Bioeksperimen, Volume 10 No. 2 (September 2024) **ISSN 2460-1365**

Diversity of Waterbirds in the Wetland of Pangpang Bay Essential Ecosystem Area, Banyuwangi, Indonesia

Elyn Fahrani*[1)], Susintowati[1)], Magdalena Putri Nugrahani[1)], Sungkono[2)], Yusuf Eko Prasetyo[2)]
[1]Pendidikan Biologi, FKIP, Universitas 17 Agustus 1945 Banyuwangi, Jl. Adi Sucipto 26 Banyuwangi, 68416, Indonesia
[2]BISA Indonesia, Daerah Istimewa Yogyakarta, 55581, Indonesia
*Corresponding e-mail: elynfahrani944@gmail.com
Paper submit : 7 November 2023, Paper publish: 10 January 2025

Abstrak *– Pangpang Bay Essential Ecosystem Area, Banyuwangi is a wetland traveled by the East Asia Australia Flyway (EAAF) bird migration route. This research aims to study the diversity, and abundance of waterbird species, and the relationship between the presence of waterbird species and environmental factors in each wetland habitat type. This research was conducted in October 2023-January 2024 using the 'Concentration Count' method in each wetland habitat type. Based on observations, 34 species of waterbirds were found in all wetland habitats with a total of 7468 individuals. The mudflats of Muncar Beach had the highest species diversity with a total of 32 waterbird species, one of which, the East Gajahan species, was the first recorded finding in eastern Java. 22 migratory waterbird species, 8 resident waterbird species, and 4 resident migratory waterbird species were found. Based on IUCN status, 5 species were found to be Near Threatened (NT), and 3 were found to be Endangered (EN). The index value of waterbird species diversity in each wetland habitat type was categorized as moderate (H'=1.895 - 2.594), except for the mangrove habitat which was classified as low (H'=0.719). The PCA results showed that the presence of waterbirds was influenced by habitat conditions and environmental parameters (temperature, air humidity, light intensity, salinity).*
Keywords: *Waterbirds, Migration, Wetlands, Diversity*

INTRODUCTION

Waterbirds are ecologically dependent on wetland ecosystems for foraging, roosting, resting, nesting, egg-laying, and incubation (Soendjoto, 2018). Waterbirds are generally categorized into three groups based on habitat, although the boundaries between groups are not very clear. Firstly, seabirds that feed in the sea. Second, freshwater birds that feed in freshwater waters such as rivers, ponds, or rice fields. Third, shorebirds whose habitat is in coastal waters for feeding, nesting, and resting (Gitayana, 2011, Nurdin et al., 2021). Based on their stay in an area, waterbirds are divided into residents and migrants (Soendjoto, 2018). Most shorebirds in Indonesia are migratory birds in Indonesian wetland areas to feed, breed, and rest while waiting to return to their breeding grounds (Howes et al., 2003, Qomariah et al., 2022).

Waterbirds live in wetland habitats, such as mangrove forests, mudflats, and artificial wetlands such as ponds (Anggreani, 2019). Waterbirds (shorebirds and seabirds) are often found foraging for invertebrates in puddles on mudflats (Khalil et al., 2021). Seabirds use mudflats to rest. Some species of water birds such as little egrets (Egretta garzetta) prefer pond areas with shallow water. This is because in pond areas with shallow water, there are small fish that are food for little egrets (Zou et al., 2006, Khalil et al., 2021). The presence of waterbirds in wetland areas is related to the occurrence of food webs in the area (Noor et al., 1995, Lasantu et al., 2020).

Essential Ecosystem Areas have the potential for high levels of biodiversity, and habitat for endangered/endemic species and can become buffer zones for conservation areas. One of them is Pangpang Bay, which has become an Essential Ecosystem Area by providing wetland habitat for migratory and resident waterbirds. Pangpang Bay Essential Ecosystem Area is an East Asia Australia Flyway (EAAF) bird migration route because

it has the potential for migratory waterbird stopover habitat (Sari, 2023, Ananda, 2023).

Increasing development and human activities are affecting the pathways of EAAF migratory birds and could potentially lead to the loss or reduction of waterbird populations (migratory shorebirds). Migratory waterbirds require healthy flight paths to find optimal environments and habitats for foraging, breeding, and caring for their young (Newton, 2010, Basu Roy et al., 2023). The presence of waterbirds is critical in the balance of wetland ecosystems as waterbirds can control insect populations, and assist with pollination, and seed dispersal (MacKinnon et al., 2010, Nurmaeti et al., 2018).

