

Diversity of waterbirds around Ekasoghi mangrove area, Sumenep, with the first record of Australian tern (*Gelochelidon macrotarsa*) from Madura Island, Indonesia

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Abstract. Andrimida A, Sonhaji A, Hardiyana FZ. 2024. Diversity of waterbirds around Ekasoghi mangrove area, Sumenep, with the first record of Australian tern (*Gelochelidon macrotarsa*) from Madura Island, Indonesia. *Indo Pac J Ocean Life* 8: 10-17. Mangrove forests provide an essential habitat for a lot of organisms, and they also provide an important habitat for waterbirds. This study aims to provide an overview of waterbirds' diversity and abundance around Ekasoghi mangrove area situated on the eastern coast of Sumenep, Madura Island on East Java, Indonesia. This research was conducted at three stations, each representing a different habitat type around Ekasoghi mangrove area. Waterbird data was collected using the exploration method, and waterbird species were determined by examining their morphological characteristics. Waterbirds' diversity was determined using the Shannon-Wiener diversity index, and the abundance was determined using the abundance index. Moreover, 38 individuals belonging to 15 species from 4 orders and 6 families were recorded during this study, with more than half belonging to the Charadriiformes order; the waterbird diversity index ranged from the highest 1.97 to the lowest 1.33. Three species with the highest abundance index value are striated heron (*Butorides striata*) with an abundance index value of 18.42, followed by Javan plover (*Anarhynchus javanicus*) and common sandpiper (*Actitis hypoleucos*) as the second with an abundance index value of 13.16. This research also provides the first record of the migrating seabird Australian tern (*Gelochelidon macrotarsa*) from Madura Island.

Keywords: Charadriiformes, distribution extension, new record, waterbirds

INTRODUCTION

Mangrove forests hold an enormous amount of biodiversity within their ecosystem; various animals from different taxa, from fishes to mammals, reptiles, and waterbirds, are known to inhabit the ecosystem of mangrove forests (Kaskoyo et al. 2023). It provides sheltering, foraging, breeding, and hiding sites and a place to perch, especially for waterbird families (Nurrofik et al. 2021). It also provides a habitat for several types of marine organisms, like fish and invertebrates, to breed, further providing an important food source for waterbirds (Salahuddin et al. 2021). The structural integrity of the mangrove trees also provides a potential nesting site, especially for large waterbird species (Mardiastuti et al. 2023). In addition, the mangrove ecosystem provides physical coastal protection from wind and abrasion, as well as sequestering carbon and remediates pollutants (Salahuddin et al. 2021; Ramadhani et al. 2022)

Waterbirds are a group of birds that are ecologically dependent on the existence of wetlands (Dilrangi et al. 2021), which include different types of habitats such as mangroves, marshes, mudflats, lakes, aquaculture ponds, and rice paddies (Makkatenni et al. 2023). Waterbirds is a large group of birds that includes species from the Anseriformes, Charadriiformes, Ciconiiformes, Gaviiformes, Gruiformes, Pelecaniformes, Podicipediformes and Procellariiformes orders (Manikannan et al. 2012). The

recent Ramsar Convention also proposes to include some species of raptors and passerines in the waterbirds category (Marigmen 2023). The diversity of waterbirds, with their distinct characteristics and behaviors, has made them occupy many essential roles within the mangrove ecosystem. These roles include predators, seed vectors, providing habitat for invertebrate populations, and maintaining the nutrient cycle within mangrove areas (Arzel et al. 2015). Some waterbirds that feed by probing the soil with their bills help oxygenate it and provide nutrients to the surrounding waters by releasing their feces and food left over (Purify et al. 2019).

Birds are among organisms that are very sensitive to environmental changes, which means birds could be used as an appropriate indicator in monitoring changes within an ecosystem (Rachmaputra et al. 2018; Li et al. 2021). The presence of birds can be used as bioindicators to represent the biodiversity in an ecosystem within a certain area; this includes the mangrove forests because birds could occupy a different type of habitat, having dynamic mobility and also have an important role in the ecosystem food chain and ecological networks (Isworo and Oetari 2020). Regarding biodiversity assessments, birds are often used as biological indicators that are easy to observe, have versatile ecology, are well-known, and have a highly developed survey method (Arzel et al. 2015). In such cases, understanding the waterbird diversity and abundance is important to provide information to design conservation strategies on a

regional scale (Dilrangi et al. 2021).

