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Title:

Habitat, diversity, and abundance of waterbirds in lantebung mangrove ecotourism area, Makassar city

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by

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human activities, the waterbirds population is very vulnerable because of hunting activities for hobbies and souvenir making and the paradigm of the society that regards waterbirds as a nuisance animal. Therefore, the population of waterbirds, as well as their habitat, need to be conserved in order to maintain the function and productivity of coastal wetlands, especially mangrove ecosystems.

On the north coast of Makassar, in Lantebung Village, there is a mangrove wetland ecosystem, which is the remnant of the green belt that was designated as a conservation and protection area based on the Makassar Regional Spatial Plan [4]. Lantebung is well-known as an important habitat for waterbirds. Lantebung was one of the locations for observing the abundance of waterbirds in Indonesia, with the number of waterbirds observed from 1983 to 1992, ranging from 1,001 to 5,000 [5].

However, the population of humans and their activities in its surroundings (included Bira and Untia villages) continue to affect the area. Today, this area is close to residential, industrial, and warehousing areas, apart from the presence of waterbirds that are still actively nesting and foraging. Therefore, this study aims to identify the types of waterbirds habitat and analyze the variety and diversity of waterbirds in the Lantebung, Mangrove Ecotourism Area.

2. Methods

The type of waterbirds habitat in the Lantebung Mangrove Ecotourism Area was determined by direct observation of waterbirds presence in the study sites. The observation was conducted by recording the characteristics of habitat, types of waterbirds activities, and taking pictures of each habitat type, which was observed. The observation of waterbirds at the study site was carried out using land survey methods [6], by walking along the edges of ponds and mudflats behind mangroves, while using binoculars to see the location where the waterbirds existed. After located, they were then identified by species and counted by individuals. The observation at the study site was held for three days at 6.00 - 10.00 am and from 3.00-5.00 pm. The instruments that were used were: Sakura binoculars with a radius of 1000 m, counter, Android phones with Avenza maps application to get GPS points and Burungnesia application, 'The Birds of Sulawesi' book to identify bird species, SLR cameras, and stationery.

The identification of bird species and its migration status was based on the field guide book 'the birds of Sulawesi [7]. The determination of scientific names and species names refers, while the status of species was based on IUCN (International Union for Conservation Nature) criteria on the IUCN Red List of Threatened Species official website (www.iucnredlist.org) and the Minister of Environment Regulation 2018 about protected species.

2.1. Diversity of waterbirds species analysis

Species density was determined by using observational data on the type and the number of species along the observation route in the morning and afternoon for three days. Species density is the average number of individuals per area (ha), which is calculated using the Line transect method with animal distance is known [8]. The line transect equation is as follows.

$$\hat{D} = n \sqrt{[2n/\pi \sum_{i} (x_i^2)/(2L)} \quad \text{.....(i)}$$

Where

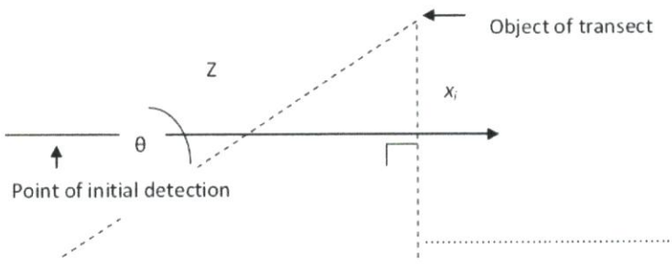
$\hat{D}$ = Estimation of population density
n = The number of detected animals
x_i = perpendicular distance of animal-i which was detected from the transect line
L = Lenght of transect

x_i value (perpendicular distance) derives from :

$$x = Z \sin \theta$$

.....(ii)

Where Z = Detection distance
Θ = Detection angle



.....(iii)

In addition, the relative frequency value was also calculated, which is the value of the frequency of occurrence of a species for three days observation, divided by the number of all waterbirds appearance frequencies multiplied by 100%. For example, in 3 days observation of a species, it only appeared in 1 day, so that the relative frequency is 1/3 x 100%= 33.34.%.

$$R = \frac{S-1}{Ln\ (NO)} \quad \text{.....(iv)}$$

The species diversity index was calculated using the equation as follows.
R = Diversity Index
S = the total of a species number in a habitat
n = the total of an individual number in a habitat
with the criteria :
R< 2,5 = low diversity level
2,5 > R > 4 = moderate diversity level
R > 4 = high diversity level

