ASSESSMENT OF THE VARIOUS TYPE OF MANGROVE AREAS BY AVIFAUNAL DIVERSITY AND COMMUNITY IN TAMBAN BEACH, SUMBERMANJING WETAN, EAST JAVA**PENILAIAN VARIASI TIPE AREA MANGROVE OLEH DIVERSITAS DAN STRUKTUR KOMUNITAS AVIFAUNA DI PANTAI TAMBAN, SUMBERMANJING WETAN, JAWA TIMUR**Agus Nurrofik¹⁾, Achmad Dadang Burhanuddin¹⁾, Lutfita Fitriana¹⁾, Luchman Hakim¹⁾, Nia Kurniawan^{1)*}

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ABSTRACT

The restoration effort in Tamban Beach may reflect the role services of mangroves as suitable habitats for those surrounding diversity, especially on avifauna. Here we assess the diversity and community of avifaunal throughout types of mangrove ecosystems. We surveyed the avifaunal within four stations (i.e., natural mangrove area, restored mangrove area since 2009 and 2014, and degraded mangrove area) in Tamban Beach, Sumbermanjing Wetan, East Java during March 2021 using Audiovisual Encounter Survey (AES) methods. We present the statistic descriptive analysis of α -diversity index (taxa diversity, dominance index, Simpson's index, Evenness, Shannon-Wiener diversity index, Brillouin index, and Margalef species richness) as diversity assessment also conservation status of each species. The Principal Component Analysis (PCA) was performed to investigate the community variation within each site. We found 38 species from 22 families and 11 orders of avifaunal across the sites. The diversity of avifauna was high in a degraded area due to the mixture of habitats, although the natural and restored area yields some specialists. The type of mangroves might not be the sole factor affecting the avifauna diversity correlation, highlighting the importance of conservation strategies in the area.

Keywords: habitat assessment, avifaunal diversity and community, Malang, mangrove ecosystem

ABSTRAK

Upaya restorasi di Pantai Tamban dapat mencerminkan pentingnya peran hutan mangrove sebagai habitat yang cocok untuk keragaman hayati sekitarnya, khususnya avifauna. Disini kami menilai diversitas dan komunitas avifaunal pada tipe mangrove dalam kawasan. Survei avifauna dilakukan di empat stasiun (area mangrove alami, area mangrove yang direstorasi sejak 2009 dan 2014, dan mangrove yang terdegradasi) di Pantai Tamban, Sumbermanjing Wetan, Jawa Timur selama Maret 2021 menggunakan metode Audiovisual Encounter Survei (AES). Kami menyajikan analisis statistik deskriptif berdasarkan indikasi α -diversity (keragaman taksa, indeks dominansi, indeks Simpson, Kemerataan, indeks Shannon-Weiner, indeks Brillouin, dan kekayaan spesies Margalef) sebagai parameter penilaian diversitas avifauna beserta status konservasi tiap spesies avifauna yang ditemukan. Principal Component Analysis (PCA) juga kami gunakan untuk menyelidiki variasi komunitas pada tiap stasiun. Kami menemukan total 38 spesies dari 22 famili dan 11 ordo avifauna di seluruh lokasi. Diversitas avifauna tertinggi terdapat pada kawasan terdegradasi dengan tipe ekosistem heterogen, meski pada zona mangrove natural dan restorasi terdapat beberapa spesialis. Tipe mangrove mungkin bukan menjadi faktor utama yang mempengaruhi korelasi keragaman avifauna dan tipe habitatnya sehingga perlu menyoroti pentingnya strategi konservasi di daerah tersebut.

