

Riparian tree and bird diversity in Cisadane River, South Tangerang City, Indonesia

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Manuscript received: 1 November 2018. Revision accepted: 31 January 2019.

Abstract. Izzati U, Hasibuan HS. 2019. Riparian tree and bird diversity in Cisadane River, South Tangerang City, Indonesia. *Biodiversitas* 20: 595-603. Riparian is a riverbank area that has unique characteristics. It is a combination of terrestrial with aquatic habitats so that riparian ecosystems have high biodiversity values. Riparian is included in a protected area that is naturally designated for vegetation, but in reality, riparian areas, especially in urban areas, have a lot of conversion of land functions by humans so that it can disrupt diversity of tree and bird species. This study aims to identify the diversity of tree and bird species and the correlation between the two. Riparian length of Cisadane River, South Tangerang City is 20.15 km. The method used was plot line with size of 20 m x 20 m for tree data and line transect for bird data by systematic sampling with a random start then analyzed using Shannon Wiener index. The results obtained were found 22 tree species included in 11 families with species diversity index (H') of 2.707 and 40 bird species belonging to 25 families with species diversity index (H') of 2.794. The diversity of tree and bird species is classified as medium. The results of the analysis using the Pearson correlation between the diversity of tree with bird species obtained that there was no relationship between the two. Based on these results, riparian zones in urban areas need to be maintained and improved in quality so that the diversity of tree and bird species increases so as to create a stable ecosystem.

Keywords: Bird, Cisadane, diversity, tree, riparian

INTRODUCTION

A riparian zone is defined as an interface between land and river or stream (Fu et al. 2016). This zone is usually called river bank. Riparian zones are integral and important components of watersheds throughout the world. While they make up only a small percentage of the total land area, their hydrological and ecological functions must be considered in watershed management (Brooks et al. 2003). One of the ecological functions of riparian zones is to conserve biodiversity (Décamps et al. 2009).

The riparian zones have high value in terms of diversity because they share features with both adjacent upland and aquatic ecosystems (Brooks et al. 2003; Hawes and Smith 2005; Frazier 2006). The riparian zones with its vegetation component is a complex ecosystem that has a vital role in aquatic and terrestrial ecosystem habitats (Hawes and Smith 2005; Clinton 2011). The riparian zone also functions as a corridor that connects separate forests for habitat and movement of terrestrial wildlife (Ramos and Anjos 2014; Miller et al. 2015). Nonetheless, riparian zones have not fared well during the process of urban development (Brooks et al. 2003).

Along with urban development, the pressure of conversion of riparian land in urban areas is getting higher. There has been a decline in riparian vegetation and an increase in built and agricultural land (Fu et al. 2016). Changes in riparian land use due to human pressure can disrupt the diversity of flora and fauna (Semiun et al. 2013;

DeCecco and Brittingham 2016). One of the fauna found in riparian ecosystems is birds.

Birds are common fauna in residential areas, such as in urban areas (Endhlicher et al. 2011). Birds are component of the ecosystem that has an important role, including controlling insect populations, helping with pollination of flowers and seed dispersal, as well as helping forest regeneration process, including in urban areas (Hadinoto et al. 2012). Birds are one of the environmental bio-indicators because they have a high sensitivity to environmental changes (Krisanti et al. 2017). The conversion of riparian green areas can reduce the diversity of tree and bird species. The diversity of tree supports the diversity of bird species (Fithri 2012; Ridwan et al. 2015), and there is a positive correlation between the two (Setiawan et al. 2006; Hadinoto et al. 2012, Fadrikal et al. 2015). The older tree stand, the more birds that use the stand (Soendjoto et al. 2018). The more diverse plant species and bird species in an area, the better quality of the environment (Ridwan et al. 2015). Therefore, it is necessary to identify existing conditions of riparian tree and bird species diversity to support riparian management in urban areas that are environmentally and pay attention to urban biodiversity conservation.