Roughly 80% of Madura Island, Indonesia, mangrove areas are in the Sumenep District (Muhsoni 2014). However, there are no data published regarding the waterbird diversity in Sumenep. A small note published in 2009 stated an observation of 71 endangered milky stork (*Mycteria cinerea*) in Nambakor fish ponds in Sumenep (van Balen et al. 2009). It suggests that the vast extent of the mangrove forest and its surrounding area in Sumenep District might provide an important habitat that holds a diverse number of waterbirds that are sometimes neglected. This study aimed to provide preliminary species checklists of waterbirds, as well as to assess species diversity and abundance of waterbirds around Ekasoghi mangrove area in Eastern Sumenep and to report an interesting finding of possible distribution extension of a certain waterbird species within Madura Island, Indonesia.

MATERIALS AND METHODS

Study area

This research was conducted in Ekasoghi mangrove area located in the eastern Madura Island, within the administration area of Tanjung Village, Saronggi Subdistrict, Sumenep District, East Java, Indonesia (Figure 1). The research area was then divided into three stations, representing different habitat types around Ekasoghi mangrove area. The first station is located on the shore around the perimeter of a mangrove forest with mudflats and rocky shallows that are exposed during low tide. The second station is behind the mangrove area, with a near-dried aquaculture pond bordering plantations. The third station was located in the eastern part of the mangrove area, on which the path of the inner mangrove forest, below the canopy, was selected as the third research station.

Thus, the first station has an open mangrove habitat, the second station has an open habitat with low tree cover, and the third station has a more closed habitat with lots of tree cover. These areas were selected to represent different ecosystems along the Ekasoghi mangrove area. Different types of habitat selected might affect the diversity of waterbird species in a given area, as different types of waterbirds utilize different parts of coastal wetlands to support their need to forage or rest (Krebs 2014; Khalil et al. 2021). This research was conducted during low tide in the morning, starting from 6.00-10.00 in West Indonesian Time (UTC+07:00) on 20 January 2024. This particular time was chosen because, in the morning, the waterbirds are actively locomoting or searching for food; thus, the chance of encountering the waterbirds is higher (Pettalolo et al. 2020).

Procedures

This research was conducted using the exploration method, where every bird encountered during the survey at each station was recorded. The observations were conducted at each station by walking through the observation path with an occasional pause around every 50 meters. The observation time for each observation point was around 15 minutes, with the total time for each station being around two hours. At the same time, the observer explored the research area or during a pause in a place with wide visibility (Triliantho et al. 2022). Using this method around the mangrove area, the observer could explore the outer perimeter of the mangrove area and stop at every potential place to observe the waterbirds or venture deep into the mangrove area during the low tide (Salahuddin et al. 2021). The waterbirds encountered during the survey were all recorded, and, if possible, a photograph was taken by a digital camera capable of capturing bird images from a long distance.