The species diversity index of each species is calculated by using the equation as follows.
R = diversity index
S = the number of species in a habitat
n = the number of individual in a habitat

with the criteria :
R< 2,5 = low diversity level
2,5 > R > 4 = moderate diversity level
R > 4 = high diversity level
The relative abundance of each species is calculated by using equation as follows.

$$IKR\ \frac{The\ number\ of\ individuals\ of\ one\ species\ (ni)}{Total\ of\ individual\ that\ were\ found(N)}\ x\ 100\% \quad \text{.....(v)}$$

Abundance is regarded high if the value is above 20%, moderate if the value is between 15% -20%, and low if the value is below 15%. A diversity index is calculated by using the equation as follows.

$$H = -\sum pi \ln pi$$

$$H' = -\sum\{(ni/n)ln(ni/n)\} \quad \text{.....(vi)}$$

H = diversity index
ni = the number of species
n = the number of individual
With the criteria
H' < 1 = low diversity level
1< H' < 3 = moderate diversity level
H' > 3 = highdiversity level

while evenness index is calculated by using the equation as follows:

$$E = \frac{1/Si}{e^{H'}} \quad \text{.....(vii)}$$

E = evenness index
H' = Shannon evenness index value
Si = Simpson evenness index value

If E < 0,2 it means the distribution is not stable, but if E 0,21≤ E ≤ 1,it means the distribution is stable.

3. Results and Discussion

There were 18 species of waterbirds at the study sites (the list of waterbirds species can be seen in Appendix IV). The types of waterbirds in the vicinity of the Lantebung Ecotourism Area are shorebirds and wading birds. Table 1 provides information about the diversity of waterbirds in the Lantebung Mangrove Ecotourism Area along with their conservation status and original habitat status. There were eight species of migrant or 45% of the total and ten species of resident or 55% of the total. The status was determined based on the field guidebook 'The Birds of Sulawesi.'

The most protected species by the government based on the Minister of Environment and Forestry Regulation in 2018, are Blekok Cina (Ardeola bacchus), Gagang Bayang Timur (Himantopus leucocephalus), Gajahan Timur (Numenius madagascarensis), dan Kowak malam merah (Nyticorax Caledonicus). If these species are compared with the IUCN status, several species, including Least Concern (the population has not declined). However, there are several species that have not been registered (unlisted) at the IUCN, but they are included in endangered statuses, such as the Gajahan Timur and the Kowak Malam Merah. Among 18 observed species, none were listed on the CITES Appendix (Convention on International Trade in Endangered Flora and Fauna Species).

Table 1 shows the species density, which was calculated according toequation, with the area of observation was 20.14 ha. The highest species density and abundance were showed by Cerek shorebirds (Chadrius sp.). The density of Chadrius sp. was 74.95 individuals/m^2 while the Relative Abundance Index was 27%. The most frequent occurrence species were the species with the relative frequency value of 0.079, namely Cerek, Cerek Kalung Kecil, Gagang Bayang Timur, Kedidi, Kuntul Kecil, Kuntul Perak, dan Trinil Kaki Hijau.

Overall, the diversity index of the waterbirds community in Lantebung from Shannon Wiener (H') was 1,029029 (moderately diverse). The distribution of species was relatively stable with a value of Hill's Evenness Index was 0.35602 while the value of the Margalef Diversity Index was 2.918323, so that the species diversity was classified as moderate.

Table 1. The diversity, conservation status, and origin of waterbirds in Lantebung Ecotourism Area.