South Tangerang City is one of suburban that supported the capital city of Jakarta which has been driven by rapid development due to high urbanization (Winarso 2015). Urbanization is one of the important factors related to urban biodiversity. Urbanization has probably caused the

local extinction of thousands of species, and many non-native plants and animals are introduced (Parris 2016). The Cisadane River is the main river of Cisadane watershed. Based on The Directorate General's Strategic Plan for Watershed Control and Protected Forests in 2015-2019, Ministry of Environment and Forestry, The Cisadane watershed is one of 15 watersheds classified as a priority watershed in Indonesia. Therefore, conservation of the riparian ecosystem as one of the important parts of the watershed needs to be considered. Currently, South Tangerang City does not yet have biodiversity data for riparian ecosystem such as the diversity of riparian tree and bird species in Cisadane riparian, even though the availability of such data is needed as a basis to support riparian ecosystem and urban biodiversity conservation. This study aims to identify the diversity of riparian tree and bird species in Cisadane River, South Tangerang City and the correlation between the two. The expected benefits of this research are as a source of information about the diversity of riparian tree and bird species in Cisadane River, South Tangerang City to support conservation of riparian zones and urban biodiversity, as well as the basis for managing riparian zones in urban areas.

MATERIALS AND METHODS

Study area

This study was conducted in January until March 2017 with the survey location in the Cisadane River segment of South Tangerang City, Banten Province, Indonesia with a length of 20.15 km and a riparian width of 30 m (Figure 1). The area crossed by the Cisadane River in South Tangerang City is the riparian segment of the Setu, Serpong, and North Serpong Rivers.

Procedures

Tree samplings were done within plot line with size of 20 m x 20 m as many as 50 plots, following bird transect line with 200 m inter plot. Trees are woody plants with a stem diameter >20 cm (Kusmana 1997). The data recorded were species and number of trees. In supporting analysis data for bird habitat both in the sampling plot and along the transect line tracing, we observed the riparian land uses (agriculture, built-up land, shrubs), another types of vegetation (bamboo, banana, agricultural vegetation), and another fauna exist in the study area.



Figure 1. Study area, segment of Cisadane River of South Tangerang City, Banten, Indonesia, along 20.15 km starting from A point (106°39'6.11"BT, 6°21'45.62"LS) until B point (106°38'20.26"BT, 6°13'49.45"LS) with width of riparian 30 m.

Birds were observed within line transect method with a length of 10 km (Bibby et al. 2000). Line transect was divided into 10 segments (each segment length is 1 km). The transect segments were determined by systematic sampling with random start, by choosing the starting point of line transect segment randomly and then systematically spacing the segment as far as 1000 m. Each transect segment is located in the riparian area which is parallel to river direction. The bird observation was done using the direct watching method and walking continuously on a relatively stable pace which was performed every morning (06.00-10.00) and evening (16.00-18.00). Identification of the birds is only on birds found, not through sound to avoid biased data. The bird data have been recorded to calculate bird diversity is species and number of birds.

Data analysis

The initial step of the analysis is to categorize the data of trees and birds that have been collected. First categorization based on their conservation status. The conservation of flora and fauna in Indonesia is regulated in the Minister of Environment and Forestry Regulation Number 92 of 2018 concerning Amendment to the Regulation of the Minister of Environment and Forestry Number 20 of 2018 about Protected Flora and Fauna Species. The conservation status of flora and fauna internationally are International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species which regulates the threat status and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices which regulates the trade protection status. The next categorization for bird data is feeding guild that refers to MacKinnon (2010), while tree data is the utility based on literature.

Next step of the analysis is the diversity index. The index calculation was counted by pooling all the data for transects and sampling plots in every riparian segment (Setu, Serpong, and North Serpong) and for South Tangerang City calculation by pooling all the data. Tree and bird species diversity indices were analyzed using the following Shannon Wiener (H') index (Magurran 1988) with criteria as in Table 1.

$$H' = -\sum \{p_i \ln p_i\}$$

Where:

H' : Shannon Wiener Diversity Index

p_i : N_i/N

N_i : number of individual species i

N : total number of individual of all bird species

Table 1. Criteria of Shannon Wiener Index

H' Value	Category
Less than 1.5	Low
1.5-3.5	Medium
More than 3.5	High

Correlation analysis between the tree and bird species diversity used Pearson correlation. This analysis tool is used to find the relationship of independent variables (X) with dependent variables (Y), for ratios data (Siregar 2014). This analysis tool was used after normality, linearity, and homoscedasticity tests were carried out. Normality test using Kolmogorov-Smirnov technique with a significance level of 0.05. The independent variables (X) in this study was the tree species diversity and the dependent variable (Y) was the bird species diversity. The hypothesis of this study was:

