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RESEARCH ARTICLE

Bird community structure of small islands: a case study on the Pahawang Island, Lampung Province, Indonesia

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Abstract

Small islands are extremely vulnerable to ecosystem disturbances. One of the common factors impacting on island ecosystems is the rise of tourism activity and the associated conversion of mangrove forest's function into tourism's supporting facility. Those changes will ultimately affect the diversity of bird species inhabiting the island. Therefore, this study aimed to analyse the structure of a bird community in the mangrove forests of the Pahawang Island. The study used the transect method with tracking implemented. The obtained data were analysed using the Shannon-Wienner diversity index. We recorded 28 species from 21 families. Out of 21 families, Columbidae had the highest number of species (three species). Seven feeding guilds were observed during the present study, the maximum number of species belonged to the insectivore group and the minimum – to the nectarivore and omnivore (1 species each) guilds. Based on the abundance rank, the most abundant species was the cave swiftlet (*Collochalia linchi*). Three of the recorded species are listed in the category "Protected" according to the Indonesia Law: the brahminy kite (*Haliastur indus*), sunda pied fantail (*Rhipidura javanica*), and the black-naped tern (*Sterna sumatrana*). All bird species that have been recorded during the present study is classified as "Least Concern" in the IUCN Red List. The values of the Shannon-Wienner index suggest neither high nor low diversity (H' = 2.55). Mangrove

forest ecosystems, including the mudflat on the Pahawang Island, are important supporting populations of wild birds through providing foraging, roosting and nesting sites.

Keywords
community, mangrove, Pahawang Island, small island

Introduction

Islands accommodate an important part of global biodiversity. The house more than 10% of all mammal and bird species, although representing only less than 2% of the Earth's land surface (Del Hoyo et al., 1992-1993; Alcover et al., 1998; Clements, 2000; Hahn et al., 2016). Because they are geographically isolated, the islands have been identified as centres of speciation, also owing to the fact that a large number of their native fauna consists of endemic species (Beierkuhnlein et al., 2011; Hahn et al., 2016). The size of the smaller island would not minimize its importance as a refueling station for migratory birds and a center of endemism for other species (Hamza et al., 2018). Small islands are defined as those with an approximate area of 10,000 km^2 and an estimated population of 500,000 or fewer residents (Beller et al., 2004; Calado et al., 2014). It is a typical geographic entity (Calado et al., 2014) with specific ecosystem characteristics. The ecosystems of the small island often have high levels of biodiversity and endemicity but are very vulnerable because of the small population size of the species and the low genetic variation (Paulay, 1994; Polman et al., 2016). This suggests that the small island ecosystems are particularly vulnerable when compared to terrestrial ecosystems (Fisher, 2004).

Human activities have an impact on the biodiversity on islands (Jackson et al., 2001). These activities can reduce the overall area available for wildlife via disturbances (McLeod et al., 2013; Navedo et al., 2019). Disturbances can reduce foraging budget, increase energetic costs, limit access to profitable areas and promote the risk of predation on shorebirds (Yasue´, 2005; Yasue, 2006). The mangrove ecosystem on small islands threatened where a lot mangrove forest has been deforested for the development of settlements, aquaculture and agriculture (Vo et al., 2013) and tourism facilities (Puryono, Suryanti, 2019). However, on small islands the increase in disturbance activity triggered by the intensive tourism development can threaten natural landscapes through deforestation, loss of wetland including mangrove forests (Neto, 2003). So far, such impacts include the conversion of mangrove forests into supporting facilities for the tourism. On the other hand, Alvi et al. (2018) state that the mangrove forest is a sensitive attribute in the ecological dimension that has the most influence on the sustainability of the marine tourism. The conditions on such islands are exacerbated by the today's society who tends to be powerless to see changes in the environment (Alfandi et al., 2019; Febryano et al., 2017; Yuliasamaya et al., 2014). Social powerlessness reflected in the low sense of belonging (awareness) of the general public to the idea of environment preservation and the ten-

dency to mind only their personal affairs (Nurhasanah et al., 2017). Besides, the mangrove forest degradation resulting in the endangerment of the landscape of the Pahawang Island, as well as the life and diversity of wildlife, including birds.