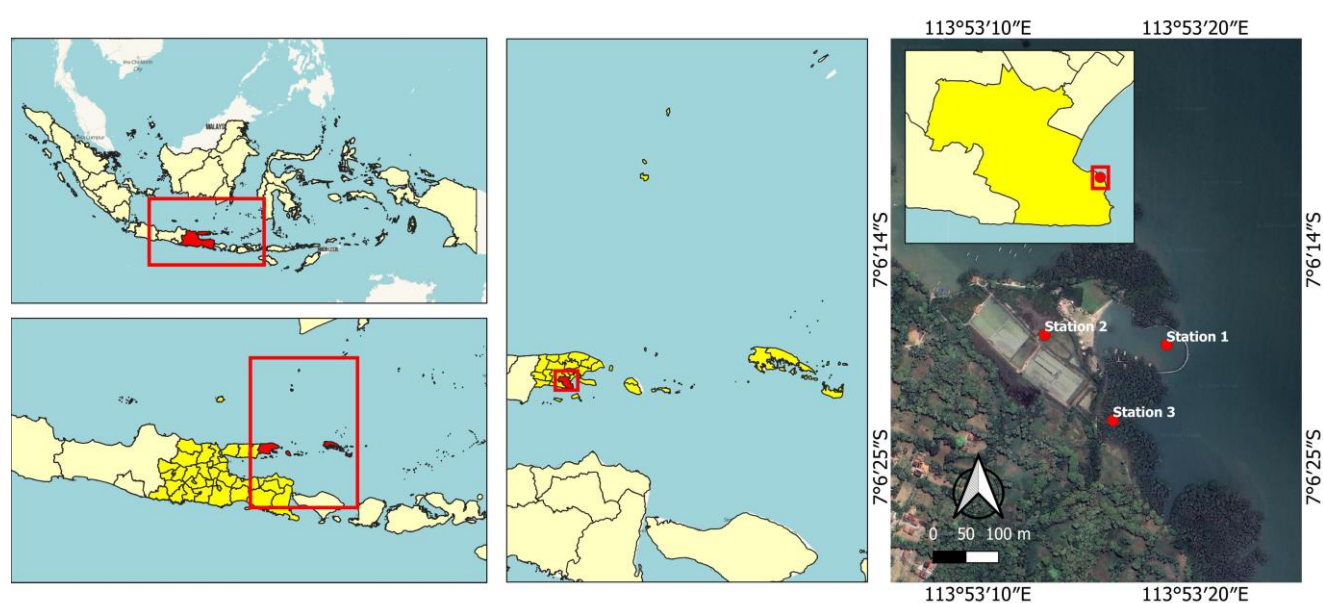


Figure 1. Location of Ekasoghi mangrove area, Sumenep District, East Java, Indonesia with every station, indicated with red dots on the map

The waterbird species identification was carried out by carefully examining the external morphology, voice, and behavior of the birds encountered during the survey (Kusmana et al. 2013). The bird species identification guide used to determine the waterbird species were the Field Guide on Birds of Indonesia Series 1: Greater Sunda (Taufiqurrahman et al. 2022), Birds of the Indonesian Archipelago: Greater Sundas and Wallacea (Eaton et al. 2016) and Shorebirds: An identification guide to the waders of the world (Hayman et al. 2011).

The protection status of the waterbird species refers to the Ministerial Regulation of Ministry of Environment and Forestry No. 106 Year 2018 on the Second Revision of Ministerial Regulation of Ministry of Environment and Forestry No. P.20/MENLHK/SETJEN/KUM.1/6/2018 on the Protected Species of Plants and Animals (Minister of Environment and Forestry 2018). Additionally, the conservation status of the waterbird refers to the IUCN Redlist 3.1 (IUCN 2023), and the migration and endemicity status of the waterbirds refers to the Birds of the Indonesian Archipelago: Greater Sundas and Wallacea (Eaton et al. 2016).

Data analysis

The waterbird species and individual data were tabulated according to each respective station. The data on the total waterbird species encountered were then used to count the Shannon-Wiener Diversity Index (Magurran 2013). The Shannon Wiener Diversity Index (H') was determined using the following formula:

$$H' = - \sum_{i=1}^n \frac{ni}{n} \ln \frac{ni}{n} \quad (1)$$

Where H' is the Shannon-Wiener Diversity Index, ni is the sum of the individuals within the i species, n is the sum of the individuals from all species, and \ln is logarithmic with a base e (Krebs 2014).

Species abundance data reflects species distribution on regional scales, so most biodiversity assessment research has focused on obtaining the species abundance data (Sun et al. 2020). The species abundance index was determined using the following formula:

$$Di = \frac{ni}{n} \times 100\% \quad (2)$$

Where Di is the species abundance index, ni is the sum of the individuals within the i species, and n is the sum of the individuals from all of the species (Ramadhani et al. 2022).

RESULTS AND DISCUSSION

Waterbird species composition

The identification of the waterbirds during this study resulted in the discovery of 38 individuals belonging to 15 species from 4 orders and 6 families (Table 1). The Charadriiformes order is the dominant one with the most

species encountered during this study (60%). The nature of the Charadriiformes waterbirds causes this large proportion of them; this order is a large waterbird with a high species diversity. The Charadriiformes waterbirds inhabit, feed, and breed in wet areas from the coastal shores to the mountainous wetlands (McCain 2015). Most Charadriiformes members are gregarious species that live in flocks, where a large flock could contain more than one bird species (Greenebaum et al. 2014). At the same time, the lowest waterbird order in terms of the species number encountered during this study is Coraciiformes and Gruiformes, with only one species encountered for each order during this research.