H_0 : There is no relationship between tree and bird species diversity

H_a : There is relationship between tree and bird species diversity

Significance level used was 0.01 with following formula (Siregar 2014):

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

RESULTS AND DISCUSSION

Tree species diversity

The results of vegetation analysis in riparian of Cisadane River found 22 species of trees which are included in 11 families (Table 2). Based on its utility, 72.72% are species that can be used for leaves, fruits, and nectar, while 27.27% are species that can be used for woods. Some trees found on riparian of Cisadane River are presented in Figure 2.

At sampling sites, other vegetation cover found beside trees are grasses, shrubs, banana plants, bamboo clumps, agricultural land that planted with peanuts, cassava, and rice. This diverse vegetation condition can provide various types of feed for birds such as grains and insects. In addition to vegetation cover, also found the land-built area in this riparian. This condition can interfere with bird existence in this area.

Bird species diversity

The results of bird analysis found 40 species of birds which are included in 25 families (Table 3). Based on the feeding guild, birds in this area are dominated by insectivorous as many as 16 species (40%), carnivorous and insectivorous-carnivorous as many as 10 species (25%), granivorous as many as 7 species (17.5 %), frugivorous-insectivorous are 4 species (10%), and the remaining 3 species (7.5%) are nectarivorous, granivorous-frugivorous, and insectivorous-granivorous. Some birds found on riparian Cisadane River are presented in Figure 3.

The correlation between tree and bird diversity

Trees in the riparian zone have a function as a provider of bird habitat that is as a provider of feed, shelter, perch, or breeding for birds. The value of diversity of tree and bird species in several locations in the riparian of the Cisadane River in South Tangerang City is presented in Table 4.

Table 2. List of trees species, individual amount, and utility

Species	Local name	Family	Ind. amount	Conservation status			Utility
				Permenlhk 92/2018	IUCN	CITES	
<i>Abroma augustum</i> (L.) L.f.	Kapas hantu	Malvaceae	7	NP	-	-	Leaf
<i>Anthocephalus cadamba</i> Miq.	Jabon	Rubiaceae	1	NP	-	-	Wood
<i>Arthocarpus heterophyllus</i> Lam.	Nangka	Moraceae	4	NP	-	-	Fruit
<i>Artocarpus altilis</i> (Park.) Fosberg	Sukun	Moraceae	5	NP	-	-	Fruit
<i>Cecropia peltata</i> L.	Ki kopong	Urticaceae	1	NP	-	-	Leaf, Wood
<i>Ceiba pentandra</i> (L.) Gaertn.	Kapuk randu	Bombacaceae	3	NP	LC	-	Fruit
<i>Dimocarpus longan</i> Lour.	Lengkeng	Sapindaceae	1	NP	NT	-	Fruit
<i>Dysoxylum gaudichaudianum</i> (Juss.) Miq.	Kedoya	Meliaceae	6	NP	-	-	Fruit
<i>Enterolobium cyclocarpum</i> (Jacq.) Griseb.	Sengon buto	Fabaceae	4	NP	-	-	Leaf
<i>Ficus callosa</i> Willd.	Ilat-ilatan	Moraceae	2	NP	-	-	Fruit, Leaf
<i>Ficus septica</i> Burm. F.	Awar-awar	Moraceae	8	NP	-	-	Fruit, Leaf
<i>Leucaena leucocephala</i> (Lam.) de Wit.	Lamtoro	Fabaceae	7	NP	-	-	Wood
<i>Mangifera indica</i> L.	Mangga	Anacardiaceae	5	NP	DD	-	Fruit
<i>Paraserianthes falcataria</i> (L.) Nielsen	Sengon	Fabaceae	24	NP	-	-	Wood
<i>Parkia speciosa</i> Hassk.	Petai	Fabaceae	1	NP	-	-	Fruit
<i>Phyllanthus acidus</i> (L.) Skeels	Cermai	Phyllanthaceae	3	NP	-	-	Fruit
<i>Pterocarpus indicus</i> Willd.	Angsana	Fabaceae	3	NP	EN	-	Fruit, Wood
<i>Samanea saman</i> (Jacq.) Merr.	Ki hujan	Fabaceae	4	NP	-	-	Fruit, Nectar
<i>Swietenia mahagoni</i> (L.) Jacq.	Mahoni	Meliaceae	1	NP	EN	App. II	Wood
<i>Syzygium malaccense</i> (L.) Merr & Perry	Jambu bol	Myrtaceae	5	NP	LC	-	Fruit
<i>Syzygium polyanthum</i> (Wight) Walp.	Salam	Myrtaceae	1	NP	-	-	Fruit, Leaf
<i>Tectona grandis</i> L.f.	Jati	Verbenaceae	13	NP	-	-	Wood