Kata kunci: penilaian habitat, diversitas dan komunitas avifauna, Malang, ekosistem mangrove

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INTRODUCTION

Mangroves ecosystem takes up to 31% of coastal area in Indonesia [1], which plays a crucial role in preserving the coastal biome and provides ecological services such as carbon sequestration, biomass stock, and protection from coastal

abrasion [2]. The county's record of mangrove area covers around 3.36 million hectares in 2017 [3], by the proportion of 22.6% of the world's total mangrove ecosystem [4]. However, the occurrence of human disturbances as impact by population growth imposes a significant impact on the mangrove ecosystem [5]. The prominent threat is

alteration into agricultures, fishponds, and human settlement, which slowly but significantly degraded the mangrove's covered area [6]. In Java island, the mangrove lost around 800.000 hectares in three decades [7], while in East Java Province, the mangrove lost around 38.100 hectares in periods 1991-2019 [8]. This serious problem not only threatens livelihood but also impacts the surrounding community of biodiversity in the mangroves [9]. Hence, to mitigate the effect of the problems, local public awareness has been conducted for several movements of rehabilitation and restoration of the remaining mangroves ecosystem [10]. In East Java province, it was recorded in Delta Porong, Sidoarjo Region [11], Clungup Beach, and Tamban Beach, Malang Region [12].

Tamban Beach is one of the rehabilitation sites of the threatened mangrove ecosystem in East Java Province. It is located in Malang along the northeast of the Sempu Island Nature Reserve. Recent studies have been carried on tourism development [13], and the detail of its mangrove ecosystem is observed by Harahab & Setiawan [12]. Formerly, the remaining mangrove ecosystem as natural sites in Tamban Beach was only 15 hectares as the effect of massive habitat alteration. The periodical mangrove restoration programs, first implemented in 2006 around the areas, then developed into 50 hectares of rehabilitated area in our survey. The restoration program was conducted by a local civilization belonging to Kelompok Sadar Wisata (POKDARWIS), changed into Gunung Pithing Mangrove Conservation (GPMC) as office manager of this area. They applied periodical sites restoration (held in 2009 and 2014) to control the mangrove growth as succession effect easier. By the type of periodical site, each mangrove site may serve its ecology roles and type of association, which is poorly understood. Therefore, it needs to be assessed using by type of surrounding community, such as avifauna diversity.

The avifauna diversity has been used as a bioindicator across various habitats, such as mangroves [14]. So far, about 170 species of avifauna are known in Indonesia, which depend on mangrove ecosystems [5]. Mangroves provided environmental services for avifauna, including shelters, foraging, and breeding site [15]. In addition, mangroves also facilitated the hiding and perching place [16], especially for the niches of water birds and arboreal bird families [17]. For mangrove restoration efforts, the avifauna parameter assessment such as species diversity, abundance, families community structure, and specialization roles could be the key factors to monitor the success of long-term mangrove

restoration [10]. Therefore, to assess the avifauna community, we conduct the comparison across the type of mangroves plot in the study location divided into natural, restored, and degraded areas. We also aim to report, compare, and evaluate the diversity of avifauna across various mangrove habitats. We hope that the results can be used as the baseline data to support future habitat management. Also, it can assist to be an example of study preferences, especially in East Java.

METHODS

Study area. The survey at Tamban Beach was conducted on the coastal mangrove ecosystem of the GPMC area, Tambakrejo village, Sumbermanjing Wetan subdistrict, East Java. Four stations were selected as the representative sites, including (1) natural mangrove area, (2) restored mangrove area since 2009, (3) restored mangrove area since 2014, (4) degraded area (Figure 1). Natural mangroves were a reference site of 1.71 hectares wide and habitus of mangrove trees including *Sonneratia alba*, *Ceriops tagal*, and *Avicennia alba*. The restored mangrove area since 2009 was located near site 1, at the end of an estuary covering an area of 0.88 hectares, dominated by the mangrove species of *Bruguiera* sp. The restored mangrove area since 2014 was located on the west side of the river banks, slightly intersecting with the agricultural, 0.67 hectares wide, and dominated by mangrove species of *Xylocarpus* sp. The degraded area was a mixture of mangrove forests and lowland forests, covering an area of 2.66 hectares, but later was converted into a banana plantation and composed of several remaining canopy trees such as *Ficus retusa* (Iprik), *Corypha utan* (Gebang), and *Inocarpus fagiferus* (Gayam). Each of the habitats was shown in Figure 2.