Moreover, of all of the identified waterbird species in this study, two species (13,3%) are Indonesian Archipelago endemic, which are the cerulean kingfisher (*Alcedo coerulescens*) and Javan plover (*Anarhynchus javanicus*). At least eight species (53,3%) of the waterbird species are migratory species, which are gull-billed tern (*Gelochelidon nilotica*), Australian tern (*Gelochelidon macrotarsa*), Eurasian whimbrel (*Numenius phaeopus*), grey-tailed tattler (*Tringa brevipes*), wood sandpiper (*T. glareola*), common greenshank (*T. nebularia*), common redshank (*T. totanus*) and common sandpiper (*Actitis hypoleucos*), all of these species belong to the Charadriiformes order (Putra 2023). The Indonesian government protects two species of waterbirds: the Javan plover and the gull-billed tern (*G. nilotica*). While referring to the IUCN (International Union for Conservation of Nature) Redlist, almost all of the waterbird species encountered during this study are categorized as Least Concern, except for one species, grey-tailed tattler (*T. brevipes*), categorized as Near Threatened (IUCN 2023).

During this study, at least 19 non-waterbird species were recorded (Table 2), of which 11 species (57,8%) belong to the Passeriform order. There are two species of non-waterbird species, are scarlet flowerpecker (*Dicaeum trochileum*) and cave swiftlet (*Collocalia linchi*), that are endemic to the Indonesian Archipelago (Eaton et al. 2016). The only species encountered at every station during this study were the scarlet flowerpecker (*D. trochileum*) and the Pacific swallow (*Hirundo tahitica*). No protected non-waterbirds were encountered during this study, and all non-waterbird species are categorized as Least Concern.

Diversity and species abundance index

Diversity index analysis shows station I has the highest diversity index with 1.97, followed by station II with 1.95, and station III with the lowest diversity index with 1.33 (Table 3). The diversity index on each station signifies that the Ekasoghi mangrove area has a medium waterbird diversity, which falls under the medium criteria based on the diversity index value of more than 1 and less than 3 (Hidayat 2013). The higher diversity index value in a community within a certain area is suggested to signify the more complex relationship between community components (Harmoko et al. 2021). Generally, the fluctuation of the diversity index in a certain community is affected by six main aspects: observation time, habitat type diversity, inter-species/individual competition, predation,

ecosystem stability, and productivity (Krebs 2014). Besides, other factors related to the observation activity also affect the diversity index value; for example, data collection method, study area, and habitat homogeneity are among the most important factors affecting diversity index output in a certain study area (Takele and Endale 2019). Specifically, the variations between birds' diversity index values in an area are more related to food availability (Adelina et al. 2016).

The waterbird species abundance index in Ekasoghi mangrove area shows that striated heron (*Butorides striata*) has the highest abundance index value (Table 4) at 18.42. Javan plover (*A. javanicus*) and common sandpiper (*A. hypoleucos*) have the second highest abundance index of

13.16 each. The abundance of waterbird species in a certain area relates to habitat conditions and food availability (Ramadhani et al. 2022). Furthermore, the abundance of waterbirds is also affected by the change in physical and chemical factors in wetlands habitat, which could affect the availability of organisms that depend on wetlands habitat, especially organisms that provide food sources to the waterbirds (Purify 2019). Waterbirds' diet mainly consists of benthic invertebrates that depend on phytoplankton availability; thus, the difference in water quality could affect the benthic invertebrate community as a food source and affect the abundance of waterbirds in an area (Manikannan et al. 2012).