Pangpang Bay Essential Ecosystem Area has several types of wetland habitat, namely Muncar beach mudflats, Kili-Kili tower mudflats, mangroves, and Kili-Kili ponds that support the presence of resident and migratory waterbirds. The availability of food sources and habitat conditions can influence the level of waterbird diversity in each wetland habitat type, especially mudflats. The level of waterbird diversity affects the balance of the wetland ecosystem. Therefore, the purpose of this research is to study the diversity and abundance of waterbirds, study the relationship between species presence and environmental factors in each wetland habitat type. In addition, this research is expected to increase information on the distribution of waterbirds in Indonesia and waterbird conservation efforts in wetland areas in the Pangpang Bay Essential Ecosystem Area.

RESEARCH METHODS

This research was conducted in Pangpang Bay EAA, Banyuwangi Regency (Figure 1), from October 2023 to January 2024. The observation locations in Pangpaang Bay EAA were divided into three locations divided into four observation points: mudflats of Muncar Beach (8°26'59.7 'S, 114°20'59.7 "E), mangroves and Kili-Kili ponds (8°29'44.3 "S, 114°21'35.3 "E) and mudflats of Kili-Kili Tower (8°30'12.6 "S, 114°21'31.1 'E).

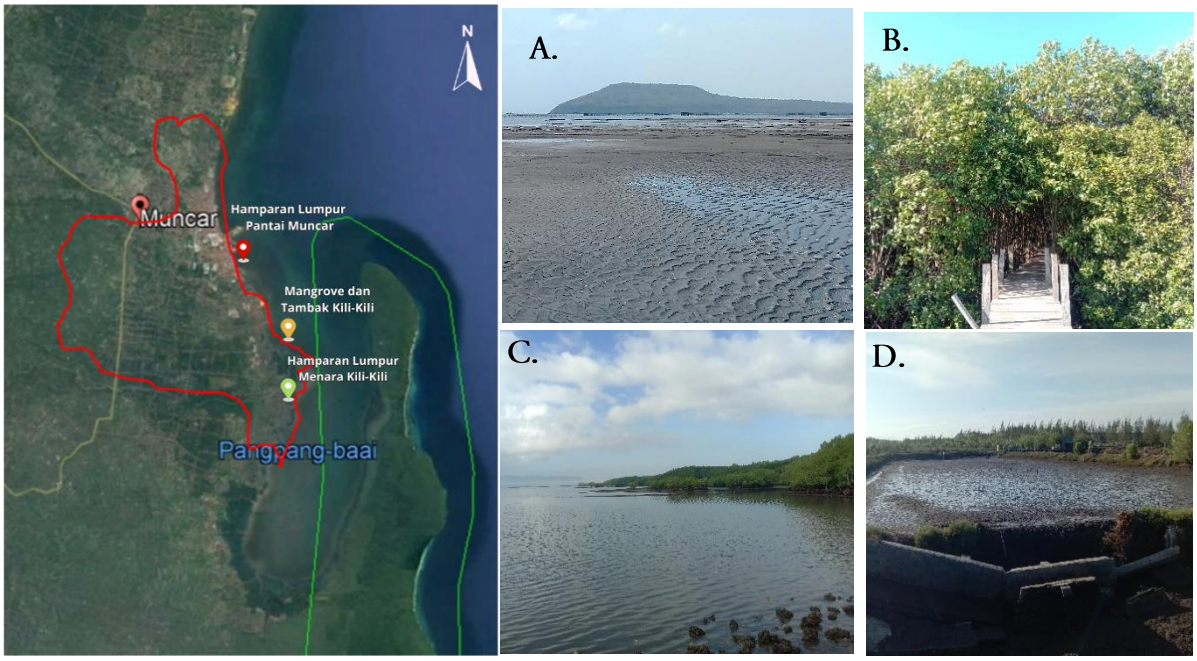

Figure 1. Research Location Map. A) Hamparan lumpur Pantai Muncar; B) Mangrove Kili-Kili; C) Hamparan lumpur menara Kili-Kili; D) Tambak mangrove Kili-Kili

1. Research Objects and Tools

The study's object was to determine the number of species and individuals of waterbirds and environmental parameters such as temperature, air humidity, salinity, and light intensity in Pangpang Bay EAA. Research tools used included GPS, camera, binoculars, stationery, bird identification books of Sumatra, Kalimantan, Java, and Bali (SKJB, 2010), thermometer, hand counter, lux meter, hand refractometer, thermometer, and hygrometer.