Note: Permenlhk = Minister of Environment and Forestry Regulation, NP = non protected, P = protected, LC = least concern, NT = near threatened, DD = data deficient, LC = least concern, EN = Endangered, App. = Appendix

Based on field observations, there are differences in each riparian segment of Cisadane River. In the Setu segment, the most commonly found land use is shrubs and agricultural land compared to other segments. As for the Serpong segment, trees are found more than the Setu segment, although fewer than the North Serpong segment. While the North Serpong segment which is most commonly found are trees and built-land area compared to other segments.

The correlation between the diversity of tree and bird species in Cisadane River, South Tangerang City is determined by the correlation coefficient. Calculation of correlation with tree species diversity index as X variable and bird species diversity as Y variable as follows:

$$r = \frac{4(23.906) - (8.782)(10.869)}{\sqrt{[4(19.697) - (8.782^2)][4(29.452) - (10.869^2)]}}$$

Where:

r : 0.678

R² : 0.460

p-value : 0.324 (Sig. 0.01)

Coefficient of determination (R²) which is used to analyze the effect of tree species diversity on bird species diversity in riparian of Cisadane River, South Tangerang City is quite small, only 46%. It means 54% is determined

by other factors. Even the correlation coefficients (r) that used to analyze the direction and strength of relationships between variables is slightly strong, with the ratio 0.678, the correlation is not significant. This result is supported by the p-value > 0.01 that is equal to 0.324. The results of the comparison between p-value and α , obtained by p-value = 0.324 > α = 0.01, so that Ho is accepted, i.e. there is no relationship between diversity of tree species and diversity of bird species.

Discussion

Tree species diversity

The functions of riparian vegetation include regulating microclimate, providing habitat for animals, stabilizing river cliffs, holding and filtering sediments, and providing organic material (Bongard and Wyatt 2010; NRCS 2011). Riparian vegetation consists of the trees, shrubs, and grasses (Brooks et al. 2003). Trees are vegetation types that have high effectiveness for providing wildlife forest habitat and stabilizing bank erosion compared to vegetation types of grasses and shrubs (Bongard and Wyatt 2010). Trees are a very important habitat for birds, 86% of birds found in activities in trees (Ridwan et al. 2015), 52.94% birds used a canopy and sub-canopy strata (Partasasmita et al. 2017). Therefore, the presence of trees in the riparian area is important in carrying out its eco-hydrological function.

