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A Mardiastuti[1]*, Y A Mulyani[2], D Rinaldi[3], W Rumblat[4], L K Dewi[5], A Kaban[6] and H Sastranegara[7]

[1,2,3]Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University (IPB University), Bogor, Indonesia
[4]Department of Biology, UIN Syarif Hidayatullah Jakarta
[5]Nurul Fikri Boarding School, Lembang
[6]PT Sinar Mas Agro Resources & Technology Tbk.
[7]Independent Consultant, Bogor

*Corresponding author: mardiastuti_ani@ipb.ac.id

Abstract. The objective of this study is to reveal birds found in Greater Jakarta Area, and categorize the bird based on the probability of encounter, namely urban exploiters, adapters, and avoiders. Bird list of 36 sites in Greater Jakarta Area collected by other workers in the last seven years were used as the basis of determination. Percentiles were used as cut off points for each category. Of the 243 bird species found the study area, there were 8 species categorized as urban exploiters and the 3 highest ranks were the Sooty-headed Bulbul, Cave Swiftlets and Eurasian Tree Sparrow. Forty-nine bird species were categorized as urban adapters. The rest of species, which constitute a big portion of the species spotted in the Greater Jakarta (186 species, 76.5%) were categorized into urban avoiders. The nocturnal species was represented only by Black-crowned Night-heron. The presence of species exploiters and adapters showed that (a) Greater Jakarta Area still have sufficient green open spaces, including significant numbers of mature and decayed trees; (b) there were still good quality of small rivers, creeks, and swampy area; (c) small mammals were sufficient to support small raptors, and (d) bird community was quite rich to perform brood parasitism habit.
Keywords: Metropolitan area, Sooty-headed Bulbul, urban adapters, urban area, urban exploiters

1. Introduction

The increasing tendency for birds (and also mammals) to colonize cities phenomenon created a new term: synurbization. Synurbization has been defined as an adjustment of animal populations to specific conditions of the urban environment [1]. Synurbization is related to synanthropization, which refers to the adaptation of animal populations to human-created (anthropogenic) conditions.

Urbanization (i.e. changes in landscape or environment caused by urban development) has been presumed to be responsible for decreasing species richness and diversity, and favoring dominance by a few species. In Indonesia, biodiversity research in cities (i.e. urban areas) has been very limited, probably because research in the wild and nature forests is more tempting and considered more challenging. The other reasons for the lack research in cities are the low habitat complexity of urban and sub-urban area.

Jakarta - the capital city of Indonesia - covers a vast terrestrial area of 662.33 km2. The city was inhabited by 10.2 million people in August 2016 and surrounded by satellite towns: Bekasi (east), Depok and Bogor (south), and Tangerang (west), creating a metropolitan area known as Greater Jakarta Area, with a total area of 6,400 km2 [2]. Although there are many big cities in Indonesia (in Java Island and other Indonesia's big island), the mass urbanization from other parts of Indonesia to Jakarta seems unstoppable, most probably because Jakarta offers many employment opportunities, excellent education, and many other modern amenities. The development of the city for human development might sacrifice biodiversity, including avian diversity.

The objective of this study was to reveal the synurbic bird species found in Greater Jakarta Area, and to categorize these species based on the encounter probability: urban exploiters, adapters, and avoiders. Categorization of bird species into 'urban exploiters' and 'urban adapters' followed the definitions given by [3]. Urban exploiters are species that tightly dependent and are most successful in the most highly human-dominated (i.e. downtown) urban areas. Urban adapters are other species found in the city. In addition to the two categories, a third category was added, namely urban avoiders, a species that can be found in a specific habitat type(s) or specific time in a year only, and tend to avoid urban environment.

2. Materials and methods

The data sets used for this study were species bird diversity previously collected by other researchers in the last seven years. In Indonesia, many data existed but unfortunately only a few was published. Almost all data were originated from unpublished documents, or documents being used internally as student projects, bachelor's theses projects, master's theses, or doctoral dissertations. Data collection and analysis was conducted from September 2014 to January 2015.

The data consisted on species name, locality, and observation date. Repeated data from the same location were also used but only if the time span is more than 3 years, allowing some changes in the bird community composition. A total of 36 data sets from the Greater Jakarta Area (Jakarta, Bogor, Depok, Tangerang and Bekasi) were collected, mostly from green open space area (city parks, urban forests, nature reserves, green corridors of rivers and roads, and residential area) with varying size of minimum 0.25 ha (a minimum size for an urban forest by Indonesia's definition) and maximum 80 ha. The published literatures used for this study were bird list of Bogor Agricultural University Campus [4], University of Indonesia Campus [5], Muara Angke Wildlife Reserve [6], Bogor Botanical Garden [7], Sentul Residential Area [8], Cibubur Urban Forest [9], and Ciliwung Riparian Area [10]. Unpublished data were mostly from city parks in Jakarta, gathered by experienced birdwatchers (e.g. Jakarta Birdwatcher Society). Due to the limitation of data availability, geographic representation was unable to be controlled and might pose some bias toward the central city of Jakarta.

