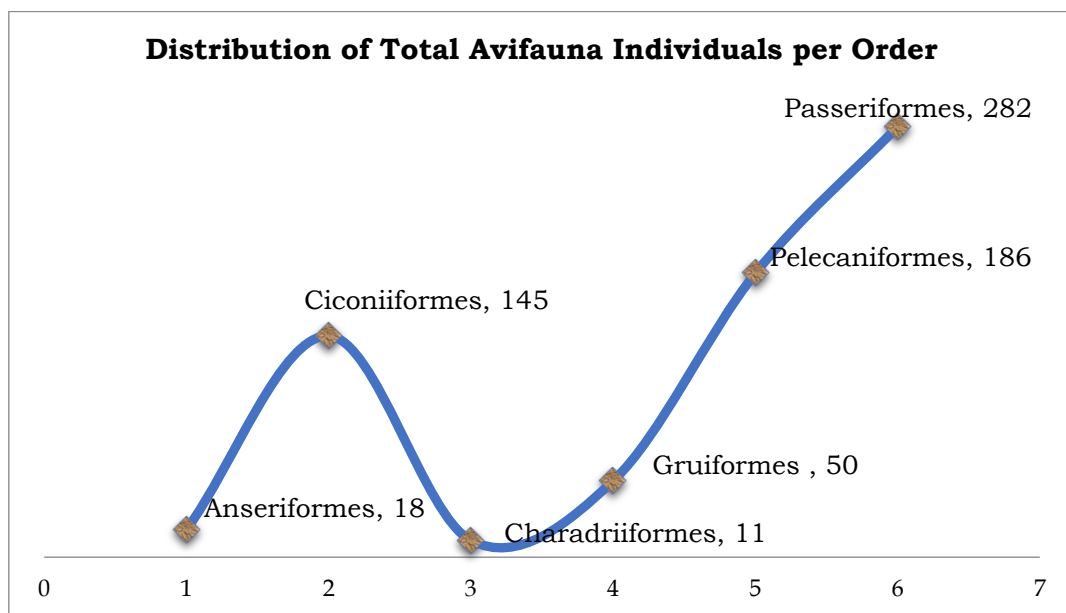


Figure 5. Distribution of Total Avifauna Individuals per Order on *Point Count*

Furthermore, birds serve as indicators of aquatic ecosystem health. An uneven distribution of bird populations often reflects underlying changes in habitat quality, whether due to the degradation of riparian vegetation, fluctuations in food availability, or anthropogenic pressures such as land conversion and pollution (Gregory & van Strien, 2010). Such imbalances can disrupt the stability of the lake ecosystem, for instance, by reducing the diversity of other species that have ecological ties to birds. However, an uneven distribution of birds not only impacts the avifauna community itself but also has broad implications for the sustainability of the lake ecosystem's overall functions. Therefore, monitoring bird distribution is crucial as part of efforts for sustainable lake conservation (Sekercioglu, 2006).

Avifauna Species of Limboto Lake

Visually, thirteen (13) species of avifauna have been identified in Limboto Lake (Figure 6), as follows:



Egretta garzetta



Ardeola speciosa



Passer montanus



Thalasseus bergii



Ardea purpurea



Loncura Malacca



Ardea alba



Agretta intermedia



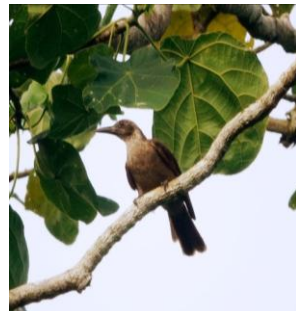
P. Phorphyrio



D. arcuate



G. torquatus L.



Oriolus szalayii



Egretta sacra

Figure 6. Avifauna Species of Limboto Lake

Figure 6 shows that Limboto Lake is rich in food resources for avifauna. The birds at this research site were observed to tend to gather and concentrate their foraging in areas where their prey is easily found. The main types of prey preferred by the avifauna include bivalves, gastropods, crustaceans, polychaetes, and fish (Alikodra, 2018). These food types are commonly found in the water. This abundance is what attracts numerous species of avifauna to the lake to forage for their survival. Furthermore, the avifauna of Limboto Lake also search for food outside the lake itself, particularly along the lake's shoreline, for fish, crabs, and snails.