Table 3. List of bird diversity, conservation status, and feeding guild

Species	Local name	Family	Ind. amount	Conservation status			Feeding Guild
				Permenlhk 92/2018	IUCN	CITES	
<i>Aegithina tiphia</i>	Cipoh kacat	Aegithinidae	4	NP	LC	-	I
<i>Amauromis phoenicurus</i>	Kareo padi	Rallidae	7	NP	LC	-	C
<i>Apus affinis</i>	Kapinis rumah	Apodidae	2	NP	LC	-	I
<i>Artamus leucorhynchus</i>	Kekep babi	Artamidae	23	NP	LC	-	I
<i>Cacomantis merulinus</i>	Wiwik kelabu	Cuculidae	4	NP	LC	-	I
<i>Centropus sinensis</i>	Bubut besar	Cuculidae	22	NP	LC	-	I, C
<i>Collocalia esculenta</i>	Walet	Apodidae	144	NP	LC	-	I
<i>Coturnix chinensis</i>	Puyuh batu	Phasianidae	41	NP	LC	-	I, G
<i>Cyornis unicolor</i>	Sikatan biru muda	Muscicapidae	1	NP	LC	-	I
<i>Delichon dasypus</i>	Layang-layang rumah	Hirundinidae	3	NP	LC	-	I
<i>Dendrocopos moluccensis</i>	Caladi tilik	Picidae	9	NP	LC	-	I
<i>Dendrocopos canicapillus</i>	Caladi ulam	Picidae	2	NP	LC	-	I
<i>Dicaeum trochileum</i>	Cabai jawa	Dicaeidae	30	NP	LC	-	G, F
<i>Halcyon cyanoventris</i>	Cekakak jawa	Alcedinidae	6	NP	LC	-	I, C
<i>Halcyon pileata</i>	Cekakak cina	Alcedinidae	1	NP	LC	-	I, C
<i>Hirundo striolata</i>	Layang-layang loreng	Hirundinidae	2	NP	LC	-	I
<i>Hirundo tahitica</i>	Layang-layang batu	Hirundinidae	4	NP	LC	-	I
<i>Ixobrychus cinnamomeus</i>	Bambangan merah	Ardeidae	1	NP	LC	-	C
<i>Lanius schach</i>	Bentet kelabu	Laniidae	2	NP	LC	-	F, I
<i>Lonchura leucogastroides</i>	Bondol Jawa	Estrildidae	128	NP	LC	-	G
<i>Lonchura punctulata</i>	Bondol peking	Estrildidae	143	NP	LC	-	G
<i>Lonchura maja</i>	Bondol haji	Estrildidae	77	NP	LC	-	G
<i>Muscicapa griseisticta</i>	Sikatan sisi gelap	Muscicapidae	1	NP	LC	-	I
<i>Nectarina jugularis</i>	Madu sriganti	Nectariniidae	4	NP	LC	-	N
<i>Nycticorax caledonicus</i>	Kowak malam merah	Ardeidae	1	P	LC	-	C
<i>Nycticorax nycticorax</i>	Kowak malam kelabu	Ardeidae	3	NP	LC	-	C
<i>Oriolus chinensis</i>	Kepudang kuduk hitam	Oriolidae	1	NP	LC	-	F, I
<i>Orthotomus sepium</i>	Cinenen jawa	Sylviidae	2	NP	LC	-	I
<i>Orthotomus sutorius</i>	Cinenen pisang	Sylviidae	50	NP	LC	-	I
<i>Otus angelinae</i>	Celepuk jawa	Strigidae	1	P	VU	App. II	C
<i>Passer montanus</i>	Gereja erasia	Passeridae	77	NP	LC	-	G
<i>Prinia familiaris</i>	Perenjak jawa	Cisticolidae	30	NP	LC	-	I
<i>Psittacula alexandri</i>	Betet biasa	Psittacidae	5	P	NT	App. II	G
<i>Pycnonotus aurigaster</i>	Cucak kutilang	Pycnonotidae	125	NP	LC	-	F, I
<i>Pycnonotus goiavier</i>	Merbah cerukcuk	Pycnonotidae	116	NP	LC	-	F, I
<i>Rhipidura javanica</i>	Kipasan belang	Rhipiduridae	4	P	LC	-	I
<i>Streptopelia bitoquata</i>	Dederuk jawa	Columbidae	2	NP	LC	-	G
<i>Streptopelia chinensis</i>	Tekukur biasa	Columbidae	80	NP	LC	-	G
<i>Todirhamphus chloris</i>	Cekakak sungai	Alcedinidae	42	NP	LC	-	I, C
<i>Tringa hypoleucos</i>	Trinil pantai	Scolopacidae	2	NP	LC	-	I, C

Note: Permenlhk = Minister of Environment and Forestry Regulation, NP = non protected, P = protected, LC = least concern, NT = near threatened, VU = vulnerable, I = insectivorous, G = granivorous, F = frugivorous, C = carnivorous, N= nectarivorous, App. = Appendix