Birds are well-known bioindicators and they have a significant role in ecosystem functioning and balancing (Tesfahunegny et al., 2016; Kiros et al., 2018). They have an important function as an agricultural pest controller, weeds controller, plant-pollinator, seed dispersal and scavengers (Whelan et al., 2008). According to Lee, Martin (2017), bird diversity is influenced by landscape heterogeneity. This is usually demonstrated by the increasing number of bird species in the community along with the increasing heterogeneity of landscapes. Moreover, the composition of birds in mangrove forests is closely related to the composition and configuration of plant structures (Azlan et al., 2015). The mangrove forest of the Pahawang Island is a habitat for several species of wild birds that perform various activities there, such as foraging, roosting, nesting and breeding (Iswandaru et al., 2018). The observations on the diversity of bird species and the condition of their habitat are important for their protection and for the assessment of damage on the habitats they inhabit (Winara, 2016). Mangrove forests play an important role in the lives of local people on Pahawang Island. The local mangrove forest is composed of natural mangroves and associated mangroves. Mustika et al. (2017) stated the role of the mangrove forest as a green belt on the Pahawang Island is important. According to Febryano et al. (2014), the development of mangrove forest management on this island is closely related to the dynamics that occur in local communities. Davinsy et al. (2015) suggest that the management of the mangrove forest on the Pahawang Island is quite good in terms of various management aspects, such as planning, implementation and supervision. This study aimed to analyse the structure of the bird community in the mangrove forest on the Pahawang Island, following a recent degradation of mangrove forests due to increased human activities that may pose a threat to the ecosystem of this small island.

Methods

Study area

The Pahawang Island is a small island that occupies an area of 10.2 km^2 (1,020 hectares). It is located at coordinates 5^{o}40.2'- 5^{o}43.2' S and 105^{o}12.2' – 105^{o}15.2' E and is a part of a group of islands in the Lampung Bay. This island is situated 9.8 km south of Sumatra Island. The Pahawang Island is an inhabited island and its population reaches 1,780 people. Since 2006, the island has become a touristic destination. Tourism activities caused the deforestation of the mangrove forest. Logging of the mangrove forest for fishpond activities by the community also causes reduction in the coverage of the mangrove forest. Wibowo (2005) has previously recorded 34 species of birds in the mangrove forest on Pahawang Island. Our study was conducted in May and June and continued in November and December 2019. The tools

used in the study included DSLR cameras, binoculars, voice recorders, hand counters, tally sheets and field manuals. We focused our study on birds and their habitats.

Data collection

Data collection was done using the line- transect method based on transects with a length of 11.13 km. The observations were made with exploration techniques following the path in the mangrove forest with data collection on each encounter and scanning (through observation) of bird habitat. The observations were carried out in the morning at 06.00 – 10.00 and at noon at 13.00 – 17.00. The recording of species and numbers per each species during each encounter was conducted either through direct observation with unaided eye or using binoculars (Kiros et al., 2018) or based on bird calls, including for birds in flight (Odewumi et al., 2017). The birds that were flying but not landing (perching) on-site were not recorded (following Ntongani, Andrew, 2013). Taking photos using a camera aimed to assist identifying the species in detail (Jhenkar et al., 2016). The identification of bird species was based on MacKinnon et al. (2010) and the nomenclature we used was based on Sukmantoro et al. (2007). Identified bird species were grouped by families, feeding guilds and activities. Furthermore, the species conservation status has been identified based on the IUCN Red List (2019), which includes Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) and Least Concern (LC). Furthermore, the protection status has been determined after the Indonesian Law (No. 5 of 1990; PP No. 7 of 1999; P.LHK No. 106 of 2018, which includes Protected (D) and Not Protected (TD)).

The data obtained were analysed using the Shannon-Wiener diversity index; Pielou evenness index and Simpson dominance index (Magurran, 1988):

$$H' = \sum pi \; ln \; pi,$$

where
H' is the diversity index of Shannon-Wiener
pi -is the number of individuals of each species
ln -is the total number of individuals of all species
pi -is natural logarithm

The relative abundance of each species is strongly influenced by the large number of individuals at a location or habitat. The relative abundance was calculated using the following formula (James et al., 2017):

$$RA = \frac{ni}{N} \; x \; 100\%,$$

where:
RA is the relative abundance
ni -is the number of individual species
N -is the total number of individuals

Results and discussion

Birds are included in the category of terrestrial fauna occupying the top of the mangrove trees and several species occupying the bottom of the mangrove trees. The existence of mangrove forests strongly supports the life of birds as their habitat. The number of species of birds recorded during our observations in the mangrove forest of the Pahawang Island was 28, belonging to 21 families (Table 1).

