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Diversity, Composition, and Abundance Distribution of Birds in Kariangau Industrial Zone, Balikpapan City, East Borneo

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Abstract

The Kariangau Industrial Zone extends industry from Balikpapan city in the Central Balikpapan to the coast in Western Balikpapan, forming a part of Balikpapan Bay. Our study aimed to estimate the diversity, species composition, and the abundance distribution of birds at the industrial zone of Balikpapan City. Our study contained six replicates each of boat transects on four rivers, the Somber, Getah, Paka Dua, and Wain rivers during the months of May and June 2017. We calculated the Margalef diversity and Bray–Curtis similarity indices to estimate diversity and species composition, whereas bird abundance distributions were analyzed using Paleontological Statistics (PAST) version 3.12. The Getah river had the highest diversity index (4.846), followed by the Somber (3.988), Wain (3.510), and Paka Dua (3.050) rivers. The Bray–Curtis index revealed high similarity in species composition between the Wain and Paka Dua. Our rarefaction analysis showed that the Wain and Paka Dua rivers were well sampled and had lower species richness, with low differences between the observed and expected species richness, than the Somber and Getah rivers. Fisher Log Series Model also showed abundance distribution being highest at Getah (11.170), and lowest at the Paka Dua Rivers (5.221). This observation may be due to heightened industrial activities and boat traffic on each river. Our study provides a useful baseline for future research on the bird assemblages on Balikpapan Bay.

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INTRODUCTION

Balikpapan is one of the fastest growing cities in Indonesia due to its economic strength in the oil and other relevant industries (Tarigan *et al.,* 2017). These industries have attracted many people to work and live in Balikpapan, thus contributing to the increase in number of residents in the city as well as the growing business and retail sectors (BPS Kota Balikpapan 2015, Tarigan *et al.,* 2017). As a result of the economic expansion therein, the local government has made plans to create new industrial areas in the Kariangau Industrial Zone to attract investment for developing the private sector (Tarigan *et al.,* 2017).

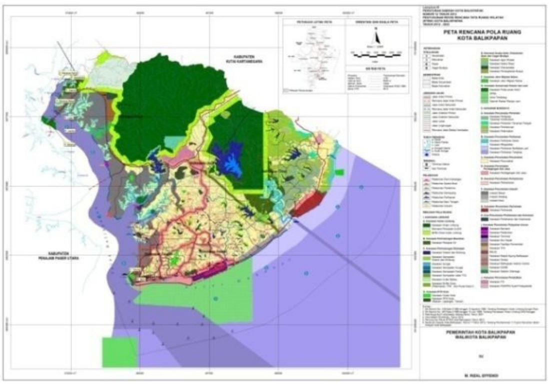

Figure 1. Balikpapan City Land Use Map (Source: Bappeda Kota Balikpapan's website). Round shape with dashed line is Kariangau Industrial Zone which consists of rivers to become research locations.

The Kariangau Industrial Zone which is located on the coast of Balikpapan City (Figure 1.) extends the industrial areas from Central Balikpapan to the coast of Western Balikpapan adjoining Balikpapan Bay. Many wildlife species have been documented in Balikpapan Bay, such as Irrawaddy Dolphin/Pesut *Orcaella brevirostris* (Kreb & Rahadi 2004, Kreb & Lim 2009), Dugong *Dugong dugon* (De Iongh *et al.*, 2007), and Proboscis Monkey/Bekantan *Nasalis larvatus* (Meijaard & Nijman 2000, Stark *et al.,* 2012); however, there is little information on the bird diversity in and around Balikpapan Bay. An earlier bird survey conducted by Slik & Van Balen (2006) focused on terrestrial parts of Balikpapan City, instead of coastal areas such as the Kariangau Industrial Zone. As the city expands, it is likely that coastal bird assemblages may become threatened. Birds were chosen as they are frequently used as bio-indicators of the environment (Caro & O'Doherty 1999) as they occupy higher tropic positions in food webs and play a major role in nutrient recycling in ecosystems (Ogden *et al.*, 2014). Our research aimed to estimate diversity, similarity of species composition, and the abundance distribution of birds at the industrial zone in Balikpapan City.