Species list were checked and the feral species from other biogeographic region within Indonesia, e.g. Palm Cockatoo which naturally was found in Papua [11] but spotted in Bogor Botanical Garden, or exotic escapee from other country (e.g., Lovebird) were omitted. Species names were standardized by using [12]. All data sets were merged for further calculation.

As there has been no standardized method to assign categories of the urban exploiters and adapters, determination of the categories in this studies was done by using probabilities. Based in the encounter probability (P), a certain species was assigned into one of the three categories. The first and second highest percentile (P≥0.8) was assigned as urban exploiters. The last two percentiles (P<0.2) was assigned as urban avoiders, while in between the two categories were assigned into an urban adapters.

As the bird species that were classified into the urban adapters were numerous, further categorization was considered necessary. The sub-categories for the urban adapters were common urban adapters (0.6≤P<0.8), frequent urban adapters (0.4≤P<0.6), and occasional urban adapters (0.2≤P<0.4).

To assist interpretation on the bird occurrence and its habitat, guild of urban exploiters and urban adapters were also analyzed. Only feeding guild was used for analysis, and each species was assign

only into a single guild, although the bird might feed on various food sources. Most information of feeding guild was derived from [12, 13].

3. Results

3.1. Urban exploiters, adapters and avoiders

There were 243 species found in the research areas, a considerably high number for a tropical urban site. Of these species, eight were fall into urban exploiters category. The three highest ranks ($P \geq 0.9$) were the Sooty-headed Bulbul, Cave Swiftlets and Eurasian Tree Sparrow (table 1). Other five species also categorized as urban exploiters ($0.8 \leq P < 0.9$) were Spotted Dove, Scarlet-headed Flowerpecker, Olive-backed Sunbird, Common Iora, and Oriental White-eye.

Forty-nine bird species were categorized as urban adapters, sub-categorized further as common, frequent and occasional urban adapters (table 2**)**. Excluding the category of urban avoiders, the Greater Jakarta Area was an excellent home for 57 bird species.

Table 1. List of birds categorized as urban exploiters in Greater Jakarta Area

No	Species	Latin Name	Encounter Probability
1	Sooty-headed Bulbul	*Pycnonotus aurigaster*	97.1
2	Eurasian Tree Sparrow	*Passer montanus*	91.4
3	Cave Swiftlet	*Collocalia linchi*	91.4
4	Spotted Dove	*Streptopelia chinensis*	88.6
5	Scarlet-headed Flowerpecker	*Dicaeum trochileum*	88.6
6	Olive-backed Sunbird	*Cinnyris jugularis*	82.8
7	Common Iora	*Aegithina tiphia*	80.0
8	Oriental White-eye	*Zosterops palpebrosus*	80.0

Table 2. List of birds categorized as urban adapters in Greater Jakarta Area

No	Species	Latin Name	Encounter Probability
Sub-Category: Common Urban Adapters			
1	Bar-winged Prinia	*Prinia familiaris*	77.1
2	Javan Munia	*Lonchura leucogastroides*	77.1
3	Scaly-breasted Munia	*Lonchura punctulata*	77.1
4	Brown-throated Sunbird	*Anthreptes malacensis*	74.3
5	Collared Kingfisher	*Halcyon chloris*	65.7
6	Red-breasted Parakeet	*Psittacula alexandri*	62.9
7	Olive-backed Tailorbird	*Orthotomus sepium*	62.9
8	Great Tit	*Parus major*	62.9
9	Pied Fantail	*Rhipidura javanica*	60.0
Sub-Category: Frequent Urban Adapters			
10	Blue-eared Kingfisher	*Alcedo meninting*	57.1
11	Common Tailorbird	*Orthotomus sutorius*	54.3
12	Golden-bellied Gerygone	*Gerygone sulphurea*	54.3
13	Fulvous-breasted Woodpecker	*Dendrocopos macei*	51.4
14	Pacific Swallow	*Hirundo tahitica*	51.4
15	Black-naped Oriole	*Oriolus chinensis*	51.4
16	Yellow-vented Bulbul	*Pycnonotus goiavier*	48.6
17	White-breasted Woodswallow	*Artamus leucorynchus*	48.6
18	Plaintive Cuckoo	*Cacomantis merulinus*	45.7