Table 4. Trees and birds diversity index in riparian of Cisadane river South Tangerang City

No.	Riparian segment of Cisadane River	Diversity index (H')	
		Trees	Birds
1	Setu	1.903	2.700
2	Serpong	1.938	2.716
3	North Serpong	2.235	2.660
4	South Tangerang City	2.707	2.794

This study (Table 2) showed that 27.27% of tree species found which the utility is from its wood. The most common species are *Paraserianthes falcataria* (L.) Nielsen and *Tectona grandis* L.f. Both are types of trees whose wood is harvested because of their high economic value. In contrary, the riparian tree species must be a type of tree that can be used for leaves, flowers, seeds, or fruits, not the

ones used by the wood. The tree species (Table 2) that suits the riparian zone are from *Syzygium* sp. and *Ficus* sp. The *Syzygium* have an important role in the stabilization of the region along the banks of the river. This is mainly due to the nature and character of roots that can withstand the river flow, as well as hold up or slows down the rate of river flow and prevent erosion of the banks of the river (Mudiana 2016). The *Ficus* are prominent components of riparian zones where they may also contribute to bank stability and ecologically significant keystone species because they sustain populations of the many seed-dispersing animals that feed on their fruits (Pothasin et al. 2014). The existence of trees is a prominent element to support hydrological function.

The existence of trees in riparian must also support the bird habitat. The presence of an animal in a place depends

on the availability of food sources and suitable habitat conditions (Warsito and Bismark 2009, Lala et al. 2013, Putri 2015). Diversity and richness of bird feed producing vegetation species greatly influence the diversity of bird species (Setiawan et al. 2006, Fithri 2012, Hadinoto et al. 2012, Putri 2015, Ridwan et al. 2015, Saini et al. 2017). The tree species found (Table 2) that can provide feed for birds are *Dysoxylum gaudichaudianum* (Juss.) Miq., *Mangifera indica* L., *Parkia speciosa* Hassk., *Pterocarpus indicus* Willd., *Samanea saman* (Jacq.) Merr., *Ficus* sp. and *Syzygium* sp. (Putri 2015, Nugroho 2015, Ridwan et al. 2015, Fadrikal et al. 2015). This tree species found is relatively small in number, so it needs to be increased.

The composition of trees affects 90.4% of the bird species diversity index (Kuswanda 2010). Tree diversity is

more important than the size of the area in influencing bird diversity (Fadrikal et al. 2015). The increasing proportion of native tree species and density of large and medium trees could increase the richness of birds (Threfall et al. 2016). Based on comparison between alternative trees for riverbank green open space that refer to Minister of Public Works Regulation Number 5 of 2008 concerning Guidelines for Provision and Utilization of Green Open Space in Urban Areas with native species and suitable in South Tangerang City that refer to Samsuedin and Waryono (2010), other species that can be planted to increase the number of tree species and to invite birds in this riparian area are *Spatodea campanulata* P. Beauv., *Erythrina variegata* L., *Antidesma bunius* (L.) Spreng., *Ficus racemosa* L., and *Sterculia foetida* L.



Figure 2. A. *Enterolobium cyclocarpum* (Jacq.) Griseb., B. *Paraserianthes falcataria* (L.) Nielsen



Figure 3. A. *Lonchura leucogastroides* classified as granivorous, B. *Todirhamphus chloris* classified as insectivorous-carnivorous, C. *Nectarina jugularis* classified as nectarivorous.

Bird species diversity

The existence of birds in the riparian of Cisadane River, South Tangerang City is still relatively large, with 40 species, even there still 10% or 4 protected species of birds (nationally and internationally) (Table 3). All four are protected by Minister of Environment and Forestry Regulation Number 92 of 2018 concerning Amendment to the Regulation of the Minister of Environment and Forestry Number 20 of 2018 about Protected Flora and Fauna Species. These birds are *Nycticorax caledonicus* from Ardeidae family, *Psittacula alexandri* from Psittacidae family, *Rhipidura javanica* from Rhipiduridae family, and *Otus angelinae* from Strigidae family. As for the status of the IUCN, *Psittacula alexandri* is classified as near threatened and *Otus angelinae* is classified as a more threatened status, namely vulnerable and according to CITES protection status, the two species are classified as Appendix II, which is a list that is not endangered, but if the trade continues without any regulation, it might turn out to be threatened.