Field survey and species identification. Field surveys were conducted audiovisually during March 2021 for two consecutive days for each observation station. Surveys were started from 06.00–10.00 AM using the Audiovisual Encounter Survey (AES) method around the study area [18]. The observation was supported by binocular (Binocular Swift 10x50D), tele-camera (Nikon Coolpix B600), while the audio was recorded using an audio recorder (Sony ICD-PX240). In addition, we identified avifauna observed using field guide books [19, 20], and vocalization was confirmed using the Avian vocal database Xenocanto [21].

Data analysis. We categorized the taxa by the presence/absence in each of the stations. We followed the conservation status of the International Union for Conservation of Nature (IUCN) [22] and nationally protected species under Permen LHK No.106 [23].

Figure 1. Map showing the observed stations in Tamban Beach, Sumbermanjing Wetan, East Java

Figure 2. Habitat condition of each station in Tamban beach: A) Natural mangrove area, B) Restored mangrove area since 2009, C) Restored mangrove area since 2014, D) Degraded area.

We analyzed the community by the descriptive statistic of an α -diversity index, including taxa diversity, dominance index, Simpson's index (D), Evenness, Shannon-Wiener Diversity index (H'), Brillouin index ($\hat{H}$), Margalef species richness (d) [24]. In addition, we used Principal Component Analysis (PCA) in PAST 4.07 software to investigate the community variation within each station using the avifaunal composition.

Below is the formula used to α -diversity index analysis:

1. Simpson's Dominance Index [25]

$$Di = \sum_i \left(\frac{n_i}{N} \right)^2$$

where: Di = Dominance Index

n_i = number of individual each species

N = Total number from all species

2. Simpson's Diversity Index [25]

$$D = 1 - D_i$$

3. Buzas-Gibson's Evenness [26]

$$E = e^H / S$$

where: E = Buzas-Gibson's Evenness

e^H = Logarithm base for Shannon-Wiener index

S = Species richness

4. Shannon-Wiener Diversity Index [27]

$$H' = -\sum n_i \cdot N^{-1} \cdot \ln(n_i \cdot N^{-1})$$

where: H' = Shannon-Wiener Index

n_i = number of individual each species

N = Total number from all species

5. Brillouin's Index [28]

$$\dot{H} = (\ln(N!) - \ln \sum_i \ln_i(n!)) / N$$

where: $\dot{H}$ = Brillouin's Index

N! = Total number from all species

n = Total of individual numbers by the sample

6. Margalef's Species Index [29]

$$d = \frac{S - 1}{\ln(n)}$$

where: d = Margalef's Species Index

S = Total number of Species

n = Total of individual numbers by the sample

RESULTS AND DISCUSSION

Avifaunal diversity and community. A total of 254 individuals from 38 species, 22 families, and 11 orders were recorded in Tamban Beach (Table 1). This species diversity included 22% avifauna in mangrove areas in Java compared by [5] and consisted of 35% avifauna species of Sempu Island [19]. The documentation of species represented for each family was shown in Figure 3.

Based on the IUCN conservation status [22], 36 species were considered as Least Concern. Moreover, one species was categorized as Near Threatened (*L. pusillus*) (Figure 3B), and one species was categorized as Vulnerable (*C. nigrorufus*) (Figure 3E). Both species were endemic Java-Bali and listed as nationally protected species under Permen LHK No.106. *L. pusillus* served as a seed-dispersing agent [23],

while *C. nigrorufus* had a preference for insects, prey, and small vertebrates [15]. Other species, including *F. mollucensis*, *C. leucopterus*, and *R. javanica* (Figures 3A, 3J, and 3K), were also listed in Permen LHK No.106, although their conservation status by IUCN was stated as Least Concern.