Table 2. Continued

No	Species	Latin Name	Encounter Probability
19	Little Spiderhunter	*Arachnothera longirostra*	45.7
20	White-breasted Waterhen	*Amaurornis phoenicurus*	42.9
21	Small Minivet	*Pericrocotus cinnamomeus*	42.9
22	Pink-necked Green Pigeon	*Treron vernans*	40.0
23	Edible-nest Swiftlet	*Collocalia fuciphagus*	40.0
24	Javan Kingfisher	*Halcyon cyanoventris*	40.0
25	Coppersmith Barbet	*Megalaima haemacephala*	40.0
26	Barn Swallow	*Hirundo rustica*	40.0
Sub-Category: Occasional Urban Adapters			
27	Oriental Magpie-Robin	*Copsychus saularis*	37.1
28	White-vented Myna	*Acridotheres javanicus*	37.1
29	Long-tailed Shrike	*Lanius schach*	34.3
30	Crested Honey Buzzard	*Pernis ptilorhynchus*	31.4
31	Zebra Dove	*Geopelia striata*	31.4
32	House Swift	*Apus nipalensis*	31.4
33	Sunda Pygmy Woodpecker	*Dendrocopos moluccensis*	31.4
34	Horsfield's Babbler	*Malacocincla sepiarium*	31.4
35	Black-crowned Night Heron	*Nycticorax nycticorax*	28.6
36	Island Collared Dove	*Streptopelia bitorquata*	28.6
37	Asian Palm Swift	*Cypsiurus balasiensis*	28.6
38	Ashy Drongo	*Dicrurus leucophaeus*	28.6
39	Slender-billed Crow	*Corvus enca*	28.6
40	Cinnamon Bittern	*Ixobrychus cinnamomeus*	25.7
41	Barred Buttonquail	*Turnix suscitator*	25.7
42	Banded Bay Cuckoo	*Cacomantis sonneratii*	25.7
43	Asian Drongo-Cuckoo	*Surniculus lugubris*	25.7
44	Lesser Coucal	*Centropus bengalensis*	25.7
45	Ashy Tailorbird	*Orthotomus ruficeps*	25.7
46	Hill Blue Flycatcher	*Cyornis banyumas*	25.7
47	Black-winged Flycatcher-shrike	*Hemipus hirundinaceus*	22.9
48	Java Sparrow	*Padda oryzivora*	22.9
49	Black Drongo	*Dicrurus macrocercus*	22.9

The rest of the species, which constitute a big portion of the species spotted in urban area (76.5%) were categorized into urban avoiders. Many of these species were related to marine environment, including waders, shorebirds, and seabirds. This is because Jakarta City is located in a bay area (i.e. Jakarta Bay), making this city capable to support various marine-related bird species.

3.2. Feeding guilds and temporal guilds of synurbic species
Avian urban exploiters and urban adapters were mostly (c. 57.8%) insectivores. Other feeding guilds found were granivores (15.8%), nectarivores (10.5%), piscivores (including other macro-invertebrates; 10.5%), and frugivores (5.2%).

Raptors were not in the list of exploiters or adapters. Although some fish-eating raptor (e.g. Brahminy Kite) and small mammal eaters (e.g. Crested Goshawk, Besra, Spotted Kestrel) were present in the study area, obviously the encounter probabilities were very low. The small raptors were mostly can be found closer to the sub-urban areas.

Nocturnal species were scarce and represented by the Black-crowned Night Heron (occasional urban adapter). Other nocturnal species found in the study area: Barn Owl, Asian Koel, and Large-

tailed Nightjar, all were urban avoiders. These species probably was identified accidentally, as most - if not all – observations were conducted during day time.

4. Discussion

4.1. The diversity of synurbic species in Greater Jakarta Area

The bird species categorized as urban exploiters for the Greater Jakarta Area were similar to other big cities in Java, for example Bandung in West Java [14, 15] and Yogyakarta in the southern Central Java [16], where Sooty-headed Bulbul, Eurasian Tree Sparrow, and Cave Swiftlets were also dominant, although the order of probabilities of encounter were slightly varied.

When comparisons were made with cities of the nearest island of Sumatra, the trend showed some differences. Pekanbaru City (Riau Province) was dominated by Sooty-headed Bulbul, but the Eurasian Tree Sparrow was absent in the city, most likely due to lower degree of urbanization [17]. In Padang, West Sumatra, Eurasian Tree Sparrow was also dominant, but the Sooty-headed Bulbul was not dominant although the bulbul was present in a relatively high number [18]. Similarity of bird assemblages in cities were noticed by [3] who concluded that the more humans manipulated the city, bird communities were expected to become more similar.

The Eurasian Tree Sparrow apparently was not only dominated the Greater Jakarta Area, but also other Asian cities as well. The species was exploited Seoul (Korea) [19], but reported to be decreased in Singapore during the last decade [20].