Table 1. Species of birds recorded in the mangrove forest of the Pahawang Island

No	Family	Species		Conservation Status	
		English Name	Scientific Name	IUCN	Indonesian Law
1	Acanthizidae	Golden-bellied gerygone*	*Gerygone sulphurea* Wallace, 1864	LC	TD
2	Accipitridae	Brahminy kite*	*Haliastur indus* Boddaert, 1783	LC	D
3	Alcedinidae	Collared kingfisher**	*Halcyon chloris* Boddaert, 1783	LC	TD
4	Alcedinidae	Cerulean kingfisher**	*Alcedo coerulescens* Vieillot, 1818	LC	TD
5	Apodidae	Fork-tailed swift**	*Apus pasificus* Latham, 1801	LC	TD
6	Apodidae	Cave swiftlet**	*Collocalia linchi* Horsfield & F. Moore, 1854	LC	TD
7	Ardeidae	Striated heron**	*Butorides striata* Linnaeus, 1758	LC	TD
8	Ardeidae	Pacific Reef egret**	*Egretta sacra* J.F. Gmelin, 1789	LC	TD
9	Artamidae	White-breasted woodswallow*	*Artamus leucorynchus* Linnaeus, 1771	LC	TD
10	Columbidae	Common emerald dove*	*Chalcophaps indica* Linnaeus, 1758	LC	TD
11	Columbidae	Green imperial pigeon *	*Ducula aenea* Linnaeus, 1766	LC	TD
12	Columbidae	Spotted dove*	*Streptopelia chinensis* (Scopoli, 1786)	LC	TD
13	Cuculidae	Lesser coucal*	*Centropus bengaensis* Gmellin, 1788	LC	TD
14	Cuculidae	Little bronze cuckoo*	*Chrysococcyx minutilus* Gould, 1859	LC	TD
15	Corvidae	Large-billed crow*	*Corvus macrorhynchos* Wagler, 1827	LC	TD
16	Dicaeidae	Scarlet-headed flowerpecker**	*Dicaeum trochileum* (Sparrman, 1789)	LC	TD

17	Hirundinidae	Pacific swallow*	*Hirundo tahitica* Gmelin, 1789	LC	TD
18	Laridae	Black-naped tern**	*Sterna sumatrana* Raffles, 1822	LC	D
19	Meropidae	Chestnut-headed bee eater**	*Merops leschenaulti* Vieillot, 1817	LC	TD
20	Nectarinidae	Brown-throated sunbird**	*Anthreptes malacensis* (Scopoli, 1786)	LC	TD
21		Mangrove whistler*	*Pachycephala grisola* (Blyth, 1843)	LC	TD
22	Picidae	Sunda pygmy woodpecker**	*Picoides moluccensis* Gmelin, 1788	LC	TD
23	Pycnonotidae	Sooty-headed bulbul*	*Pycnonotus aurigaster* (Jardine & Selby,1837)	LC	TD
24	Rhipiduridae	Sunda Pied fantail*	*Rhipidura javanica* (Sparrman, 1788)	LC	D
25	Scolopacidae	Common sandpiper**	*Actitis hypoleucos* (Linnaeus, 1758)	LC	TD
26	Sylviidae	Ashy tailorbird*	*Orthotomus rificeps* (Lesson, 1830)	LC	TD
27	Sylviidae	Yellow-bellied Prinia*	*Prinia flaviventris* (Delessert, 1840)	LC	TD
28	Timaliidae	Horsfield's babbler*	*Malacocincla sepiarium* (Horsfield, 1821)	LC	TD

Information: * = roosting; ** = foraging, LC = Least Concern, D = Protected, TD = Not Protected