Table 1. Waterbird species list encountered in Ekasoghi mangrove area, Sumenep District, East Java, Indonesia

Order	Family	Scientific Name	Vernacular Name	Station			Conservation Status	
				I	II	III	PP	IUCN
Coraciiformes	Alcedinidae	<i>Alcedo coerulescens</i> *	Cerulean kingfisher	√	-	√	-	LC
Pelecaniformes	Ardeidae	<i>Ardea intermedia</i>	Medium egret	-	-	√	-	LC
		<i>Butorides striata</i>	Striated heron	√	-	-	-	LC
		<i>Egreta garzetta</i>	Little egret	√	-	√	-	LC
		<i>Ixobrychus sinensis</i>	Yellow bittern	-	√	-	-	LC
Charadriiformes	Charadriidae	<i>Anarhynchus javanicus</i> *	Javan plover	-	√	-	√	LC
	Laridae	<i>Gelochelidon nilotica</i>	Gull-billed tern	√	-	-	√	LC
		<i>Gelochelidon macrotarsa</i>	Australian tern	√	-	-	-	LC
		<i>Numenius phaeopus</i>	Eurasian whimbrel	√	-	√	-	LC
	Scolopacidae	<i>Tringa brevipes</i>	Grey-tailed tattler	√	-	-	-	NT
		<i>Tringa glareola</i>	Wood sandpiper	√	√	-	-	LC
		<i>Tringa nebularia</i>	Common greenshank	-	√	-	-	LC
		<i>Tringa totanus</i>	Common redshank	-	√	-	-	LC
Gruiformes	Rallidae	<i>Actitis hypoleucos</i>	Common sandpiper	√	√	-	-	LC
		<i>Amaurornis phoenicurus</i>	White-breasted waterhen	-	√	-	-	LC

Note: *signify species endemic to the Indonesian Archipelago. Conservation Status, IUCN: NT: Near threatened, LC: Least Concern, PP: Protected by the Indonesian Government

Table 2. Non-waterbird species list encountered in the Ekasoghi mangrove area, Sumenep District, East Java, Indonesia

Order	Family	Scientific Name	Vernacular Name	Station			Conservation Status	
				I	II	III	PP	IUCN
Apodiformes	Apodidae	<i>Collocalia linchi</i> *	Cave swiftlet	√	√	-	-	LC
Caprimulgiformes	Caprimulgidae	<i>Caprimulgus affinis</i>	Savannah nightjar	-	-	√	-	LC
Columbiformes	Columbidae	<i>Spilopelia chinensis</i>	Spotted dove	√	-	-	-	LC
		<i>Geopelia striata</i>	Zebra dove	√	-	-	-	LC
Coraciiformes	Alcedinidae	<i>Todiramphus chloris</i>	Collared kingfisher	√	-	√	-	LC
	Meropidae	<i>Merops philippinus</i>	Blue-tailed bee-eater	√	-	√	-	LC
Cuculiformes	Cuculidae	<i>Cacomantis merulinus</i>	Plaintive cuckoo	√	-	√	-	LC
		<i>Cacomantis sepulcralis</i>	Rusty-breasted cuckoo	√	-	-	-	LC
Passeriformes	Acanthizidae	<i>Gerygone sulphurea</i>	Golden-bellied gerygone	-	-	√	-	LC
	Aegithinidae	<i>Aegithina tiphia</i>	Common iora	-	√	-	-	LC
	Campephagidae	<i>Lalage nigra</i>	Pied triller	√	-	-	-	LC
	Dicaedidae	<i>Dicaeum trochileum</i> *	Scarlet flowerpecker	√	√	√	-	LC
	Estrildidae	<i>Lonchura punctulata</i>	Scaly-breasted munia	-	√	-	-	LC
	Hirundinidae	<i>Hirundo tahitica</i>	Pacific swallow	√	√	√	-	LC
	Nectariniidae	<i>Anthreptes malacensis</i>	Brown-throated sunbird	-	-	√	-	LC
	Pycnonotidae	<i>Pycnonotus goiavier</i>	Yellow-vented bulbul	-	√	√	-	LC
		<i>Pycnonotus aurigaster</i>	Sooty-headed bulbul	-	-	√	-	LC
	Sylviidae	<i>Prinia inornata</i>	Plain prinia	√	-	-	-	LC
<i>Orthotomus sutorius</i>		Common tailorbird	-	√	√	-	LC	

Note: *signify species endemic to the Indonesian Archipelago, Conservation Status: IUCN: NT: near threatened, LC: Least Concern. PP: Protected by the Indonesian Government