Local Name	Scientific Name	The average number of individuals per day	Density (indv/ha)	Relative Frequency	Relative Abundance Index (%)	Conservation Status			Origin Status
						Permen LHK 2018	IUCN 12	CITES	
Bambangan Merah	*Ixobrychus cinnamomeus*	2	0.035	0.026	1	-	Least Concern	-	*resident*
Blekok Cina	*Ardeolabacchus*	17	1.34	0.026	5	Protected	Least Concern	-	*migratory*
Blekok Sawah	*Ardeolaspesiosa*	17	0.86	0.053	5	-	Unlisted	-	*resident*
Bondol Rawa	*Lonchuraatrica pilla*	2	0.61	0.053	1	-	Least Concern	-	*resident*
Cangak Merah	*Ardeapurpurea*	4	0.10	0.053	1	-	Least Concern	-	*resident*
Cerek	*Chadrius sp.*	41	6.26	0.079	27	-		-	*migratory*
Cerek Kalung Kecil	*Chadriusdubius*	37	4.89	0.079	11	-	Unlisted	-	*migratory*
Gagang Bayang Timur	*Himantopus leucocephalus*	26	4.31	0.079	8	Protected	Least Concern	-	*migratory / resident*
Gajahan Timur	*Numenius madagascarensis*	1	1.73	0.026	0	Protected	Unlisted	-	*migratory*
Kedidi	*Calidris sp.*	40	9.89	0.079	12	-		-	*migratory*
Kokokan Laut	*Butoridesstriatus*	1	0.08	0.026	0	-	Unlisted	-	*resident*
Kowak malam merah	*Nyticorax caledonicus*	5	0.09	0.053	1	Protected	Unlisted	-	*resident*
Kuntul karang	*Egretta sacra*	2	0.05	0.053	0	-	Least Concern	-	*resident*
Kuntul Kecil	*Egrettagarzetta*	38	4.55	0.079	11	-	Least Concern	-	*resident / migratory*
Kuntul Perak	*Ardea intermedia*	36	2.93	0.079	11	-	Least Concern	-	*resident*
Mandarbesar	*Porphyrio indicus*	2	0.01	0.026	1	-	Unlisted	-	*resident*
Mandar padikuning	*Gallirallusphilippensis*	1	0.04	0.053	0	-	Least Concern	-	*resident*
Trinil kaki hijau	*Tringanebularia*	18	3.05	0.079	5	-	Least Concern	-	*migratory*
TOTAL		289							

From 18 species of waterbirds observed in Lantebung Ecotourism Area, there were several species observed in the morni2, evening, and both times. Figure 1 shows the types of species and the average number of waterbirds in the morning.

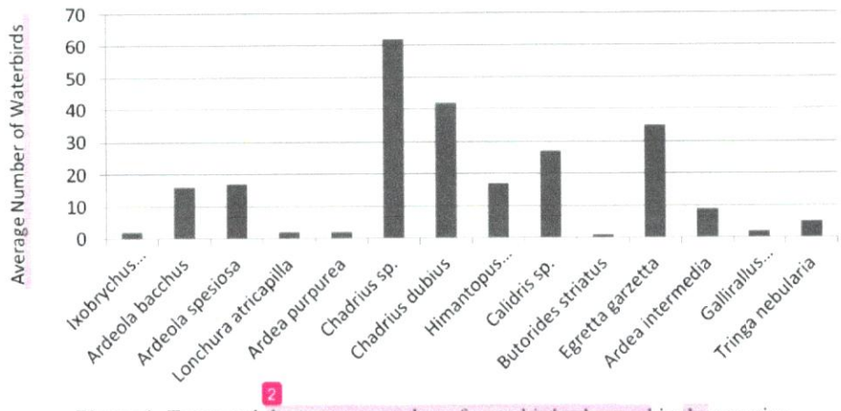


Figure 1. Types and the average number of waterbirds observed in the morning.

Figure 1 shows the average number of waterbirds observed in the morning. The total number observed was 238. The most dominant species in the morning was a shorebird type, *Chadrius sp.* (Cerek), with the average number of individuals of 26 or 26% of the total. The species of birds with the high abundance in the morning was *Egretta garzetta* (Kuntul Kecil), with an average number of individuals of 35 or 14% from the total. The least abundance type was *Butorides striatus* (Kokokan Laut), with only around one animal per day appeared in the morning.

Figure 2 gives information about the types and the average number of waterbirds observed in the afternoon. The average number of waterbirds observed in the afternoon for three days was 130.