Mangrove habitats host a moderate number of bird species around the globe. Some bird species use the mangrove for roosting only (Altenburg, van Spenje, 1989; Nagelkerken et al., 2008) and mudflat habitats support waterbird and shorebird for foraging (Putra et al., 2017). Based on our direct observations, 57.14% (16 species) were roosting, while 42.86% (12 species) were foraging. Within the study area, the roosting birds were dominated by terrestrial birds that use the canopy in the mangrove forest for resting, while the birds that were foraging were dominated by waterbird species that were utilising the mudflat habitats. According to Iswandaru et al. (2018), waterbirds use mudflats in mangrove forest areas to search for food, while terrestrial birds use mangrove forests as resting or nesting sites. Based on the feeding guild classification, of the 28 bird species recorded during the observation the highest was the percentage of the insectivores (50% or 14 species), followed by the piscivores (17.85% or 5 species), granivores (10.71% or 3 species), carnivores (7.14% or 2 species), frugivores (7.14% or 2 species), nectarivores (3.57% or 1 species) and omnivores (3.57% or 1 species). According to Ekowati et al. (2016), insects are available to birds to feed on throughout the year. In addition, insectivore bird groups have adapted to the environment so that they have ways to catch

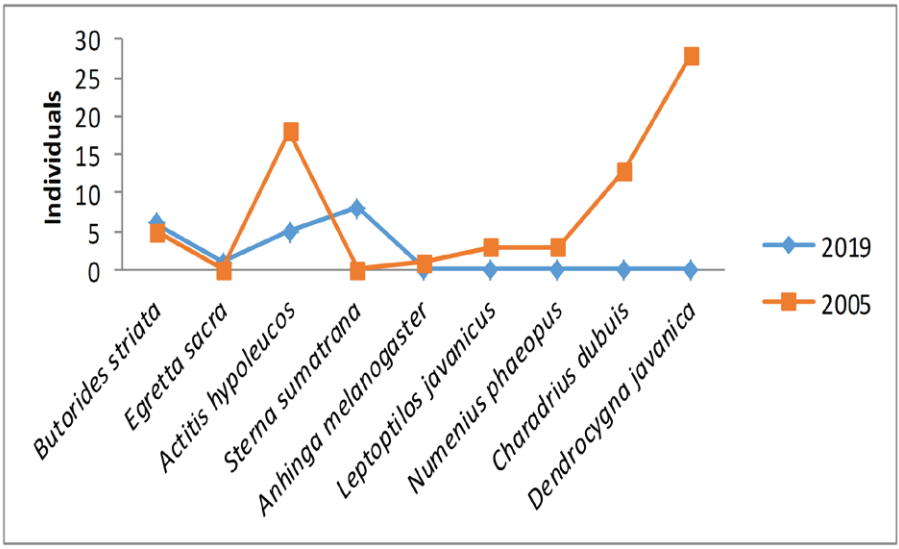

Figure 1. Comparison of the number of species and individuals of water birds on the Pahawang Island in 2019 and 2005.

insects with specialisation such as hunting while flying to pecking into tree trunks (Morse, 1971).

Many of the species reported in 2005 were not observed in the present study. When compared with the results of previous studies, the number of species and individuals differed, especially for waterbird species (Figure 1).

As a result, of the identification of the conservation status of bird species on the Pahawang Island (Table 1), there are three species with protected status (D) and 25 unprotected species (TD). The status according to IUCN for all species is included in the category of Least Concern (LC). Wibowo (2005) has previously recorded 12 species of birds with protected status (D): *Haliastur indus, Heliaeetus leucogaster, Ictinaetus malayensis, Halcyon smyrnensis, Halcyon chloris, Alcedo coerulescens, Anhinga melanogaster, Leptoptilos javanicus,, Numenius phaeopus, Rhipidura javanica, Leptocoma calcostheta, Anthreptes malacensis*.