Table 3. Waterbird species abundance index

Scientific Name	Vernacular Name	Abundance Index (Di)
<i>Alcedo coerulescens</i> *	Cerulean kingfisher	7.89
<i>Ardea intermedia</i>	Medium egret	2.63
<i>Butorides striata</i>	Striated heron	18.42
<i>Egreta garzetta</i>	Little egret	7.89
<i>Ixobrychus sinensis</i>	Yellow bittern	2.63
<i>Anarhynchus javanicus</i> *	Javan plover	13.16
<i>Gelochelidon nilotica</i>	Gull-billed tern	2.63
<i>Gelochelidon macrotarsa</i>	Australian tern	2.63
<i>Amauormis phoenicurus</i>	White-breasted waterhen	5.26
<i>Numenius phaeopus</i>	Eurasian whimbrel	5.26
<i>Tringa brevipes</i>	Grey-tailed tattler	2.63
<i>Tringa glareola</i>	Wood sandpiper	7.89
<i>Tringa nebularia</i>	Common greenshank	2.63
<i>Tringa totanus</i>	Common redshank	5.26
<i>Actitis hypoleucos</i>	Common sandpiper	13.16

Table 4. Waterbird species diversity

Parameter	Stasiun		
	I	II	III
Diversity index (H')	1.97	1.95	1.33
Number of species	9	8	4
Number of individuals	16	17	5

Notes on the first record of Australian tern (*Gelochelidon macrotarsa*) in Madura Island

During the survey, two individuals of tern are observed and photographed. Both individuals are observed at Station I, soaring above the waters off the Ekasoghi mangrove area. Those observed terns have mostly white bodies with grayish primary wings, black legs, black bills, and black patches behind their eyes, signifying their non-breeding plumage (Eaton et al. 2016). However, further inspection conducted after the survey showed that both individuals belong to different species. The latter individual encountered has a larger bill and a thicker black patch behind its eye (Figure 2).

The description of the second individual observed based on the photograph evidence aligns with del Hoyo et al. (2014) and Eaton et al. (2016); within its non-breeding plumage, *G. macrotarsa* is distinguished from *G. nilotica* by its overall larger body, thicker bill, and larger, black ear coverts with the squarish end. The black mark on the *G. macrotarsa* runs continuously from the eye to the ear coverts, whereas in *G. nilotica affinis* (the Asian subspecies of Gull-billed tern) is slightly broken behind its eye or narrowly joined (Lilleyman and Hensen 2014). Both species are very similar because *G. macrotarsa* was formerly classified as a subspecies of *G. nilotica* under the name *G. nilotica macrotarsa* (Australian Bird Study Association 2020), on which, along with *G. nilotica affinis* were the only two subspecies of Gull-billed tern recorded in the Indonesian Archipelago (Eaton et al. 2016). After further assessment, *G. nilotica macrotarsa* was later separated as a distinct species, *G. macrotarsa*, based on its distribution and distinct morphological features (del Hoyo et al. 2014; Blaylock et al. 2020).