METHODS

We conducted research between May and June 2017 in the following four rivers in the Kariangau Industrial Zone - Somber, Getah, Paka Dua, and Wain (Figure 1.). The field methods described by Ronconi & Burger (2009) were followed, which used boat-based transects with six replicates (three transects in the morning and three in the afternoon). Most surveys were carried out from the downstream to the upstream sections on each river because most rivers could only be accessed by boat from estuary. This survey took place during the dry period of the year (Zhang *et al.*, 2016). Water in rivers we have surveyed was saline to brackish. The length of transect was approximately 3 km. Data collection followed Sutherland *et al.* (2004) by moving along each riverine transect. We noted the bird species observed, the number of species and individuals. We used binocular Nikon Aculon A211 12x50 and whilst counting, took note of the flight directions of each individual in order to minimize double counting on each species. Transects were sampled in the morning (05.30-08.00a.m.) and early evening (04.00-06.30p.m.) when birds were most active.

Margalef Diversity Index was calculated from species data collected along each river (Table 1.) using the formula:

$D_{Mg} = (S - 1) / \ln N$

with S as the number of observed species on each river and N is the number of individuals on each river. Bray–Curtis Similarity Index (Bray & Curtis 1957) was also used to calculate the similarity index among rivers. The formula of Bray–Curtis Similarity Index is shown below:

$C_N = 2w / a + b$

with w as the number of the lowest abundance value among two location (a and b), a is the number of all individuals on the first location, and b is the number of all individuals on the second location.

To standardize sampling effort (Gotelli & Colwell 2001) and estimate expected species richness on each river (Sanders 1968, Hurlbert 1971), we analyzed our sample data (Table 1) by using Rarefaction (James & Rathbun 1981). In addition to this and to show the abundance distribution of species on each river (Fisher *et al.,* 1943, Magurran 2004), we calculated the formula of Fisher log series model (Fisher *et al.,* 1943) as well as below:

$S/N = (1 - x) / x(-\ln(1 - x)$

with S and N are described for the Margalef index formula. Through the ratio (S / N), we could predict x and input it into this formula:

$\alpha = N(1 - x) / x$

To test for differences in species density, we used the non-parametric Friedman test t due to rank transformations (Conover & Iman 1981) in the Fisher log series model and our small sample size (n = 34) (Hattori & Mae 2001). We used the software PAST version 3.12 to calculate and analyze species abundance (Hammer *et al.*, 2001).

RESULTS AND DISCUSSION

A total of 34 species were recorded in our surveys (Table 1). The Getah river showed the highest diversity, while the Paka Dua river had the lowest diversity (Table 2, Figure 2). The Margalef diversity index showed more variability than common diversity and Shannon−Wiener indices (Magurran and Pitcher 1987).

The Bray–Curtis similarity index (Figu-

Table 1. Observed bird list and the number of individual of each species during the surveys of each river.

English name*	Species*	Conservation status by IUCN	Protected by Indonesian Law (P.92/2018)	Rivers			
				Somber	Getah	Paka	Wain
Common Iora	*Aegithina tiphia*	LC	N	2	1	3	1
Green Iora	*Aegithina viridissima*	NT	N	2	1	3	2
Asian Glossy Starling	*Aplonis panayensis*	LC	N	0	0	10	0
Purple Heron	*Ardea purpurea*	LC	N	0	3	0	0
Javan Pond-heron	*Ardeola speciosa*	LC	N	0	2	0	0
White-breasted Wood-swallow	*Artamus leucorhynchus*	LC	N	0	1	0	0
Striated Heron	*Butorides striatus*	LC	N	3	3	1	1
Lesser Coucal	*Centropus bengalensis*	LC	N	0	1	0	1
Short-toed Coucal	*Centropus rectunguis*	VU	Y	0	0	2	0
Glossy Swiftlet	*Collocalia esculenta*	LC	N	1	10	0	0
Cave Swiftlet	*Collocalia linchi*	LC	N	3	0	0	0
Large-billed Crow	*Corvus macrorhynchos*	LC	N	3	0	0	0
Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	LC	N	0	1	0	0
Green Imperial-pigeon	*Ducula aenea*	LC	N	0	1	12	7
Zebra Dove	*Geopelia striata*	LC	N	0	0	0	2
Golden-bellied Gerygone	*Gerygone sulphurea*	LC	N	1	4	0	0
Brahminy Kite	*Haliastur indus*	LC	Y	1	8	0	1
Pacific Swallow	*Hirundo tahitica*	LC	N	4	0	0	1
Lesser Adjutant	*Leptoptilos javanicus*	VU	Y	0	10	0	1
Dusky Munia	*Lonchura fuscans*	LC	N	13	0	0	0
Blue-throated Bee-eater	*Merops viridis*	LC	N	0	1	11	22
Copper-throated Sunbird	*Nectarinia calcostetha*	LC	N	0	1	0	0