Avifauna Abundance

Bird species abundance naturally differs significantly from the abundance of other wildlife. This is due to their high mobility, meaning bird populations fluctuate according to habitat conditions and temporal changes. The research results indicate that Limboto Lake has a varied relative abundance of avifauna across the observation sites.

Overall, the most frequently encountered species was the Eurasian Tree Sparrow (*Passer montanus*) at 20.52%, followed successively by the Chestnut Munia (*Lonchura malacca*) at 18.50%, the Javan Pond-Heron (*Ardeola speciosa*) at 18.06%, and the Little Egret (*Egretta garzetta*) at 13.87%. In contrast, the lowest relative abundances were recorded for the Greater Crested Tern (*Thalasseus bergii*) at 1.59% and the Purple Heron (*Ardea purpurea*) at 1.30% (Table 3).

The high individual abundance of the Eurasian Tree Sparrow (*Passer montanus*) (20.52%) compared to other species is notable. This species is a member of the Passeridae family, which shows a particular affinity for lake waters, specifically those of Limboto Lake (Table 3).

Table 3. Avifauna Abundance of Lake Limboto

No	Species	Family	Σ Individual	<i>Di</i>
1	<i>Dendrocygna arcuata</i>	Anatidae	18	2.60
2	<i>Egretta garzetta</i>	Ardeidae	96	13.87
3	<i>Egretta sacra</i>	Ardeidae	40	5.78
4	<i>Ardea purpurea</i>	Ardeidae	9	1.30
5	<i>Thalasseus bergii</i>	Sternidae	11	1.59
6	<i>Porphyrio porphyrio</i>	Rallidae	22	3.18
7	<i>Gallirallus torquatus</i>	Ralliade	28	4.05
8	<i>Ardea alba</i>	Ardeidae	28	4.05
9	<i>Mesophoyx intermedia</i>	Ardeidae	33	4.77
10	<i>Ardeola speciosa</i>	Ardeidae	125	18.06
11	<i>Lonchura malacca</i>	Estrildidae	128	18.50
12	<i>Oriolus szalayi</i>	Oriolidae	12	1.73
13	<i>Passer montanus</i>	Passeridae	142	20.52
Total			N= 692	100

Source: Primary research data analysis, 2025

Table 3 shows that the bird species with the smallest individual abundances can be influenced by their life behavior; these species tend to be non-gregarious and generally hunt alone or in pairs to sustain their lives, including foraging for food and water. For example, the Purple Heron (*Ardea purpurea*) was found with only nine (9) individuals during the observation. This species was observed gliding through the air

in flight. The abundance of individual bird species is highly dependent on their habitat conditions. Birds will inhabit a suitable habitat if it can support their survival in terms of foraging, drinking, and seeking shelter from predators or other threats. In principle, birds require places to forage, take refuge, breed, and remain safe from all types of disturbances (Hasibuan et al., 2018; Aliyani et al., 2018). Additionally, diverse vegetation with complete stratification will increase the diversity of bird species in an area.

The following are the diversity, evenness, and richness indices of the avifauna. The results of the bird diversity index analysis (Figure 7) show that the bird diversity index in Limboto Lake is 2.14, while the evenness index is 0.33 and the richness index is 1.84. These results indicate that the bird species are distributed stably in Limboto Lake. This aligns with the following statement by Annisa et al. (2016): if the species evenness index falls within the range $E < 0.20$, the species distribution can be considered unstable, whereas if the value is $0.21 < E < 1$, the species distribution is considered stable.