We did not record *Leptoptilos javanicus* with conservation status write in full and leave the abbreviations in the brackets (VU), *Anhinga melanogaster* with conservation status write in full and leave the abbreviations in the brackets (NT), *Numenius phaeopus* with conservation status write in full and leave the abbreviations in the brackets (LC) in the present study. However, both are protected waterbirds in Indonesia. We could speculate that this was owing to habitat loss. Loss of habitat and degradation due to various human disturbances on the Pahawang Island will pose a threat to other waterbird populations in the future. Protection of suitable areas, such as mudflats, mangroves and inactive fish ponds, is required. According

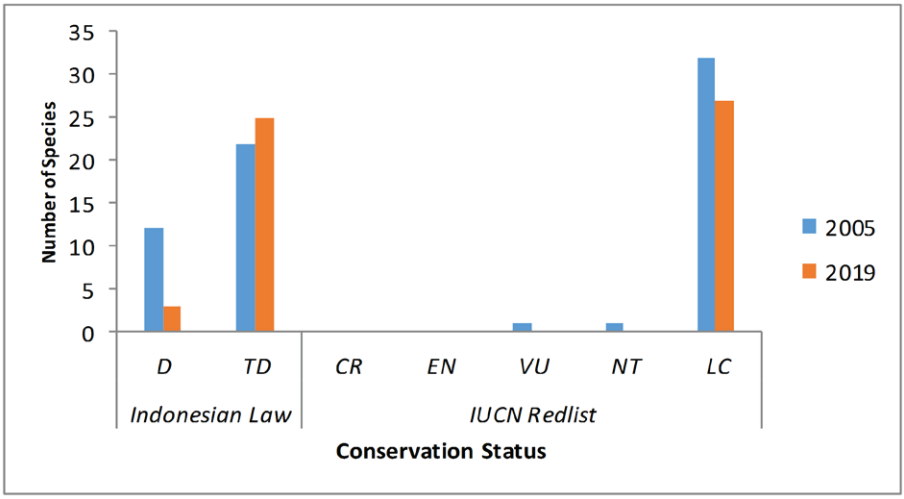

Figure 2. Comparison of the Bird Conservation Status of the birds on the Pahawang Island

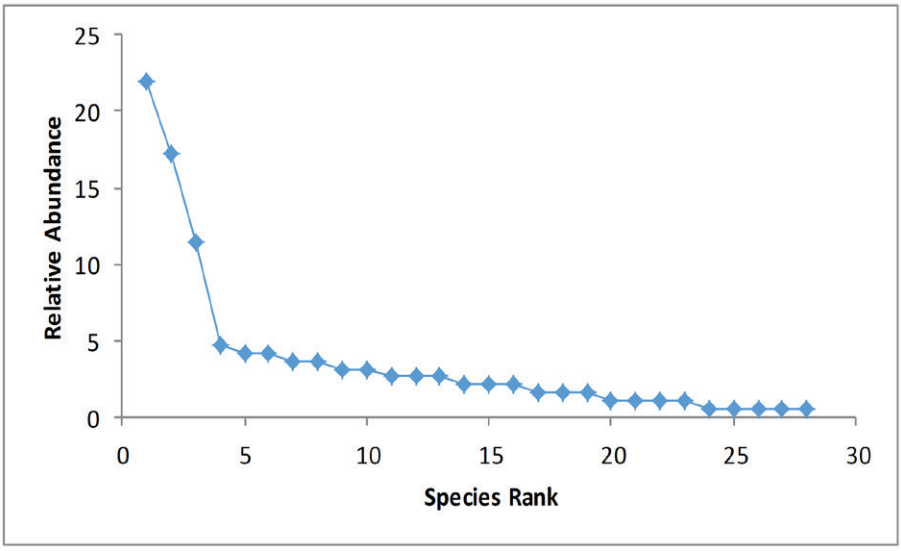

Figure 3. Species- rank abundance curve for the birds on the Pahawang Island

to Pierce and Gawlik (2010) and Purify et al. (2019), suitable areas where great varieties of food sources are available need to be protected from human disturbances. The choice of habitat by waterbirds in wetlands is strongly influenced by the availability of food sources and the ease of getting food according to the daily needs of each waterbird species foraging in a particular area.

Based on the rank abundance of bird species on the Pahawang Island (Figure 3), the birds with the highest abundance were *Collocalia linchi* (21.88%), *Apus pasificus* (17.19%) and *Merops leschenaulti* (11.46%). The birds with the lowest abundance were *Egretta sacra*, *Chalcophaps indica*, *Prinia flaviventris*, *Centropus bengalensis*, *Pachycephala grisola* with a value of 0.52% each.