Whimbrel	*Numenius phaeopus*	LC	Y	0	1	0	0
Common Tailor-bird	*Orthotomus sutorius*	LC	N	0	0	1	2
Rufous-tailed Tai-lorbird	*Orthotomus sericeus*	LC	N	3	0	0	0
Stork-billed King-fisher	*Pelargopsis capensis*	LC	N	1	2	1	0
Sunda Woodpecker	*Picoides moluccensis*	LC	N	1	1	0	1
Black Magpie	*Platysmurus leucopterus*	LC	Y	0	2	0	0
Yellow-vented Bulbul	*Pycnonotus goiavier*	LC	N	0	0	1	0
Pied Fantail	*Rhipidura javanica*	LC	Y	1	0	4	1
Spotted Dove	*Streptopelia chinensis*	LC	N	0	0	1	0
Collared Kingfisher	*Todiramphus chloris*	LC	N	3	7	1	5
Sacred Kingfisher	*Todiramphus sanctus*	LC	N	1	1	0	0
Cinnamon-headed Green Pigeon	*Treron fulvicollis*	NT	N	0	0	20	6
	Total observed species			16	21	14	15
	Total number of indi-vidual			43	62	71	54

*Based on English and species names following MacKinnon *et al.,* (2010), N = No, Y = Yes, LC = Least Concern, NT = Near Threatened, VU = Vulnerable.

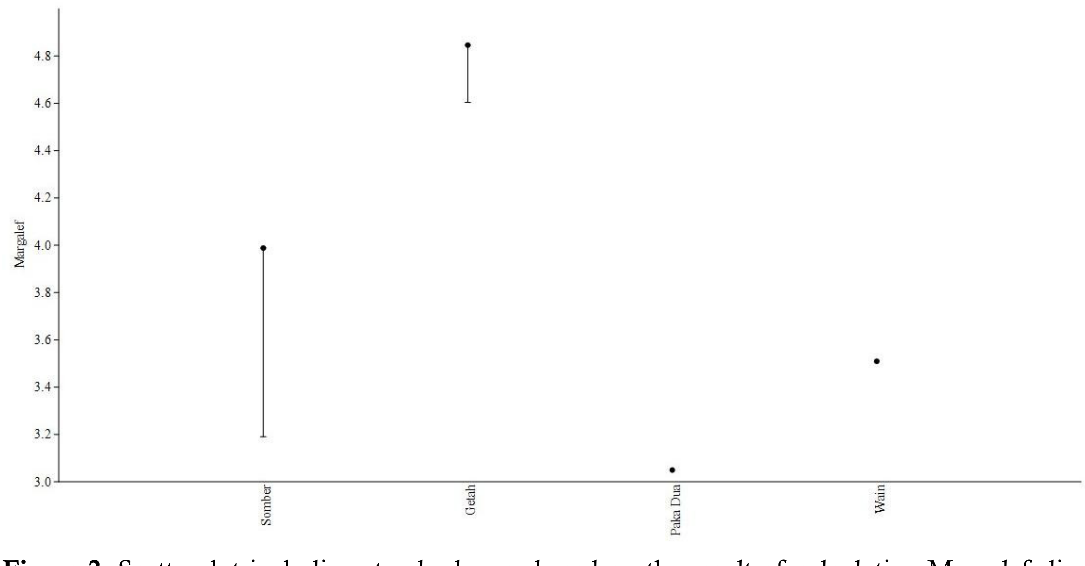

Figure 2. Scatterplot including standard error based on the result of calculating Margalef diversity index

Table 2. The result of calculating Margalef diversity index

	Habitat											
Index	Somber	L*	U**	Getah	L*	U**	Paka Dua	L*	U**	Wain	L*	U**
Diversity (Margalef)	3.988	3.190	3.988	4.846	4.604	4.846	3.050	3.050	3.050	3.510	3.510	3.510

*L** = *Lower* of Standard Error; *U*** = *Upper* of Standard Error re 3) formed two clusters among the four rivers sampled based on the shared species between the rivers. The Paka Dua and Wain rivers created a cluster that had the same higher value than the cluster comprising the Getah and Somber rivers, indicating that the first cluster had similarities in terms of certain habitat components. In fact, we found that empty space was found on the both rivers like Clearcut. Clearcut was found on Paka Dua dan Wain rivers, whilst residual regeneration was found on Getah dan Somber rivers (Figure 3). Clearcut was area covered by dense vegetation but it was cut into open vegetation, while residual regeneration was habitat with some residual trees that regenerate successfully by succession (Hagan *et al.,* 1997).