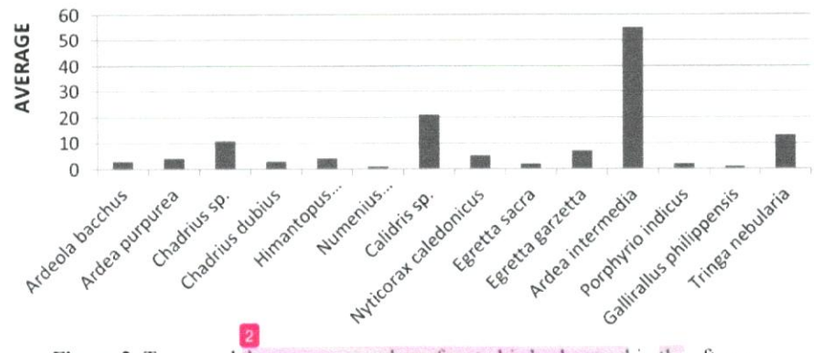


Figure 2. Types and the average number of waterbirds observed in the afternoon.

The most dominant species in the afternoon was the merandai waterbirds, Ardea intermedia (Kuntul Perak), with an average number of individuals, was 55 or 42.3% of the total. The highest number of shorebirds in the afternoon was *Calidris sp.* (Kedidi), with the average number of individuals of 21 or 16.2% from the total. The least abundance species in the afternoon were *Numenius madagascarensis* (Gajahan Timur) and *Gallirallus phillippensis* (Mandar Padi Kuning), with on around one animal per day appeared in the morning.

The average number of individuals observed in the morning was higher than in the afternoon. Their average number of individuals in the morning was 238, and in the afternoon, it was 130. In the morning and evening, there were 14 species of waterbirds at the study site, but not all of the observed individuals were the same species. *Ixobrychus cinnamomeus* (Bambangan Merah), *Ardeola spesiosa* (Blekok Sawah), *Lonchura atricapilla* (Bondol Rawa), and *Butorides striatus* (Kokokan Laut) only appeared in the morning, while *Nyticorax caledonicus* (Kowak Malam Merah), *Egretta sacra* (Kuntul

Kerang), *Numenius madagascarensis* (Gajahan Timur), and *Porphyrio indicus* (Mandar Besar) were the species that were observed only in the afternoon. Other types were: *Ardeola bacchus* (Blekok Cina), *Ardea purpurea* (Cangak Merah), *Chadrius sp.* (Cerek), *Chadrius dubius* (Cerek Kalung Kecil), *Himantopus leucocephalus* (Gagang Bayam Timur), *Calidris sp.* (Kedidi), *Egretta garzetta* (Kuntul Kecil), *Ardea intermedia* (Kuntul Perak), *Gallirallus philippensis* (Mandar Padi Kuning), and *Tringa nebularia* (Trinil Kaki Hijau) were observed in the morning and evening.

3.1. Types of waterbirds based on its habitat

The types of species that were observed in each habitat at the time of observation can be seen in Table 2.

Table 2. Types of habitats and waterbird species were observed in the lantebung ecotourism area.

Habitat	Description	Type	Scientific Name	Observation Time	
				Morning	Afternoon
Mudflats area	The empty land behind mangroves is the *feeding habitat,* which is influenced by ocean tide that brings foods for the waterbirds, such as gastropoda andsea worms.	Blekok Cina	*Ardeola bacchus*	-	√
		Cerek	*Chadrius sp.*	√	-
		Gajahan Timur	*Numenius madagascarensis*	-	√
		Kowak malam merah	*Nyticorax caledonicus*	-	√
		Kuntul karang	*Egretta sacra*	-	√
		Kuntul kecil	*Egretta garzetta*	√	√
		Kuntul perak	*Ardea intermedia*	√	√
		Mandar besar	*Porphyrio indicus*		√
		Mandar padi kuning	*Gallirallus philippensis*	√	√
Inactive pond	Ponds that are not being used and are submerged in shallow water. There is a mud mound in the middle, which is used by small-sized waterbirds as feeding habitats.	Blekok Cina	*Ardeola bacchus*	√	-
		Blekok Sawah	*Ardeola spesiosa*	√	-
		Cerek	*Chadrius sp.*	√	√
		Cerek Kalung Kecil	*Chadrius dubius*	√	√
		Gagang Bayam Timur	*Himantopus leucocephalus*	√	√
		Kedidi	*Calidris sp.*	√	√
		Kuntul Kecil	*Egretta garzetta*	√	-
		Trinil kaki hijau	*Tringa nebularia*	√	√
Mangrove tree	Mangrove, *Avicennia.sp*is used for*resting*	Kuntul Kecil	*Egretta garzetta*	-	√
		Bondol Rawa	*Lonchura atricapilla*	√	-
Shrub	Shrub beside the edge of mudflats dan ponds that are usually occupied by waterbirds solitary. It is used as *a grooming* and *resting* area	Kuntul Perak	*Ardea intermedia*	-	√
		Cangak Merah	*Ardea purpurea*	√	√
		Kokokan Laut	*Butorides striatus*	√	-
		Bambangan Merah	*Ixobrychus cinnamomeus*	√	-
		Mandar besar	*Porphyrio indicus*	-	√