The species richness by Table 1 showed in the natural mangrove area were 13 species, restored mangrove area since 2009 were 16 species, restored mangrove area since 2014, 20 species, and 24 species from degraded mangrove, respectively. The circumstances of the degraded mangrove area by species richness showing the highest avian diversity might be due to the heterogeneous habitat (i.e., a transition of mangrove habitat and the mixture of lowland forests). This condition might support the high diversity of both generalist and specialist avifauna, including the complexity of insect diversity as their main prey [16]. In terrestrial landscapes, the pattern of heterogeneous habitat was related to the improvement of the diversity of microhabitat that suits avifauna [30]. Even though the habitat has been degraded, the existence of canopy tree remains still provided ecological corridors as well as the feeding ground for most avifauna [31]. While, in natural and restored mangroves, the lower species richness might be influenced by selective niches integrated by the type due to the food webs [32].

Based on Table 2, all site conditions were reflected by the relative abundance of the avifauna community, which was reflected by α -diversity indices. Four sites had scores ranging from 0.80-0.89 for Simpson's Diversity Index, and Evenness indices ranged 0.71-0.91, which serve good quality (Table 2). This condition was also related to the dominance value, which showed a low score. Those parameters generally showed the abundance of prey, low competition, and species inhabiting their specific niche [16]. The avian quality by Shannon-Wiener, Brillouin, and Margalef index showed low until moderate biodiversity value. The low scores were shown by natural mangroves and restored areas from 2009, while moderate scores showed by restored mangroves from 2014 and degraded areas. Those biodiversity indexing parameters' quality depended on the actual condition of the avifaunal community at each site at certain times, which longer duration of research was needed [18]. The latest consensus by the scores revealed the urgency of sustaining and improving the habitat quality to support avifaunal community and diversity [33].

Figure 3. Avifaunal species represented for each family in Tamban Beach, Sumbermanjing Wetan, East Java: A) *F. mollucensis* [Falconidae]; B) *L. pusillus* [Psittacidae]; C) *G. striata* [Columbidae]; D) *D. trochileum* [Dicaeidae]; E) *C. nigrorufus* [Cuculidae]; F) *A. phoenicurus* [Rallidae]; G) *L. punctulata* [Estrildidae]; H) *A. tiphia* [Aegithinidae]; I) *C. jugularis* [Nectariniidae]; J) *C. leucopterus* [Lariidae]; K) *R. javanica* [Rhipiduridae]; L) *P. mollucensis* [Picidae]; M) *P. haemocephalus* [Caprimulgidae]; N) *P. cinnamomeus* [Campephagidae]; O) *T. chloris* [Alcedinidae]; P) *O. sepium* [Cisticolidae]; Q) *A. leucoryn* [Artamidae]; R) *H. striolata* [Hirundinidae]; S) *T. nebularia* [Scolopacidae]; T) *C. linchi* [Apodidae]; U) *P. goiavier* [Pycnonotidae]; V) *A. speciosa* [Ardeidae]

Composition of avifauna's family across a variety of mangrove habitats. The result of PCA reflected 85.5% information of composition and complexity based on the avifauna family demonstrated to the ecosystem services to the avifauna's life by all sites, shown by PC 1 and PC 2 (Figure 4). The 2009 restored area showed similarities to natural mangroves, which strongly correlated to Alcedinidae, Scolopacidae, and Apodidae families due to proximity habitat. Alcedinidae and Scolopacidae were specialist families in mangrove areas as fish eaters, crustaceans, and bivalves, while Apodidae had a general function as aerial insect eaters [15]. In addition, both stations were also positively correlated with the families Nectariniidae,

Estrildidae, Lariidae, and Rhipiduridae. The positive correlation of some avian families and their particular habitat, such as natural and restored mangroves, constituted a reference site supporting each family's roles [30]. Also, by utilization patterns in study sites, both accessible habitats might serve different sources for those families to feed and breed [34], except for Apodidae, which was used only as a feeding place, by its character [15].