2. Research Methods and Design

This research method uses a *Concentration Count* at each observation point, which focuses on one or several points that are considered the center of bird presence (Sabrina et al., 2019). The location and observation points were determined by purposive sampling method based on the type of wetland habitat that supports the presence of waterbirds, especially migratory waterbirds. The observation points consisted of Muncar Beach mudflats (HL1), Kili-Kili tower mudflats (HL2), mangroves (Mr), and ponds (Tb) in Kili-Kili.

3. Data Collection

Waterbird data were collected using the concentration count method with an interval distance of 50 meters. Waterbird observations at each observation point (HL1, HL2, Mr, and Tb) were carried out with a certain time interval, namely 2-3 hours based on the tidal schedule (Tides application). Each observation point was conducted 7 times during the migration season (October-January). Waterbird data was supported by environmental parameters at each observation point including air temperature, air humidity, salinity, and light intensity.

4. Data Analysis

Waterbird data were analyzed using the Shannon-Wiener species diversity index (H'), species evenness index (E), and Margalef species richness index (DMg) (Rifai et al., 2024). Correlation analysis between waterbird species components and environmental parameters in each wetland habitat type was analyzed using PCA, with XLSTAT software (Vidal et al., 2020).

RESULT AND DISCUSSION

1. Waterbird Species Diversity in the Wetland Habitat of Pangpang Bay Essential Ecosystem

There were 34 waterbird species with a total of 7468 individuals found across all wetland habitat types of Pangpang Bay (Table 1), with 32 waterbird species in the mudflats of Muncar Beach, 18 waterbird species in the mudflats of Kili-Kili tower, 5 waterbird species in Kili-Kili mangrove, and 10 waterbird species in Kili-Kili pond. Species diversity was highest in the mudflats of Muncar beach (Figure 2).

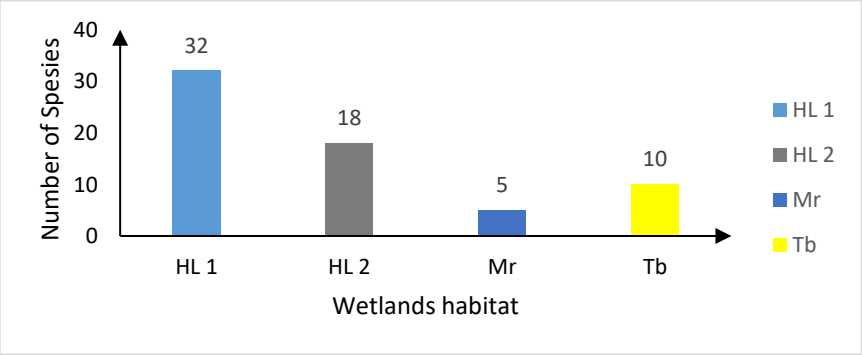

Figure 2. Diversity of Waterbirds in the wetland of Pangpang Bay

Habitat conditions and the amount of food are factors that influence the presence of waterbirds. The mudflats of Muncar Beach are dominated by muddy sand and are adjacent to the fish harbor area. Organic waste from the disposal of fishermen's catches becomes a substrate that supports the life, development, and diversity of macrozoobenthos (Rosdatina et al., 2019). Invertebrates are a source of food for waterbirds. The presence of large numbers of invertebrates can attract a variety of waterbird species to choose wetland areas for feeding, breeding, and other activities (Fairbairn and Dinsmore 2001, Kostecke et al. 2005, Chanate et al., 2020).

The mudflat habitat of Kili-Kili tower has a lower diversity of waterbirds than that of Muncar Beach. Differences influence this in location and habitat conditions. In the mudflats of Kili-Kili tower, the habitat is waterlogged mud and surrounded by mangroves (Figure 1). Habitat conditions in the form of stagnant water in the mudflats of Kili-Kili tower interfere with waterbirds in finding food. This is supported by research (Winara, 2017) which says that stagnant water on mudflats is a means of spreading invasive plants so that water bird habitat is threatened, especially habitat as a place to find food.

Kili-Kili mangrove and pond habitats have waterbird species diversity that tends to be lower than mudflat habitats. Few waterbird species were encountered in the mangroves and ponds, except for a few species of egrets that utilized the mangroves and ponds for roosting, foraging, and breeding. Mangroves have fewer waterbirds than muddy beaches because mangrove beaches are more often used as resting and nesting sites for waterbirds (Irmawan et al., 2014). Waterbirds tend to prefer pond habitats because they provide a variety of food sources, especially for fish- and shrimp-eating waterbirds (Master et al., 2016, Makkatenni et al., 2023).