Psittacula alexandri was common in Java and Bali, but now the number is reduced because it is traded for pets, and now only in more remote forest areas, except for large wild colonies around Ragunan zoo (MacKinnon et al. 2010). *Otus angelinae*, endemic birds in Java, are known from various places in Java, recorded on Mount Salak, Mount Pangrango, Mount Tangkuban Perahu, Mount Ciremai, and the highlands of Ijen (MacKinnon et al. 2010). The discovery of *O. angelinae* in this riparian is a good indication, that the Cisadane riparian function as an animal corridor is still relatively good. MacKinnon et al. (2010) stated that recently *O. angelinae* was only found in Gede Pangrango and Halimun Salak National Park. Gede Pangrango National Park is located in the upstream of Cisadane watershed. So, this condition showed that this riparian serves as a corridor for bird movement between upstream and downstream. The many protected species found on the riparian of the Cisadane River located in urban areas also indicate that this riparian zone has high conservation value. This riparian zone is also still able to provide habitat for other animals, which is indicated by the discovery of weasels (order of Carnivora) and squirrels (order of Scandentia) during field observations. There are many animal species that permanently colonize riparian wetlands, especially anurans, snakes, turtles, raccoons, otters, and many smaller mammals, like muskrats, voles, and shrews (Wantzen and Junk 2008). Therefore it must be maintained and needs to be considered during the urban development process.

This study (Table 3) found that the most dominant is insectivorous birds (40%). This showed that the insects in riparian are abundant. The insects can be found at trees, shrubs, grasses, or rice field. Insects that are most preferred by insectivorous bird are found in leaves of rice, grasses, legumes, acacia, and teak (Lala et al. 2013). Further stated that insectivorous birds are generally found on the strata between shrubs and trees. The second most dominant is carnivorous and insectivorous-carnivorous bird (25%). This bird species showed the uniqueness of riparian habitat because this bird species will rarely be found in habitats that do not have water areas. The carnivorous birds found

in wetlands by Nababan et al. (2015), but not found in the urban forest by Endah and Partasasmita (2015) are *Ixobrychus cinnamomeus*, *Todirhamphus chloris*, *Amauornis phoenicurus*, and *Nycticorax caledonicus*. Other bird species found are granivorous, frugivorous, and nectarivorous birds which are less numerous than insectivorous and carnivorous. The granivorous bird can find its feed in rice fields and grasses, while frugivorous and nectarivorous birds can obtain feed from trees.

The correlation between tree and bird diversity

The coefficient of determination (R^2) from the results of correlation analysis between tree and bird species diversity in riparian of Cisadane River showed that 46% of the tree species diversity affects the bird species diversity on the riparian. It means 54% of the riparian bird species diversity is influenced by other factors. In the North Serpong segment, the tree diversity index value is highest, but the bird index is the smallest. This is because most of the built-up land found in this segment. The existence of this built-up land can disrupt the existence of birds. McClure et al. (2015) stated that species richness was negatively related to the amount of surface within 100 m of a survey with richness declining by more than two species for every hectare of paved surface. As for the Setu segment, even though the tree diversity index is the smallest, the bird diversity index is also classified as medium. This condition is caused by a large amount of agricultural land and shrubs found in this segment which is also still able to provide feed for birds. The existence of understorey also influenced bird species diversity (Threlfall et al. 2016). Based on field observation in Cisadane riparian, the various riparian land uses in this area consist of agriculture, rice fields, grasses, and shrubs. Those various land uses can provide various kinds of food for birds such as grains and insects. In addition, the presence of river water can also affect the availability of other feed such as fish, water insect, frogs, and mollusca. Many birds profit by the rich food offered from the aquatic habitats (Wantzen and Junk 2008). This kind of feed is for carnivorous birds. Riparian habitat is a unique habitat, it is the meeting between terrestrial and aquatic habitats so that bird species diversity is not only affected by trees but other land uses and also river waters. This study showed that the availability of bird feed is influenced by the riparian land use and river water bodies.