The family composition in the 2014 restored area showed a positive correlation by Campephagidae, Hirundinidae, Columbidae, Ardeidae, and Rallidae. Its abundance might be affected by the type of adjacent habitat (Agricultural area covers rice fields and coconut

groves) from the 2014 restored area. The adjacent habitat could support specific food resources for avifauna's family [35]. Agriculture type, such as coconut groves, had a huge amount of arboreal insects [36] potentially to feed insectivorous avifauna, while the rice field as artificial wetlands might be worked as foraging sites for carnivorous and granivorous avifauna [34]. In the study, we found restored mangroves from 2014, as a recovery zone, just provided a shelter for perching and hiding places for those families. Therefore, we assumed it might also be influenced by the domination of single species by type of restored mangroves. By the time, the services of the restoration zone potentially increased as a succession effect [37]. To maximize it, the support of mangrove-associated vegetation further was needed. Thus, the effect of succession would raise the avifauna's ecological communities [5].

In the degraded area, the family of terrestrial avifauna such Falconidae, Aegithinidae, Cuculidae, Capitonidae, Psittacidae, Artamidae, Cisticolidae, Pycnonotidae, and Dicaeidae was positively correlated. Its richness may be supposed by the heterogeneity proportion, such mangroves and lowland forest, assumed the lowland forest mostly covered than the mangroves area in the past. The heterogeneous area consisted of more vegetation mosaic, such as scrubs, bushes, mangroves, and dense tree vegetation to attract more avifaunas families [32]. By the time of degradation occurrence, the entire family in the degraded site presented an adaptation to respond to habitat change [17]. They might be adapted by opened areas, potentially provided a location for grooming and hunting [16].

Figure 4. PCA diagram showing the variation of avifaunal family in Tamban Beach, Sumbermanjing Wetan, East Java

Table 2. Score of α -diversity parameters each site in Tamban Beach, Sumbermanjing Wetan, East Java

Parameters	Natural mangrove area	Restored mangrove areas 2009	Restored mangrove areas 2014	Degraded area
Family richness	9	9	10	14
Individu	55	77	64	68
Dominance (Di)	0.1987	0.1746	0.1187	0.1029
Simpson Index (D)	0.8013	0.8254	0.8813	0.8971
Evenness	0.7167	0.7521	0.9093	0.8077
Shannon-Wiener (H')	1.864	1.912	2.207	2.426
Brillouin (H)	1.642	1.738	1.971	2.138
Margalef (d)	1.996	1.842	2.164	3.081

The implication of restoration for avifauna conservation.

Overall, the avifauna's family presence by all sites, besides the vegetation condition, was easily influenced by the abiotic factors [30]. Natural coastal climatic conditions (strong wind and big waves), temperatures, salinity, and humidity could be impacted the avifauna's occurrence [32]. Besides that, anthropogenic factors such as fragmentation, deforestation, pollution, garbages, noises, and poaches also impacted avifaunas distribution, which may also be related to the decline of its habitat [38]. Hence, to reduce the risk of avifauna's absence and habitat loss in study location, the necessary step must be considering the aspect of the sustainable conservation management plan for vegetation and abiotic factor cycle, such as habitat quality improvement program (planting avifauna's native house plant, intensification of reforestation in degraded areas, keeping the area from hunting or poaching) simultaneously by mangrove succession effect [10]. Thus, the specific improvement for heterogeneous habitats, such as degraded areas which consist of the highest terrestrial avifauna species, by the similar type composition of lowland forest was recommended for the reforestation of forest vegetation referring to the area of Sempu Island Natural Preserve [39]. Therefore, the importance of suspending an area could be established officially by coordinated steps to protect Tamban Beach's Mangrove Area by the managers, stakeholders, and local civilization also made community-based conservation movements to control and monitor that area [40]. Based on the situation of the study sites, we proposed the main priority reached by managers before running the program is education and advocate local civilization around Tamban Beach to improve their perception, especially on mangroves and avian ecological also their sustainable utilization. Their support was needed to keep the conservation of restored mangrove improvement progress in the future, besides doing their activity.