The Pangpang Bay Essential Ecosystem Area has great potential to support migratory waterbirds, especially the mudflats of Muncar Beach (Table 1). Based on data collection, 22 migratory waterbird species, 8 resident waterbird species, and 4 resident migratory waterbird species were found. Research (Sari, 2023) suggests that Pangpang Bay EAA is traversed by the East Asia Australia Flyway (EAAF) migratory bird path and plays an important role as a stopover for migratory waterbirds, especially in mudflat habitats (Sari, 2023). Habitat conditions and the presence of food sources in the mudflats of Muncar Beach support the presence of migratory birds.

Based on IUCN status, 3 waterbird species were found to be endangered (EN), namely Numenius madagascariensis, Charadrius Mongols, and Calidris tenuirostris. 5 species of waterbirds are near threatened (NT), namely Limosa lapponica, Numenius arquata, Calidris ferruginea, Calidris ruficollis, and Tringa brevipes. The discovery of the species Numenius madagascariensis or Gajahan Timur is the first record in eastern Java in Pangpang Bay EAA, Banyuwangi Regency (Atlas Burung Indonesia, 2020).

Table 1. Waterbird species diversity and abundance in each wetland habitat type of Pangpang Bay Essential Ecosystem Area

No.	Spesies Name	Simbol PCA	Number of Individual					Status Migrasi			Status IUCN
			HL1	HL2	Mr	Tb	Σ	M	R	M&R	
1	*Ardeola speciosa*	A.spc	195	151	129	44	519	-	+	-	LC
2	*Butorides striata*	B.str	1	7	0	3	11	-	+	-	LC
3	*Egretta sacra*	E.sac	1	0	0	0	1	-	+	-	LC
4	*Egretta garzetta*	E.gar	243	201	309	45	798	-	+	-	LC
5	*Ardea intermedia*	A.intrm	111	66	286	55	518	-	+	-	LC
6	*Bubulcus ibis*	B.ibis	0	0	3002	41	3043	-	+	-	LC
7	*Pluvialis squatarola*	P.sqt	8	0	0	0	8	-	+	-	LC
8	*Charadrius javanicus*	C.jav	175	0	0	0	175	-	+	-	LC
9	*Pluvialis fulva*	P.fulv	302	11	0	0	313	+	-	-	LC
10	*Charadrius dubius*	C.dubius	8	0	0	0	8	+	-	-	LC
11	*Charadrius leschenaultii*	C. lesch	35	75	0	0	110	+	-	-	LC
12	*Charadrius mongolus*	C.mgl	24	119	0	0	143	+	-	-	EN
13	*Gelochelidon nilotica*	G.nlt	5	0	0	0	5	+	-	-	LC
14	*Thalasseus bergii*	T. bergii	4	0	0	0	4	-	-	+	LC
15	*Sterna hirundo*	S. hrd	503	62	0	0	565	-	-	+	LC
16	*Himantopus himantopus*	H.htps	4	0	0	0	4	-	-	+	LC
17	*Limosa lapponica*	L. lpnc	4	0	0	0	4	-	-	+	NT
18	*Numenius arquata*	N.aqt	87	28	0	0	115	+	-	-	NT
19	*Numenius madagascariensis*	N.mcs	7	0	0	0	7	+	-	-	EN
20	*Numenius phaeopus*	N.phae	58	0	0	0	58	+	-	-	LC
21	*Calidris tenuirostris*	C.trs	130	225	0	20	375	+	-	-	EN
22	*Calidris ferruginea*	C. fgn	2	0	0	0	2	+	-	-	NT
23	*Calidris ruficollis*	C.rcl	4	0	0	0	4	+	-	-	NT
24	*Calidris alba*	C.alba	46	0	0	0	46	+	-	-	LC
25	*Xenus cinereus*	X. cnr	4	0	0	0	4	+	-	-	LC
26	*Tringa brevipes*	T.brv	5	4	0	0	9	+	-	-	NT