Based on the results of correlation analysis, the tree and bird species diversity in the riparian of Cisadane River slightly strong but not significant, so there was no correlation between the two. This result is different from Setiawan et al. (2006) and Hadinoto et al. (2012). This is because the bird species found not only those that get food from trees (frugivorous, nectarivorous, insectivorous) but also found carnivorous species that eat fish, water insects, frogs, small snakes, small mice, mollusca. Insects are not only found in trees, but can also be found in shrubs, rice field, and grasses. The relationship of birds to feeding guild on the Cisadane River in South Tangerang City, based on interaction cycle analysis between birds and feeds availability that found in this study, is illustrated by food web as in Figure 4.

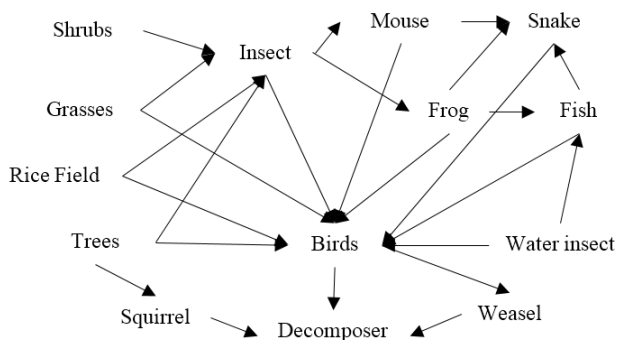


Figure 4. Food web in riparian of Cisadane River, South Tangerang City, Banten Province, Indonesia

Birds found on the riparian of Cisadane River have many alternative feed sources when viewed from existing food webs (Figure 4). The bird composition with feed source other than trees is relatively large, 40% insectivorous and 25% carnivorous and carnivorous-insectivorous. Based on Figure 4 the insects for insectivorous birds not only could be found in trees but also could be obtained from other riparian land use (shrubs, grasses, rice field), while feed for carnivorous birds obtained from river water such as fish, mouse (order of Rodentia), frogs (order of Anura), water insects (order of Hemiptera), and snakes (order of Squamata). This abundant availability of food causes many insectivorous and carnivorous birds to be found in this riparian. An increase in frugivorous and nectarivorous birds are needed because it is found in relatively small amounts. This increase in the number of this bird species can be done by planting bird-producing trees. The availability of feed greatly influences the presence (number of individuals and number of species) of frugivorous and nectarivorous birds (Putri 2015).

Planting trees with various species and strata in the riparian area of Cisadane River in South Tangerang City is one of vegetative riparian restoration. Riparian areas are naturally reserved for vegetation for river and watershed protection. Riparian and river flow from upstream to downstream are integral watershed ecosystems. Decreasing quality of riparian vegetation can disrupt riparian ecosystems, including birds and watershed eco-drainage as a whole. Therefore, even though a small part of the watershed, the ecological and hydrological functions of this riparian vegetation are important to be considered in watershed management. This riparian vegetation restoration is needed to maintain the existence of vegetation on the riparian and its eco-hydrological function.

The conclusion of this study is the diversity of tree and bird species in riparian of the Cisadane River, South Tangerang City is classified as medium. The results of the correlation analysis obtained that there was no relationship between the two. Birds found have complex food webs. The birds are not only dependent on trees but also on other riparian land uses and river waters. The availability of bird feed in riparian is unique, a combination of terrestrial and aquatic habitat. However, the presence of trees in riparian

rivers is a necessity to support riparian eco-hydrological functions. Therefore, the condition of trees and other vegetation riparian in the Cisadane River, South Tangerang City must be maintained to support urban biodiversity conservation and need to be improved to increase the stability of riparian ecosystems.

ACKNOWLEDGEMENTS

The author would like to thank the School of Environmental Science, Universitas Indonesia, Jakarta that have funded this publication of research. We also thanks to the Ministry of Environment and Forestry from supporting this research. And to South Tangerang City Environmental Service which has given permission to conduct research on the Cisadane River in South Tangerang City, Indonesia.

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