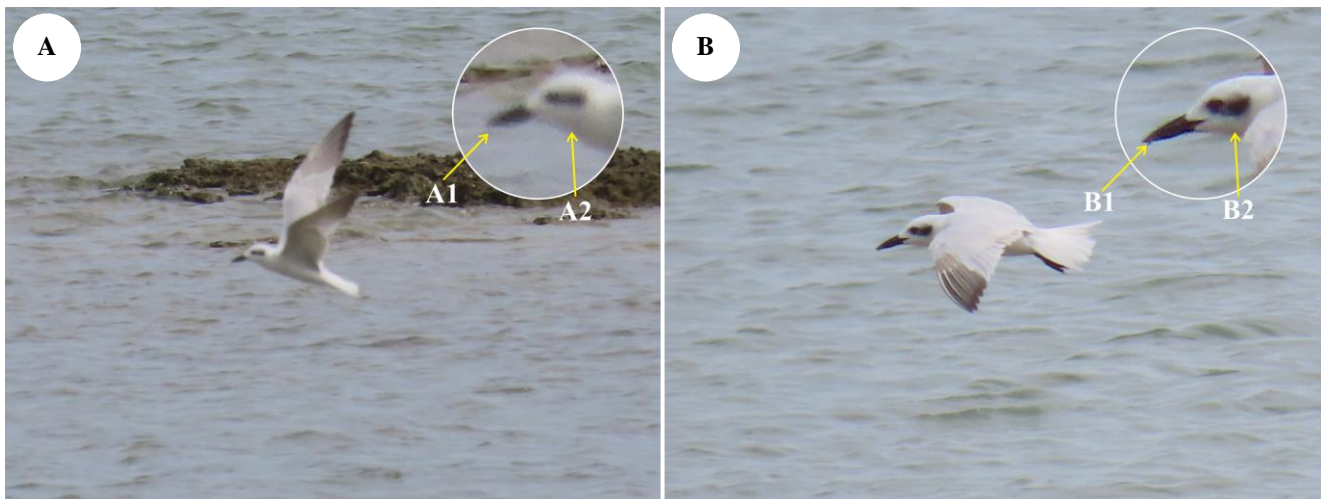


Figure 2. In-situ photograph taken during a survey of (A) Gull-billed tern *G. nilotica* and (B) Australian tern *G. macrotarsa* on their non-breeding plumage, highlighting the comparison of the beaks (A1 with B1) and black ear coverts (A2 with B2)

The first individual, *G. nilotica*, was observed flying and slowly scooping the water with its beak. This behavior indicates the feeding behavior of *Gelochelidon*, which feeds on shallows and mudflats, compared to other tern that plunge-dive into deeper waters to feed (Kushwaha et al. 2017). After that, this individual was observed to rest on the rocky shallows near mudflats. It is also observed to be the common daily routine of migratory waterbirds to feed on mudflats on low tide and roost when the tide is high (Lilleyman and Hensen 2014). Furthermore, for a brief moment, the latter individual, presumed to be *G. macrotarsa*, was observed flying on the same site above where the first individual was still visible. The latter individual is also photographed while the first individual rests on the rocky shallow tops. The latter individual flew for about 5 minutes and then flew away towards the east without doing the swooping behavior nor resting as the first individual did.

Discussion

The study revealed 15 waterbird species found in Ekasoghi mangrove area of Sumenep District, with an additional 19 non-waterbird species. Several similar studies conducted in other parts of Madura Island have successfully recorded 11 species of waterbirds belonging to 2 families (Charadriidae and Scolopacidae) and 1 Order (Charadriiformes) from Talang Siring Beach, Pamekasan District (Firmansyah et al. 2022), and 15 waterbird species belong to 6 families and 4 orders from four mangrove sites in South Bangkalan (Ramadhani et al. 2022). Moreover, this study and two other studies mentioned above recorded four species living in at least three regencies in Madura Island: Javan plover, common sandpiper, grey-tailed tattler, and Eurasian whimbrel. The Javan plover (*A. javanicus*) formerly had a limited distribution on Java and Bali Islands (MacKinnon and Phillips 1993). However, recent publications stated that this species' distribution extends as far as Timor Leste and South Sumatra, and the species also breed in these areas (Trainor 2011; Setiawan et al. 2019). The extension of Javan plover's distribution area is related to the availability of a suitable breeding habitat, where this species is known to inhabit a wet shortgrass area surrounded by fragmented, deeper water pools (Setiawan et al. 2019). Common sandpipers, grey-tailed tattlers, and Eurasian whimbrels are migrant species capable of traveling long distances and occasionally moving into safer habitats on their migration route (Ramadhani 2022; Putra 2023). These migratory waterbird species prefer wetlands habitats, such as mangrove areas, as this area could sustain their migration routes by providing a suitable habitat to feed and shelter from the extreme weather or from any threat that poses any danger to their survival (Ramadhani 2022; Seipalla 2020).

The Shannon-Wiener diversity index (H') is a formula to measure diversity that combines species richness and relative abundances (Dilrangi et al. 2021). The highest species diversity value is obtained at Station I, which has mudflats and rocky shallows habitat types on the edge of the mangrove forest. It has a more open habitat with plenty of shallow, watery areas for waterbirds to graze for food.