No.	Spesies Name	Simbol PCA	Number of Individual					Status Migrasi			Status IUCN
			HL1	HL2	Mr	Tb	Σ	M	R	M&R	
27	*Tringa nebularia*	T. neb	20	3	0	0	23	+	-	-	LC
28	*Tringa totanus*	T.ttn	44	32	0	7	83	+	-	-	LC
29	*Actitis hypoleucos*	A.hpc	12	71	0	0	83	+	-	-	LC
30	*Arenaria interpres*	A.itp	60	62	16	42	180	+	-	-	LC
31	*Tringa stagnatilis*	T.snt	6	0	0	0	6	+	-	-	LC
32	*Tringa glareola*	T.glar	15	4	0	2	21	+	-	-	LC
33	*Glareola maldivarum*	G.mdv	177	7	0	8	192	+	-	-	LC
34	*Fregata minor*	F.min	0	31	0	0	31	+	-	-	LC
	Jumlah Spesies		32	18	5	10	0	22	8	4	
	Jumlah Individu		2300	1159	3742	267	7468				

Description: HL1 = Hamparan Lumpur Muncar, HL2 = Hamparan Lumpur Kili, Mr = Mangrove, Tb = Tambak, R = Residen, M = Migrasi, LC = Least concern, NT = Near threatened, EN = Endangered.

2. Waterbird Species Abundance in Pangpang Bay

The abundance of waterbird species in wetland habitats was 7468 individuals spread across all wetland habitats, namely Muncar beach mudflats, Kili-Kili tower mudflats, mangroves and Kili-Kili ponds (Table 1).

The highest abundance of waterbirds in each habitat was found in the Kili-Kili mangrove with 3742 individuals, with the highest number of waterbird individuals being the species Bulbulus ibis with 3043 individuals (Table 1). Mangroves are used by Bulbulus ibis in the breeding phase, namely making nests, and storing and incubating eggs. Mangroves are habitats for waterbirds such as heron species that support nest building, provide perches, and provide abundant food sources (Purify et al., 2019, Ramadhani et al., 2022).

The lowest abundance of waterbirds in Kili-Kili pond habitat was 267 individuals. There were many human activities such as pond farmers, people looking for shellfish, and other activities that influenced the low diversity of waterbirds in pond habitats. In addition, the limited number of food sources needed by waterbirds in pond habitats is a factor in the abundance of waterbirds.

In the mudflats of Muncar Beach, 2300 waterbirds were found, some of which included migratory waterbird species with relatively high abundance, namely Pluvialis fulva, Sterna hirundo, Glareola maldivarum, and Charadrius javanicus (Table 1). In contrast, the mudflats of Kili-Kili tower had a relatively moderate abundance of 1159 waterbirds.

3. H', E, DMg values of Waterbirds in each Wetland Habitatof Pangpang Bay

Waterbird species diversity index values for each wetland habitat type in Pangpang Bay varied (Table 2). Based on the results of research on the mudflats of Muncar Beach, it is known that the H‘ index value is relatively high, namely H’=2.594 in the medium category, which indicates that the Muncar Beach mudflats ecosystem supports the presence of waterbirds, especially migratory

waterbirds (Rifai, Bakhtiar Ahmad et al, 2024). Migratory waterbirds travel periodically from the Northern to Southern hemisphere or vice versa to avoid winter and food shortages in their place of origin, then return to their place of origin in early spring when climatic conditions and resources are sufficient to support their breeding (Gagarin et al., 2022). The lowest H' value was found in the Kili-Kili mangrove habitat, H'= 0.719.

Likewise, the DMg value obtained in the mudflat habitat type of Muncar Beach provides an understanding that the habitat conditions with moderate category values obtained DMg = 4.005. The species richness index if the value of 2.50 <DMg'≤4.00 has a medium-level criterion (Krebs, 2014). The lowest DMg value is found in the Kili-Kili mangrove habitat, namely DMg = 0.486 with a low category. This is supported by (Ismaini et al, 2015) which says the greater the number of species found, the higher the richness index value obtained.

The species evenness index value (E) found in each wetland habitat has a relatively high category, except for the relatively small evenness index value in the mangrove habitat (E = 0.447). The evenness index value of the range E < 0.5 means the low evenness of the community is depressed (Krebs, 2014). The relatively small value of E indicates that there is a waterbird species that dominates the community with many individuals that is significantly different from the number of other individuals in the community. Meanwhile, a relatively high value of the E index tends to have a relatively uniform number of individual bird species found (Rifai, Bakhtiar Ahmad, et al., 2024) in the sense that each species has the same number of individuals at each observation location (Fauzi et al., 2023).