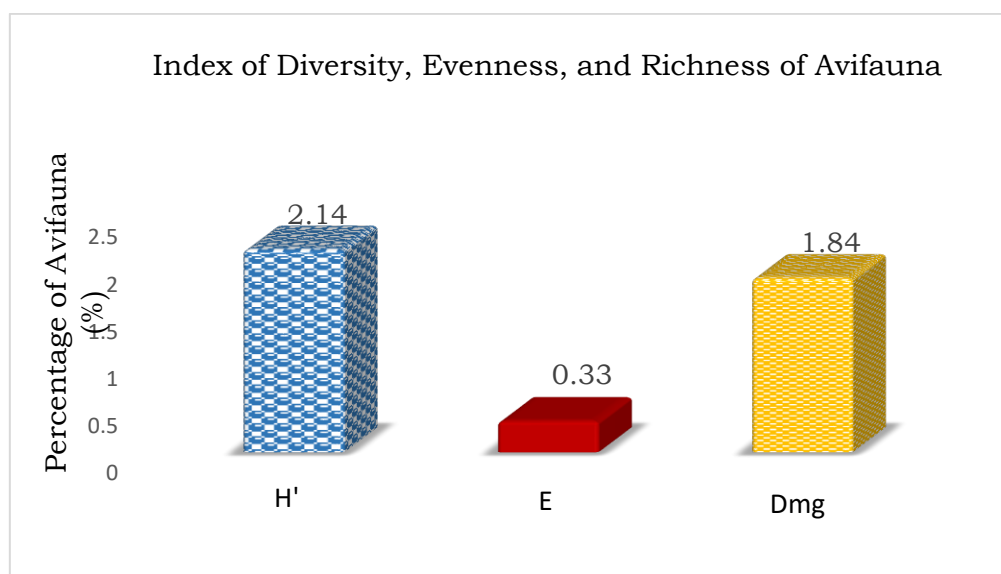


Figure 7 Analysis of Index Values: H', E, and Dmg

Conservation Status of Avifauna Species

The conservation status of birds is closely linked to various aspects related to species preservation, including protection, rarity status, and endemism (Table 3). Seven avifauna species are categorized as protected under Regulation of the Republic of Indonesia Number 106 of 2018 (P.106/MENLHK/SETJEN/KUM.1/12/2018) concerning the Second Amendment to Regulation Number 20 of 2018 (P.20/MENLHK/SETJEN/KUM.1/6/2018) on Protected Species of Birds and Wildlife. These species are: Wandering Whistling Duck (*Dendrocygna arcuata*), Little Egret (*Egretta garzetta*), Pacific Reef-Heron (*Egretta sacra*), Greater Crested Tern (*Thalasseus bergii*), Great Egret (*Ardea alba*), Javan Pond-Heron (*Ardeola speciosa*), Brown Oriole (*Oriolus szalayii*).

The conservation status of avifauna, whether categorized as Vulnerable (VU), Endangered (EN), or Critically Endangered (CR), reflects the level of extinction risk a species faces. The presence of waterbirds in the lake, such as storks, wild ducks, and swamp passerines, serves as an indicator of aquatic ecosystem quality (Bibby et al., 2000). A decline in the populations of these birds can signal habitat degradation caused by sedimentation, wetland conversion, and water pollution.

Furthermore, the loss of species with high conservation status can disrupt ecosystem functions. For example, fish- and insect-eating birds play a role in maintaining food web balance, while seed-dispersing birds support the regeneration of riparian

vegetation. The loss of these ecological functions can accelerate the decline in lake ecosystem quality, including reduced fisheries productivity and increased pest outbreaks (Sutherland et al., 2019).

Moreover, a decline in avifauna diversity also reduces ecotourism value and the potential for ecosystem services that local communities can benefit from. This implies a loss of alternative economic opportunities based on conservation (BirdLife International, 2022). Therefore, the conservation status of avifauna is not merely an ecological issue but also a socio-economic one.

Table 4. Conservation Status of Avifauna Species in Limboto Lake

No	Species	Conservation Status			
		IUCN	CITES	UU/PP	Distribution
1	<i>Dendrocygna arcuata</i>	LC		D	K,S, J, NT, M, P
2	<i>Egretta garzetta</i>	LC		D	J,B,K,S, SU, A
3	<i>Egretta sacra</i>	LC		D	S, J, B, K
4	<i>Ardea purpurea</i>	LC		TD**	S K J B S NT
5	<i>Thalasseus bergii</i>	LC		D	S K J B S NT M P
6	<i>P. porphyrio</i>	LC		TD**	J B I S S K JT
7	<i>Gallirallus torquatus</i>	EN)		TD**	S, P
8	<i>Ardea alba</i>	LC		D	S,K, J, B, S, NT, M, P
9	<i>Ardea intermedia</i>	LC		TD**	S,K,J,B,S, NT, M, P
10	<i>Ardeola speciosa</i>	LC		D	SB, S K J B S
11	<i>Lonchura atricapilla</i>	LC		TD**	S, K, S
12	<i>Oriolus szalayi</i>	LC		D	P, S
13	<i>Passer montanus</i>	LC		TD**	S,J, K

Notes:

Threat Status According to IUCN refers to LC = Least Concern; species in this category are widespread and abundant, not currently qualifying as threatened, they also face no immediate risk of extinction, and EN = Endangered; species in this category face a very high risk of extinction in the wild.

The international trade of avifauna species is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which categorizes species into three appendices based on their conservation status.