Furthermore, the existence of the mangrove nearby with lots of vegetation provides sheltering for waterbirds that prefer to feed in a more shaded area (Dilrangi et al. 2021). The difference in the habitat structure and vegetation covers are the main factors providing habitat and food that affect the waterbird diversity index value around the mangrove area (Salahuddin et al. 2021). The diversity index values of stations I and II are similar because it has a similar species number and abundance compared to the diversity index value of station III. This similarity could be attributed to the habitat variation in Stations I and II, with plenty of open areas and adequate vegetation, than Station III which lacks open areas and dense vegetation. It is indicated that different habitat structures might increase waterbird diversity (Mohd-Azlan et al. 2015). During the survey, waterbirds from Scolopacidae and Charadriidae families were found in an open water habitat, wandering on the shallows for food. In comparison, the waterbirds from Alcedinidae and Ardeidae families were found perching on tree branches or man-made bamboo structures, such as bridges and floating mariculture structures around Ekasoghi mangrove areas.

The abundance index is related to the population size of waterbirds in an area (Ramadhani 2022). Furthermore, the waterbird abundance also reflects habitat quality, which signifies the abundance in food supply (Kleijn et al. 2014). In the Ekasoghi mangrove area, the striated heron has the highest abundance among the waterbirds found during this study. The striated heron is a cosmopolitan species in almost all tropical regions worldwide (Hayes et al. 2018). This species could be found in wide habitats, such as small streams, ponds, and marshes, where this bird generally hunts small fishes, frogs, and crustaceans for its main diet (McLachlan 2011). This bird is a nocturnal bird that actively hunts at night time or dusk (Yanuar et al. 2017). Striated heron is also known to have adapted to breed on a floating mariculture structure (Qaneer and Butcher 2013); such structures are also encountered in the Ekasoghi mangrove area, where this bird is also found perching on top of it. The other waterbirds' abundance, such as the common sandpiper and Javan plover, are related to their behavior. The common sandpiper is a species of waterbird that lives solitarily or in a small flock and is generally common throughout the year. It could inhabit many habitats, like coastal waters, mangrove forests, marshes, rice paddies, and even inland water bodies (Eaton et al. 2016). The Javan plover is a species of waterbird that is locally common in its distribution area and lives in a pair or small flock that inhabits coastal areas, shrimp ponds, and coastal marshes (Eaton et al. 2016). In some of its distributional range, Javan plover was also observed to feed and breed on a dried shrimp aquaculture pond (Iqbal et al. 2013).

This study also successfully records a sighting of Australian tern (*Gelochelidon macrotarsa*) outside its known natural range. Australian tern breeds on inland water bodies during the rainfall season, and frequent the northern coastal water of Australia during non-breeding season (Lilleyman and Hensen 2014). It is a fairly common species to be observed on the Northern Australian

coastline, with small but regular sightings of gull-billed tern also being observed as non-breeding visitors (Lilleyman and Hensen 2014; Lilleyman 2016). However, in Indonesia, the Gull-billed tern is a fairly common migrant in Indonesian coastal waters, where it migrate to warmer areas during winter months in Australia (Eaton et al. 2014) and was recorded from every major island in Indonesia (GBIF 2023a). Furthermore, the Australian tern in Western Indonesia records is still limited, and the nearest records of this species were two records from Serangan Island, Denpasar, Bali (GBIF 2023b), which separated for about 233 km from Ekasoghi mangrove area. There were also dozens records of Australian tern sightings from the Lesser Sunda Islands and the Moluccas, but no single observation has been registered from Madura and Java (eBird 2023). Thus, it is concluded that this research also provides information on the extended migration range of Australian tern to Madura Island and East Java.

Based on this research conducted in Ekasoghi mangrove area on the eastern coast of Sumenep, Madura Island, 15 water birds were found, dominated by the waterbirds from the Charadriiformes order. Based on the data obtained during this study, it has a range of diversity index from the highest 1.97 to the lowest 1.33. Three species with the highest abundance index value are striated heron with an abundance index value of 18.42, followed by Javan plover and common sandpiper, tied on second place with an abundance index value of 13.16. The stations with more open areas and adequate vegetation hold more species and individuals during this study. Mangrove forests are a haven for biodiversity, and it has a high level of productivity for a wide array of organisms that depend on their existence. Specifically, it also provides the necessity for waterbirds to feed, rest, and shelter during their migration.

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