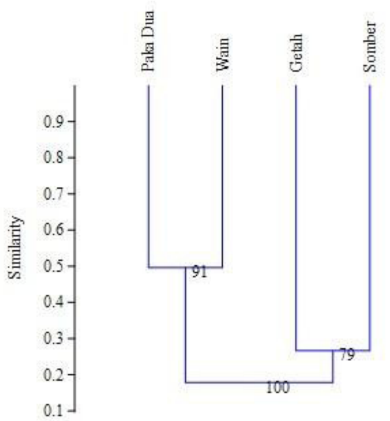

Figure 3. Cluster analysis based on Bray–Curtis similarity index.

Rarefaction (Figure 4) displayed the curves of Paka Dua and Wain which was estimated to be constant. However, the curves of Getah and Somber rivers estimated the increased number of species (Figure 4). Each curve on Wain and Paka Dua rivers looked like earlier turning down the number of taxa approximately 6 to 9 species than remain rivers. This method also showed no crossing over among curves. Hagan *et al.* (1997) reported that clearcut habitats exhibit lowest rarefaction trends and diversity index, whereas residual regeneration habitats produce highest trends and indices.

The low values of similarity index and rarefaction for the Paka Dua and Wain rivers may be attributable to the presence of clearcuts in the mangrove forest, since the canopy of mangrove vegetation provides nesting locations for passerine and non-passerine birds. In addition, the mangrove ecosystem, a coastal wetland, attracts many birds, especially waterbirds (Ogden *et al.,* 2014, Wingard & Lorenz 2014). Kartijono *et al.*, (2010) found that the Collared Kingfisher and Copper-throated Sunbird are species that commonly occur in mangrove forests on Nyamuk Island, while Nisbet (1968) noted the nesting of many species such as Striated Heron, Lesser Adjutant, Copper-throated Sunbird and green pigeons *Treron* sp. on mangrove trees in Peninsular Malaysia. Clearcut in the Paka Dua and Wain rivers might be used for industrial activities and in the plan for expanding the Kariangau industrial zone (Tarigan *et al.*, 2017) into the surrounding area. This expansion due to growing industrial activities causes disturbance to birds living in the both rivers (Machlis & Forester 1996, Fitzherbert *et al.*, 2008).

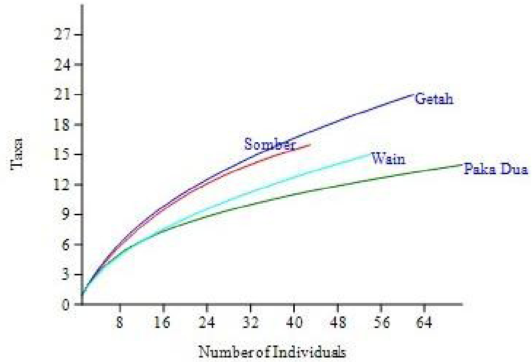

Figure 4. The numbers of species and individual on each river estimated by *Rarefaction*

Table 3. The result of analyzing model by using Fisher log series model

Model Component	Habitat			
	Somber	Getah	Paka Dua	Wain
Log series index (α)	9.229	11.170	5.221	6.879
x value	0.823	0.847	0.932	0.887

Based on species rank abundance, the Getah river exhibited the highest species abundance with an α-value of approximately 11.170, followed by Somber (α = 9.229), Wain (α = 6.879) and Paka Dua (α = 5.221). Despite of cautiousness to the Margalef diversity index (Gamito 2010), log α (Table 3) exhibited a significant correlation with the Margalef diversity index (Table 2), indicating that log α can be used to determine diversity index in certain cases (Magurran 2004). The Friedman test revealed no significant difference in terms of species density between Somber and Getah (F = 1.348, $p > 0.05$) and between Paka Dua and Wain (F = 1.251, $p > 0.05$), suggesting that Somber and Getah as well as Paka Dua and Wain have similar species abundance distribution patterns. Magurran (1988) and Putman (1994) agreed that the Fisher's log series model reflects