The protection status of species in Indonesia, particularly for birds (avifauna), is formally categorized as Protected (D = *Dilindungi*) or Not Protected (TD = *Tidak Dilindungi*) based on national legislation. At the national level, legal protection for avifauna in Indonesia primarily refers to Government Regulation No. 7 of 1999 concerning the Preservation of Wild Plant and Animal Species (PP No. 7/1999), which designates protected species and prohibits all forms of trade and hunting, and Government Regulation No. 8 of 1999 concerning the Utilization of Wild Plant and Animal Species (PP No. 8/1999), which regulates sustainable utilization for research, scientific purposes, and breeding. Thus, the protection status of avifauna in Indonesia not only addresses conservation aspects by prohibiting exploitation (PP No. 7/1999) but also accommodates responsible and sustainable utilization (PP No. 8/1999) in accordance with CITES principles.

The distribution status indicates the geographic regions or islands in Indonesia where a specific bird species can be found. The following alphabetical codes represent these regions: A: Ambon, B: Bali, I: Irian (a historical name for the island of New Guinea, now encompassing the Indonesian provinces of Papua and West Papua), J: Java, JT: East Java (*Jawa Timur*), K: Kalimantan (Borneo), M: Maluku (Moluccas), NT: Nusa Tenggara (Lesser Sunda Islands), P: Papua, S: Sulawesi (Celebes) or Sumatera (Sumatra), SU: North Sulawesi (*Sulawesi Utara*)

Several crucial recommendations require attention and are expected to address various issues related to wildlife protection, particularly avifauna:

1. Restoration of Aquatic and Riparian Habitats
Rehabilitating swamp areas, planting cover vegetation, and controlling sedimentation are essential to ensure the sustainability of waterbird habitats.
2. Strengthening Protection for Critical Species
Establishing special protection zones in key areas for birds, particularly nesting and feeding grounds (Important Bird Areas - IBAs), is necessary.
3. Ongoing Monitoring and Research
Routine monitoring of avifauna populations is needed to serve as a bio-indicator for assessing the ecological health of Limboto Lake.
4. Community and Local Government Collaboration
Educational programs and empowerment initiatives for communities around the lake must be strengthened, enabling them to become key actors in safeguarding bird habitats.
5. Integration of Conservation with Ecotourism
The potential for developing birdwatching tourism can serve as a dual strategy for both conservation and improving local community economies.

CONCLUSION

A total of 13 avifauna species have been identified in the lake, classified into six (6) orders and seven (7) families, with a total recorded abundance of 692 individual birds. The species diversity index (H') value of 2.14 indicates moderate diversity. The ecosystem conditions of Limboto Lake are generally stable enough to support the long-term survival of avifauna. The species evenness index (E') value of 0.33 is classified as relatively stable, while the species richness index value of 1.84 is considered low. Furthermore, seven protected bird species have been identified, namely: Wandering Whistling Duck (*Dendrocygna arcuata*), Little Egret (*Egretta garzetta*), Pacific Reef-Heron (*Egretta sacra*), Greater Crested Tern (*Thalasseus bergii*), Great Egret (*Ardea alba*), Javan Pond-Heron (*Ardeola speciosa*), Brown Oriole (*Oriolus szalayii*). This summary highlights the ecological significance of the lake as a habitat for both common and protected bird species, emphasizing the need for continued conservation efforts to maintain its biodiversity.

REFERENCES

- Adelina, M., Harianto, S. P., & Nurcahyani, N. (2016). Keanekaragaman Jenis Burung Di Hutan Rakyat Pekon Kelungu Kecamatan Kotaagung Kabupaten Tanggamus. *Jurnal Sylva Lestari*, 4(2), 51-60.
- Alikodra, H. S. (2018). Migrasi Burung Air Dan Daerah Persinggahannya Bagi Pengembangan Ekowisata. In *Prosiding Seminar Nasional Lingkungan Lahan Basah*, 3 (1), 5-10.
- Aliyani, Y. P., Irsyad, F. S., & Retno, T. M. (2018). Komunitas Burung Di Daerah Aliran Sungai Waduk Sermo Kulon Progo Dan Status Konservasinya. *Bioma: Jurnal Biologi Makassar*, 3(2), 18-24.
- Annisa, A., Iswandar, D., Darmawan, A., & Fitriana, Y. R. (2023). Analisis Keanekaragaman Jenis Dan Status Konservasi Burung Pada Agroforestri Berbasis Kopi. *Jurnal Hutan Tropis*, 11(3), 355-363.
- Bibby, C. J., Burgess, N. D., Hill, D. A., & Mustoe, S. (2000). *Bird Census Techniques* (2nd ed.). Academic Press.
- BirdLife International. (2022). *State Of The World's Birds: Indicators For Our Changing World*. Birdlife International.