Table 2. H', E, DMg values of Waterbirds

Aspek	HL 1	HL 2	Mr	Tb
Jumlah Spesies	32	18	5	10
Jumlah Individu	2300	1159	3742	267
Indeks Keanekaragaman (H')	2.594**	2.392**	0.719*	1.895**
Indeks Kemerataan (E)	0.748***	0.828***	0.447*	0.823***
Indeks Kekayaan (DMg)	4.005**	2.410*	0.486*	1.611*

Description: HL1 = Hamparan Lumpur Muncar, HL2 = Hamparan Lumpur Kili, Mr = Mangrove, Tb = Tambak, ***) kategori tinggi, **) kategori sedang, *) kategori rendah.

4. *Principal Component Analysis* (PCA) of Waterbirds Spesies in the Pangpang Bay

The interpretation results of the biplot graph based on PCA analysis (Figure 4) for each quadrant showed a correlation between bird species and habitat conditions, both from environmental parameter factors and the presence of vegetation in each wetland habitat. Quadrant I shows that the presence of waterbirds in the mudflats of Kili-Kili Tower (HL2) is influenced by temperature. Some waterbird species that depend on temperature conditions are Glareola maldivarum, Butorides striata, Tringa tetanus, and Charadrius mongolus.

Quadrants II and III have relatively high levels of waterbird diversity and abundance (Figure 3). Environmental parameters such as salinity, air humidity, and light intensity influence the high diversity of waterbird species. In addition, tidal conditions are also an important factor in supporting the presence of waterbirds. Based on observations, the presence of waterbirds during low tide conditions is found in mudflats as a source of food.

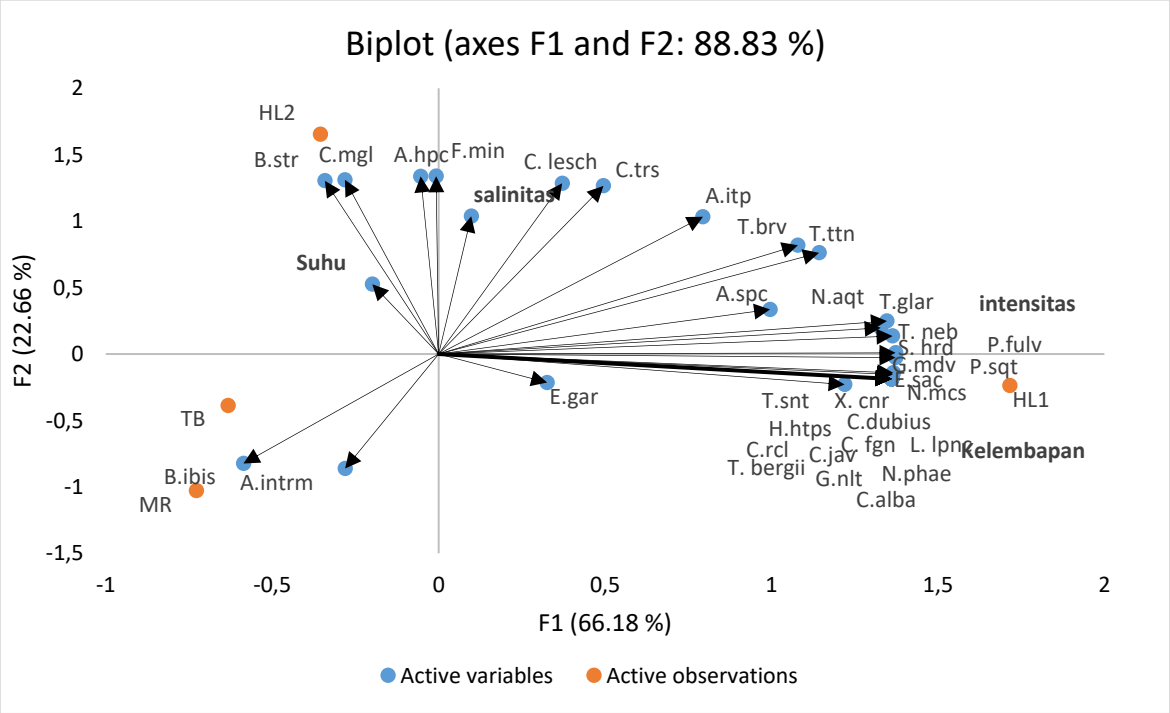

Figure 3. PCA Results of Waterbird Species in Pangpang Bay EAA

Quadrant IV shows the similarity of species occupying mangrove and pond habitats. PCA results show that waterbird species found in mangrove and pond habitats are not influenced by environmental parameters (Figure 3). Mangrove vegetation density can provide food sources and breeding. As done by Bubulcus ibis and Ardea intermedia found in mangrove and pond habitats.