Kopij (2000) has previously observed *Collocalia linchi* and *Apus pasificus* to be flying in large numbers around mangrove forests, both of which flying round and round to hunt down insects. *Collocalialinchi* and *Apus pasificus* are species of birds that have a wide distribution and are very common worldwide from the lowlands to the highlands. They show flocking behaviour (MacKinnon, et al. 2010). This is supported by the study of Arifin et al. (2012) which showed that *Collocalia linchi* is a species of swallow that has a wide distribution. In some locations, detailed swiftlets are commonly found in large groups (Prasetya, Siswoyo, 2017) and their abundance is high (Wulandari, Kuntjoro, 2019). Another species that was often recorded was *Merops leschenaulti* of the family Meropidae. These birds can be seen flying in groups while voicing and hunting insects. Some species of the family Meropidae capture their prey in the air and are important predators on the orders of Coleoptera, Dermaptera, Diptera, Lepidoptera and Odonata (Sihag, 1993; Ali, Taha, 2012).

The highest encounter intensity was found for *Collocalia linchi* and *Apus pacificus* in the morning between 07.00 and 09.00 am, while *Merops leschenaulti* had a peak in numbers in the afternoon between 16.00 and 18.00. In addition, the relative abundance (RA) was strongly influenced by the number of individuals of each bird species encountered during the observation.

Based on the results of the Shannon-Wiener (H ‘) species diversity analysis, the level of species diversity of birds in the mangrove forests of the Pahawang Island could be classified as average (1.0 <2.55 <3.0). These results suggest that the conditions in the mangrove forest ecosystem of the Pahawang Island are still relatively good to support the life of wild birds (Odum, 2016) and provide the necessary food resources and sites for nesting (Paramita et al., 2015), perch or rest and play (Jamili et al., 2014). According the results of the previous study conducted by Wibowo (2005), the diversity of birds on the Pahawang Island is 3.00. Therefore, the diversity of the birds on the island has decreased from a high- scale to a medium- scale. Some of the mangrove forests on the Pahawang Island have been converted into physical facilities supporting tourism or into agricultural land, settlements and fishponds.

Theonversion of land from mangrove forests to non-forested land on the Pahawang Island is causing a decrease in the value of bird diversity and changes in the composition of birds as demonstrated by the lower number of recorded bird species in this study as compared to a previous study (Wibowo, 2005). According to Swastianingrum, et al. (2012), bird diversity is determined by environmental conditions, the number of species and the distribution of the individuals of each species. In addition, the conversion of mangrove forest land causes the loss of suitable habitats, such as mudflat which is essential for the presence of migratory birds. Such examples are *Charadrius dubuis*, *Numenius phaeopus* and other bird species,

which generally occupy mudflat areas but were not recorded when this study was conducted. Many studies demonstrated that the mangrove forests and mudflats are important for the migratory shorebirds (Haryoko, 2014; Hutabarat et al., 2016; Putra et al., 2017; Sutopo et al., 2017; Chan et al., 2019) and the loss of such habitats has a negative impact on the migratory birds (Xu et al., 2019).

Conclusions

Bird species found on the Pahawang Island amounted to 28 species from 21 families with a composition of 14.29% of waterbirds and 85.71% of terrestrial birds. Based on feeding guild, the bird fauna on the island consisted of 50% insectivore, 17.85% piscivore, 10.71% granivore, 7.14% carnivore, 7.14% frugivore, 3.57% nectarivore and 3.57% omnivore. The highest ranking of relative abundance (RA) of bird species was the one of *Collocalia linchi* (15.48%). Our results on the identification of the conservation status suggest that there are three species of protected birds (D) and 25 unprotected species (TD). Diversity index indicate medium-scale (H' = 2.55). That is, the mangrove forest ecosystem, including mudflat on the Pahawang Island, is important to support wild birds foraging, roosting and nesting. To effectively conserve bird species, we suggest policymaker emphasize the designation and management of important resources such as mangrove forest and mudflat that strongly contribute to protecting the suitable area for wild birds. Both measures will help to make compatible important human activities with essential of bird community and migratory processes, which are also potential complementary sources for the local economics such as birding ecotour in the Pahawang Island.

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