- Burger, J., & Gochfeld, M. (2020). Terns (Sternidae). In J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, & E. de Juana (Eds.), *Handbook of the Birds of the World Alive*. Lynx Edicions.
- CITES (*Convention On International Trade In Endangered Species Of Wild Fauna And Flora*). (2023). Appendices I,II,III. <https://cites.org>, Diakses pada 30 Juli 2023.
- Dauda, T.O., Baksh, M.H., Shahrul, A.M.S., (2017). Birds' Species Diversity Measurement Of Uchali Wetland (Ramsar Site) Pakistan. *Jurnal Asia-Pacific Biodivers*. 10(2), 167–174.
- Del Hoyo, J., Elliott, A., Sargatal, J., Christie, DA & de Juana, E. Erard, C. (Eds.). (2014). *Handbook of the Birds of the World Alive*. Lynx Edicions, Barcelone. *Revue d'Écologie (La Terre et La Vie)*, 69(3), 361-361.
- Gregory, R. D., & van Strien, A. (2010). Wild bird indicators: Using birds as biodiversity indicators. *Bird Conservation International*, 20(2), 1–22.
- Hariato, Sugeng, P., & Nurcahyani, N. (2016). Studi Populasi Burung Famili Ardeidae Di Rawa Pacing Desa Kibang Pacing Kecamatan Menggala Timur Kabupaten Tulang Bawang Provinsi Lampung. *Jurnal Sylva Lestari*, 4(2), 109-116.
- Hasibuan, R. S., Nitibaskara, T. U., & Mahardika, R. (2018). Interpretation Trail” Bird Watching” in Bogor Botanical Garden. *Media Konservasi*, 23(1), 28-36.
- IUCN(International Union for Conservation of Nature and Natural Resources Red List of Threatened Spesies. (2020). www.iucnredlist.org, Diakses pada 20 Agustus 2023.
- Iskandar, J., Husodo, T., Wulandari, I., Megantara, E. N., Partasasmita, R., & Shanida, S. S. (2021). Bird diversity and ethno-ornithological knowledge of local people in Ciletuh-Palabuhanratu Geopark, Sukabumi, West Java, Indonesia. *Biodiversitas: Journal of Biological Diversity*, 22(8),3409-3422.
- Iswandaru, D., Khalil, A.R.A., Kurniawan, B., Permana, R., Febryano, I.G., Winarno, G.D. (2018). Kelimpahan Dan Keanekaragaman Jenis Burung Di Hutan Mangrove Kphlgunung Balak. *Indonesian Journal of Conservation*, 7(1):57-62.
- Iswandaru, D., Novriyanti, N., Banuwa, I. S., & Harianto, S. P. (2020). Distribution of bird communities in University of Lampung, Indonesia. *Biodiversitas Journal of Biological Diversity*, 21(6):2629-2637.
- James, A.O., Emmanuel, D., Bright, A.Y. (2017). Diversity and Abundance of Bird Species in Mole National Park, Damongo, Ghana. *Journal of Natural*, 7(12):20-33.
- Jumilawaty, E. 2021. Community structure of shorebirds (Charadriiformes: Scolopacidae) in Percut Sei Tuan District, North Sumatra. In *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 713(1):012041.
- Kartikasari, D., Abidin, A., Agustina, C. S., & Nurdianyoto, I. (2024). Keanekaragaman dan Kelimpahan Burung Pemakan Biji di Area Persawahan Tanjungsari, Tulungagung. *LenteraBio: Berkala Ilmiah Biologi*, 13(2), 262-269.
- Keddy, P. A. (2010). *Wetland ecology: Principles and conservation* (2nd ed.). Cambridge University Press.
- Kim, J. H., Park, S., Kim, S. H., & Lee, E. J. (2021). Identifying high-priority conservation areas for endangered waterbirds using a flagship species in the Korean DMZ. *Ecological Engineering*, 159, 106080.
- Kushlan, J. A., & Hancock, J. (2005). *The Herons*. Oxford University Press.
- MacKinnon, J., Philipps, K., Balen, B.V. (2010). *Seri Panduan Lapangan Burung-Burung di Sumatera, Jawa, Bali, dan Kalimantan*. Bogor: LIPI.
- Maclean, I. M. D., Rehfisch, M. M., Delany, S., & Robinson, R. A. (2011). The effects of climate change on migratory waterbirds within the African–Eurasian flyway. *Biodiversity*, 12(1), 89–109.