CONCLUSION

Thirty-four species of waterbirds were found in all wetland habitats of Pangpang Bay. The highest diversity of waterbird species was found in the mudflat habitat of Muncar Beach with 32 waterbird species, while the lowest diversity was found in the Kili-Kili mangrove with a total of 5 waterbird species. The abundance of waterbird species in all wetland habitats was 7468 individual waterbirds. The highest abundance was Bulbulus ibis with a total of 3742 individuals in the Kili-Kili mangrove habitat. **Diversity index**, DMg and E values indicate that overall wetland habitats in Pangpang Bay support resident and migratory waterbirds. **Principal component analysis** results showed that waterbird presence was related to habitat conditions and environmental parameters, particularly light intensity and air humidity. Conservation efforts are needed in Pangpang Bay to maintain optimal flight paths for migratory waterbirds. The importance of community engagement and socialization on the presence of migratory waterbirds in Pangpang Bay.

ACKNOWLEDGMENTS

The researcher would like to thank the BISA Indonesia team for helping to collect waterbird data in Teluk Pangpang KEE

REFERENCE

Anggreani, R. F. (2019). Perilaku Menangkap Mangsa Pada Burung Air di Areal Lahan Basah Desa Margasari Kecamatan Labuhan Maringgai Kabupaten Lampung Timur. Universitas Lampung.

Atlas Burung Indonesia. (2020). Atlas Burung Indonesia: wujud karya peneliti amatir dalam memetakan burung nusantara. Yayasan Burung Indonesia.

Basu Roy, A., Chatterjee, L., Khan, A., Panja, B., Samanta, T., & Jana, S. (2023). Inventory of Migratory Waterbirds in the coastal areas of Purba Medinipur district, West Bengal, India. Cuadernos de Biodiversidad, 65, 23–35. https://doi.org/10.14198/cdbio.23488

Chanate, W., Wasan, D., Pisarut, Y., & Rungtip, S. A. (2020). The Diversity, Population, Ecology and Conservation Status of Waterbirds in the Wetland of Bangpu Nature Education Center, Thailand. Biodiversitas, 21(8), 3910–3918. https://doi.org/10.13057/biodiv/d210862

Fauzi, N. A., Munian, K., Mohd Kharip Shah, A. K., & Norazlimi, N. A. (2023). Species composition and diversity of waterbird communities in Important Bird and Biodiversity Area (IBA) of South West Johor Coast, Malaysia. Biodiversitas, 24(6), 3471–3480. https://doi.org/10.13057/biodiv/d240644

Gagarin, Y., Tarmizi, H., Wahyudi, T., Abdullah, & Ramadhan, H. (2022). Studi Burung Air di Kawasan Pesisir Pantai Timur Kota Banda Aceh Provinsi Aceh, Indonesia. Prosiding Seminar Nasional Biotik, 10(1), 2022. https://jurnal.ar-raniry.ac.id/index.php/PBiotik/index

Gitayana, A. (2011). Seri Buku Informasi Potensi Burung Air TN Alas Purwo.

Howes, J., Bakewell, D., & Noor, Y. R. (2003). Panduan Studi Burung Pantai. Wetlands International.

Irmawan, A., Nurdjali, B., & Siahaan, S. (2014). Identify the Types ofWater Birds In Region Mangrove Snapper Subdistrict Saleh village ofTanjung Kubu Raya District. Jurnal Hutan Lestari, 2(3), 444–453.

Khalil, A. R. A., Mulyani, Y. A., Mardiastuti, A., & Iswandaru, D. (2021). Diversity of waterbirds in mudflat and fishpond habitats in coastal Wetlands of East Lampung, Indonesia. IOP Conference Series: Earth and Environmental Science, 948(1). https://doi.org/10.1088/1755-1315/948/1/012025

Krebs. (2014). The Experimental Analysis of Distribution and Abudance. Person Education Limited.

Lasantu, T. W. N. L. T. W. N., Tasirin, J. S., & Nurmawan, W. (2020). Keanekaragaman Jenis Burung Air Di Kecamatan Kakas, Sulawesi Utara. Cocos, 6(6). https://ejournal.unsrat.ac.id/index.php/cocos/article/view/30878

MacKinnon, Phillips, & Balen, V. (2010). Seri Panduan Lapangan Burung-Burung Di Sumatera, Jawa, Bali dan Kalimantan. Birdlife International-Indonesia Program-Pusat Penelitian dan Pengembangan Biologi LIPI.