CONCLUSION

The diversity of avifauna and their families' correlation revealed the specific ecological services across a variety of types of mangrove habitats (natural, restored, and degraded) where the degraded area site consisted of the highest diversity due to its heterogeneity. In restoration sites (2009 and 2014), avifauna was influenced by the type of its adjacent ecosystem that serves the preference site. The evaluation by α -diversity indicated the urgency of habitat quality improvement on each site to support the avifauna community better.

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Table 1. List of avifaunal species in Tamban Beach, Sumbermanjing Wetan, East Java by family, species, conservation status (International Union for the Conservation Nature [IUCN]: LC—Least Concern, NT—Near Threatened, Vu—Vulnerable; and list of species under national protected law [Permen LHK No. 106]: NP—Non-Protected, P—Protected)

Family	Scientific Name	IUCN	P LHK No. 106	Sites			
				Natural mangrove area	Restored mangrove area 2009	Restored mangrove area 2014	Degraded area
Columbidae	<i>Geopelia striata</i>	LC	NP			√	√
	<i>Treron griseicauda</i>	LC	NP				√
	<i>Streptopelia chinensis</i>	LC	NP			√	√
Alcedinidae	<i>Halcyon cyanoventris</i>	LC	NP		√		
	<i>Todiramphus chloris</i>	LC	NP	√	√	√	√
	<i>Alcedo coerulescens</i>	LC	NP	√	√	√	
Ardeidae	<i>Ixobrychus cinnamomeus</i>	LC	NP			√	
	<i>Ardeola speciosa</i>	LC	NP	√	√	√	
	<i>Butorides striata</i>	LC	NP		√	√	
	<i>Egretta sacra</i>	LC	NP	√	√	√	
Rallidae	<i>Amaurornis phoenicurus</i>	LC	NP			√	
Laridae	<i>Chlidonias leucopterus</i>	LC	P		√		
Scolopacidae	<i>Tringa nebularia</i>	LC	NP		√		
	<i>Actitis hypoleucos</i>	LC	NP	√	√		
Estrildidae	<i>Lonchura maja</i>	LC	NP			√	√
	<i>Lonchura leucogastroides</i>	LC	NP			√	√
	<i>Lonchura punctulata</i>	LC	NP		√	√	√
Nectarinidae	<i>Anthreptes malacensis</i>	LC	NP	√	√		√
	<i>Cinnyris jugularis</i>	LC	NP	√	√		√
Cisticolidae	<i>Orthotomus sepium</i>	LC	NP			√	√
	<i>Orthotomus sutorius</i>	LC	NP	√	√	√	√
Pycnonotidae	<i>Pycnonotus aurigaster</i>	LC	NP	√	√	√	√
	<i>Pycnonotus goiavier</i>	LC	NP	√	√	√	√
Dicaeidae	<i>Dicaeum trochileum</i>	LC	NP				√
Aegithinidae	<i>Aegithina tiphia</i>	LC	NP	√			√
Artamidae	<i>Artamus leucorhynchus</i>	LC	NP				√
Hirundinidae	<i>Hirundo striata</i>	LC	NP			√	
Rhipiduridae	<i>Rhipidura javanica</i>	LC	P	√			
Campephagidae	<i>Pericrocotus cinnamomeus</i>	LC	NP			√	
Apodidae	<i>Apus pacificus</i>	LC	NP			√	
	<i>Collocalia linchi</i>	LC	NP	√	√	√	√
Capitonidae	<i>Psilopogon australis</i>	LC	NP				√
	<i>Psilopogon haemacephalus</i>	LC	NP				√

Family	Scientific Name	IUCN	P LHK No. 106	Sites			
				Natural mangrove area	Restored mangrove area 2009	Restored mangrove area 2014	Degraded area
Picidae	<i>Picoides moluccensis</i>	LC	NP				√
Psittacidae	<i>Loriculus pusillus</i>	NT	P				√
Cuculidae	<i>Centropus nigrorufus</i>	VU	P				√
	<i>Cacomantis merulinus</i>	LC	NP				√
Falconidae	<i>Falco moluccensis</i>	LC	P				√