- Manembu, I. S., Rondonuwu, S. B., & Tilaar, W. (2019). Keanekaragaman jenis burung air di Danau Tondano Sulawesi Utara. *Jurnal Ilmiah Sains*, 19(1), 28–37.
- Maruapey, A., Saeni, F., & Nanlohy, L. H. (2022). Studi Kelimpahan Jenis Avifauna Di Perairan Danau Ayamaru Kabupaten Maybrat. *Jurnal Riset Perikanan dan Kelautan*, 4(2), 435-450.
- Maulidya, A. L., Dasumiati, D., & Widodo, W. (2021). Keragaman dan Kepadatan Populasi Burung di Kawasan Hijau Cibinong Science Center (CSC) LIPI, Jawa Barat. *Al-Kauniyah: Jurnal Biologi*, 14(2), 325-334.
- McKinney, R. A., Raposa, K. B., & Cournoyer, R. M. (2011). Wetlands as habitat in urbanizing landscapes: patterns of bird abundance and occupancy. *Landscape and Urban Planning*, 100(1-2), 144-152.
- Nugroho, M. S., Ningsih, S., & Ihsan, M. (2013). Keanekaragaman Jenis Burung Pada Areal Dongi-Dongi Di Kawasan Taman Nasional Lore Lindu. *Jurnal Warta Rimba*, 1(1), 1-9.
- Oktafitria, D., Pradana, F. E., Purnomo, E., & Saputra, A. (2022). Biodiversitas Burung Air Di Pesisir Pantai Socorejo, Kecamatan Jenu, Kabupaten Tuban, Jawa Timur. *Biology Natural Resources Journal*, 1(1), 7-14.
- Pattiselanno, F., & Arobaya, A. Y. (2013). Avifauna at Lake Sentani, Papua, Indonesia. *Biodiversitas Journal of Biological Diversity*, 14(2), 83–88.
- Peraturan Menteri Lingkungan Hidup dan Kehutanan. 2018. No. 106 tentang Jenis Tumbuhan dan Satwa Dilindungi yang terdiri dari satwa Dilindungi (D) dan Tidak Dilindungi (TD).
- Sari, D. P., Lestari, D. I., Saputra, A., Prabowo, C. A., & Harlita, H. (2022). Keanekaragaman Avifauna Daerah Terbuka dan Tertutup di Wilayah Kampus Ketingan Universitas Sebelas Maret. *BIOMA: Jurnal Biologi Makassar*, 7(1), 56-67.
- Sekercioglu, Ç. H. (2006). Increasing Awareness Of Avian Ecological Function. *Trends In Ecology & Evolution*, 21(8), 464–471.
- Suhardiman, A. (2016). Keanekaragaman burung air di kawasan Danau Rawapening Kabupaten Semarang. *Biosaintifika: Journal of Biology & Biology Education*, 8(1), 45–52.
- Sukmantoro, W., Irham, M., Novarino, W., Hasudungan, F., Kemp, N., & Muchtar, M. (2007). Daftar Burung Indonesia No. 2. Indonesian Ornithologists' Union.
- Sutherland, W. J., Dicks, L. V., Ockendon, N., & Smith, R. K. (2019). What Works in Conservation 2019. Open Book Publishers.
- Warmetan, H., Kesaulija, F. F., & Sadsoeitoeboen, B. M. (2015). Keragaman dan Status Konservasi Jenis Avifaunadi Danau Yamor. *Jurnal Kehutanan Papuaasia*, 1(2), 99-107.
- Wetlands International. (2020). Waterbirds and wetlands: Conservation needs and priorities. Wetlands International.
- Whelan, C. J., Wenny, D. G., & Marquis, R. J. (2008). Ecosystem services provided by birds. *Annals of the New York Academy of Sciences*, 1134(1), 25–60.
- Zakaria, M., & Rajpar, M. N. (2010). Bird species composition and feeding guilds based on point count and mist netting methods at the Paya Indah Wetland Reserve, Peninsular Malaysia. *Tropical life sciences research*, 21(2), 7-26.