Makkatenni, Jalil, Amirullah, Ahmad, S. W., Muhsin, & Nasaruddin. (2023). Biodiversitas Burung Air di Kawasan Mangrove di Sekitar Muara Sungai Lakawali dan Sungai Ussu Kecamatan Malili, Kabupaten Luwu Timur, Sulawesi Selatan. Jurnal Sumberdaya Hayati, 9(1), 24–29. https://doi.org/10.29244/jsdh.9.1.24-29

Master, J., Nurcahyani, N., Natalia, S., & Pertiwi, H. (2016). Keanekaragaman Jenis Burung pada Areal Tambak Intensif di Sumatera Selatan dan Lampung. Biospecies, 9(2), 24–31.

Nurdin, Kosasih, D., Supartono, T., Ghojali, N. M., & Rahardian, H. (2021). Keanekaragaman jenis dan karakteristik habitat burung di Ekosistem Mangrove Indramayu. Jurnal Penelitian Universitas Kuningan: Logika, 12(2), 130–140.

Nurmaeti, C., Abidin, Z., & Prianto, A. (2018). Keanekaragaman Burung Pada Zona Penyangga Taman Nasional Gunung Ciremai. Quagga : Jurnal Pendidikan Dan Biologi, 10(2), 54. https://doi.org/10.25134/quagga.v10i2.1297

Purify, A., Nurdin, N., Maulani, R. I., & Lanuru, M. (2019). Water Bird Habitat Suitability Analysis in an Urban Coastal Wetland (case study: Lantebung Mangrove Ecotourism Area). IOP Conference Series: Earth and Environmental Science, 370(1). https://doi.org/10.1088/1755-1315/370/1/012042

Qomariah, I. S., Irwanto, R., Mardiastuti, A., & Hidayati, N. A. (2022). Keanekaragaman Burung Pantai di Pantai Pukan, Merawang, Kabupaten Bangka. Biota : Jurnal Ilmiah Ilmu-Ilmu Hayati, March, 49–59. https://doi.org/10.24002/biota.v7i1.4713

Ramadhani, A., Ambarwati, R., & Gumilang, R. S. (2022). Diversity and abundance of water birds in the mangrove area of south coast of Bangkalan, Madura Island, Indonesia. Biodiversitas, 23(6), 3277–3284. https://doi.org/10.13057/biodiv/d230657

Rifai, B. A., Febriyanti, E. N., Kardina, J. R., Andhini, R. N., Satriawan, M. H., & Kurnia, I. (2024). Diversity of Bird Types on Untung Java Island Thousand Islands Province DKI Jakarta. Jurnal Hutan-Hutan Pulau Kecil: Jurnal Ilmu-Ilmu Kehutanan Dan Pertanian, 8(1), 1–10.

Rosdatina, Y., Apriadi, T., & Melani, W. R. (2019). Makrozoobentos sebagai bioindikator kualitas perairan Pulau Penyengat, Kepulauan Riau. Jurnal Pengelolaan Lingkungan Berkelanjutan (Journal of Environmental Sustainability Management), November, 309–317. https://doi.org/10.36813/jplb.3.2.309-317

Sabrina, H., Mardiastuti, A., & Hernowo, J. B. (2019). Waterbirds Diversity in Bengawan Solo Estuary, Gresik, East Java. Media Konservasi, 24(1), 103–108. https://doi.org/10.29244/medkon.24.1.103-108

Sari, D. A. (2023). Keanekaragaman Spesies Burung Pantai di Biosite Teluk Pangpang Ijen Geopark. Universitas Jember.

Soendjoto, M. A. (2018). Burung air, antara kepentingan ekonomi dan ekologi (Waterbirds, between economic and ecological interests). Prosiding Seminar Nasional Lingkungan Lahan Basah, 3(1), 14.

Vidal, N. P., Manful, C. F., Pham, T. H., Stewart, P., Keough, D., & Thomas, R. H. (2020). The use of XLSTAT in conducting principal component analysis (PCA) when evaluating the relationships between sensory and quality attributes in grilled foods. MethodsX, 7. https://doi.org/10.1016/j.mex.2020.100835

Winara, A. (2017). Keragaman Jenis Burung Air Di Taman Nasional Wasur, Merauke. Jurnal Hutan Tropis, 4(1), 85. https://doi.org/10.20527/jht.v4i1.2885.