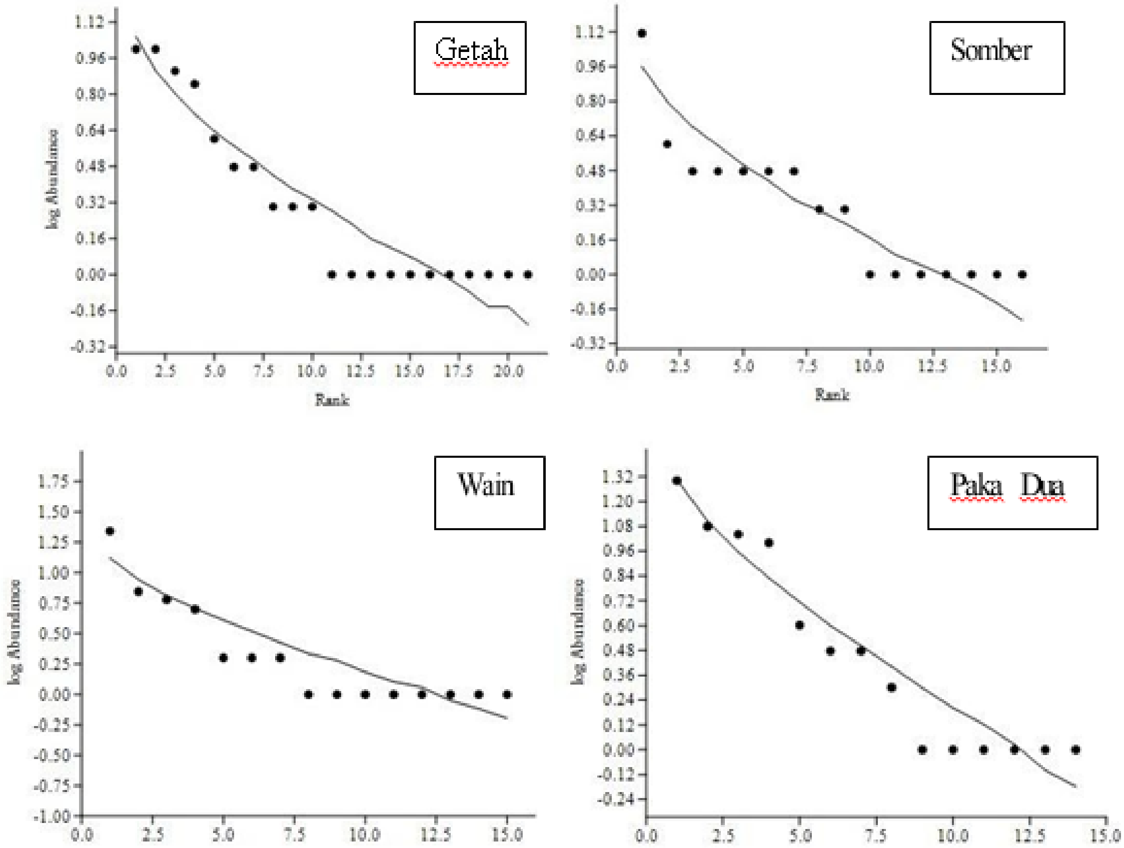

Figure 5. Modelling approach by using Fisher log series model (α) to the rivers

Table 4. Non-parametric test for species density of each river

Result from non-parametric test	First Samples–Second Samples					
	Somber–Getah	Somber–Paka Dua	Somber–Wain	Getah–Paka Dua	Getah–Wain	Paka Dua–Wain
F value	1.348	3.466	2.771	2.572	2.056	1.251
p value	0.397*	0.001	0.004	0.008	0.042	0.524*

*p > 0.05 means no significant difference

a more simple community determined by some factors. Instead of industrial activity, traffic was a factor affecting species diversity in the rivers.

Paka Dua and Wain rivers were both heavily used, and showed heavy river traffic when we were conducting our surveys, with numerous barges docked or passing through mangroves. While we conduct the birds as the object, this research also surveyed the Proboscis Monkey in Balikpapan Bay so that research team had to manage time for both object and also helped to survey the Proboscis Monkey to the where we found the monkey. This boat traffic might affect to the presence of the birds, possibly preventing humans and birds from migrating to other rivers (Perry & Deller 1996, Quan *et al.,* 2002). The species abundance distribution provides a useful indication of the level of disturbance on the species assemblages of each rivers (Hill *et al.* 1995, Hammer *et al.,* 1997). The result of this research could inform the presence of birds in Balikpapan Bay which was not recorded, discussed, and published yet in any scientific forum held by ornithologists. However, further research about monitoring the bird communities regularly based on this first published database might be useful for coastal zone management of Balikpapan Bay, involving stakeholders, local people, and government.

CONCLUSION

In the industrial zone of Balikpapan City, Getah river has the highest diversity index and species abundance distribution among all rivers such as Somber, Wain, and Paka Dua rivers. In contrast, Paka Dua river become a river with the lowest for both indices. However, Paka Dua river has higher similarity with Wain river than a cluster that consists of Getah and Somber rivers. Further research focused specifically on birds is needed, in order to reduce bias and give the better accuracy and precision than this study, which was primarily designed to survey primates. Monitoring bird species intensively is also required to be implemented because there were protected birds on the bird list, for example Lesser Adjutant. This recommendation could form a base research for the development of further research on the coastal ecosystem of Balikpapan Bay to obtain the better result as it included the unreported areas of Balikpapan Bay.

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