The habitats that were occupied by most of waterbirds species were a mudflat and ponds with 9 and 8 species, respectively. The habitats with the least number of waterbirds were a mangrove tree and a bush with 2 and 5 species, respectively. The type of waterbirds found in almost all types of habitats was Kuntul kecil, which was observed in the wet mud area, ponds, and trees.
The species of water birds that were only found in the wet mud area were Gajahan Timur, Kowak Malam Merah, Kuntul Karang, and Mandar Padi Kuning. The only species that were observed in the ponds area were the Cerek Kalung Kecil, Gagang Bayam Timur, Kedidi, and Trinil Hijau. The only species found in mangrove tree habitat was Bondol Rawa, while the only species found in shrub habitat were Cangak Merah, Kokokan Laut, and Bambangan Merah.

4. Discussion

In Lantebung Mangrove Ecotourism Area and its surroundings, some habitats were used for nesting and foraging as the two main activities of waterbirds. The nesting habitat was mostly mangrove trees, which act as a shelter from disturbances of human and predators. Foraging activities usually are done at midday for diurnal water birds (which are active at noon) and at night for nocturnal water birds (which are active at night). In this region, foraging activities locate near the ponds or shallow waters where t[8] food sources exist. Diurnal foraging is a normal activity for waterbirds outside its breeding period, and nocturnal foraging only occurs when their daily energy requirements are not enough at midday [9].

The waterbird habitats observed at the study site were a stretch of mudflat, ponds, shrubs, and mangroves. From all of these habitats, the abundance and variety of waterbirds species are mostly found in the mudflats and ponds. There were nine species in the mudflat (the average number of individuals per day was 64), and eight species in inactive ponds (the average number of individuals per day was 218). These results were caused by the number of food sources that were rich in macrozoobenthos were greater than other habitats. In this kind of habitat, there were four classes of macrozoobenthos. Moreover, the opportunity to find food in mudflats region was greater than other habitats. Besides, this habitat could also be used for resting. Waterbirds usually do several activities such as feeding (41.6%), resting (20.9%), and grooming (18.8%) [10].

The habitat of waterbirds in the inactive pond at the study sites was also in the form of mudflats. The other ponds that were drained or converted into salt ponds could not support the water birds foraging activity, due to the unavailability or inaccessibility of food source (macrozoobenthos, sea worms, and small fish). The existence of food and its accessibility are influenced by water level and the quality of habitat, thus affect the abundance and diversity of waterbirds, especially in anthropogenically disturbed ecosystems, where availability of habitat is constantly changing [11].

In addition to the habitat for foraging activities, at the study site, there was also a mangrove habitat where its perimeter part was used for roosting, and the core was used for nesting. The aggregation pattern between nesting and feeding sites is very dominant in the Ardeidae family, water birds that live in urban wetlands with mangrove vegetation [12]. Waterbirds species from this family were dominant in the Lantebung Mangrove Ecotourism Area. Most species of waterbirds choose patches with open landscape for foraging areas and a little vegetation cover for the needs of sight and flight. Patches provide protection from predators as well as human disturbances. This habitat feature determines the distribution and presence of waterbirds, especially Ardeidae species, in the urbanized landscape.

The shrubs in the study site also provide sight and flight needs. This is more obvious in solitary waterbirds that prefer to choose not extensive patches because they require a combination of specific habitat variables. Interspecific competition in foraging habitats also regulates aerial bird communities, as well as species that are more aggressive than others [13]. This can encourage solitary or weaker species to use shrubs for protection.

5. Conclusion

There were 18 species of waterbirds in Lantebung, with a Shannon Wiener Diversity Index (H') was 1.029029 (moderately diverse). The distribution of species was relatively stable with Hill's Evenness Index was 0.35602 while the Margalef species richness Index was 2.918323, so that the diversity level

of species was classified as moderate. *Cadrius* sp. (Cerek) had the largest species abundance index, which was 27%.

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