Cave Swiftlets are aerial feeders [21], continuously hovering above the city in searching for insects. The species probably gain advantage from its closely related species, the Edible-nest Swiftlets. A high number of swiftlet houses has been built in Java, in order to farm Edible-nest Swiftlet for their nests [22]. Although the main target of the farming is the Edible-nest Swiftlets, the Cave Swiftlets (which does not produce edible nests) have been farmed as foster parents for the Edible-nest swiftlets during the establishment of a new population [23].

Unlike other country, e.g. in England [24], Germany [25], Italy [26,27], Poland [28], United States [29] and Pakistan [30] where feral pigeons were easily spotted and even abundant, in Jakarta there was no feral pigeon. The closest relative to the pigeon was the Spotted Dove, ranked the fourth in the list of urban exploiters in Greater Jakarta Area.

House Crow *Corvus splendens*, a species listed as the world's worst one hundred invasive alien species due to its ecological flexibility and obligate association with human presence [31], was absent in the Greater Jakarta Area. The House Crow was listed as a very common bird in Singapore [20] and potentially could invade Hong Kong in the future if the population is not properly controlled [32].

White-vented (Javan) Myna constantly was listed as the most abundant species in Singapore in the last decade [20]. In the Greater Jakarta Area, this species was seldom to be seen and fall into occasional adapter category.

4.2. Bird species as indicators for urban habitat

Sooty-headed Bulbul was the most often encountered in the Greater Jakarta Area. Unfortunately, scientific study on this species has been extremely lacking. General description [12] suggested that this species prefers open areas and shrubs. The fact that the encounter probability of Sooty-headed Bulbul surpassed the Eurasian Tree Sparrow in the Greater Jakarta Area reflected that the study area still have sufficient green open spaces.

This conclusion also supported by the high encounter rates of some urban exploiter nectar-feeding species such as Scarlet-headed Flowerpecker, Olive-backed Sunbird, Common Iora, and Oriental White-eye. Although the diversity of nectar feeding birds has been known to reduce due to urbanization in previous study [33], in the Greater Jakarta Area it seemed that they were well flourished.

The Red-breasted Parakeet (common urban adapters), Great Tit (common urban adapters) and Coppersmith Barbet (frequent urban adapters) are hole nesters, utilizing existing natural or

woodpecker-made tree cavities. Some species of woodpeckers also can be easily found. Cavity-nesting birds are sensitive to urbanization, as they depend on snags for roosting and nesting. Unfortunately, the snags often removed from urban areas for safety reasons [34], as also happened in Greater Jakarta Area.

Cavity-nesters may benefit from the large numbers of nest boxes in urban parks [1]. However, unlike other places especially in Europe and Northern America, provision of bird nests in Greater Jakarta Area was not a common practice, and thus the birds had to rely on the natural tree cavities. This was also implies that there were significant numbers of mature and decayed trees in the Greater Jakarta Area.

Further, species closely linked with water such as kingfishers, waterhen, bittern and night-heron were also common, indicating the existence of good quality of small rivers, creeks, and swampy area in the research area. Waterbirds utilized a wide array of food sources, including fishes, insects, macro-zoobenthos, small herpetofauna.

Horsfield's Babbler and Barred Buttonquail, both preferred dense understory habitat [12], indicated that shrubs and other lower canopy were still available. Cuckoos (Plaintive Cuckoo, Banded Bay Cuckoo, and Asian Drongo-Cuckoo) were also presence, showing that the bird community was quite rich to perform brood parasitism habit.

Nocturnal species, however, was rather lacking and only represented by the Black-crowned Night Heron as occasional urban adapter. Other nocturnal species, such as owl, koel and nighjars, were present, but in a very low encounter probability. The low presence of nocturnal species could be underestimated, as there was no attempt to specifically look for nocturnal birds.

4.3. Adaptation of avian urban exploiters and adapters
Adaptation to urban ecological niches requires changes in the behavior and ecology of synurbic populations, in comparison with non-urban (rural) species. In temperate zones, [35, 36] has proven that bird communities of residential and urban areas contain higher bird densities than outlying natural areas, with only forest edge communities supporting greater densities. Further, study in the urban area in the US revealed that the diversity of birds in urban areas is affected by the age of the neighborhood [37], degree of urbanization [38], and fragment size [39].

Compared to a forest, urban vegetative cover in the cities in Java was (1) replaced by human-made structures, ground cover and ornamental vegetation in the low and middle layers but dominated the high single layer, especially along roads and streets; (1) significantly less in all layer but the lower and middle layer; and (3) highly discontinuous in vertical layer, creating isolated strata, and (4) distributed in small mosaic patches. Due to the shift of the habitat type, foraging guilds in the research area have been reduced. Big raptors and frugivores were presence in low numbers.

The Sooty-headed Bulbul, the most commonly found avian species in urban areas of the Greater Jakarta Area, is an opportunistic species, capable of feeding on various food sources although the main food is insects. Although this species is very popular as cage birds [40] apparently harvesting of this species does not affect much on the survival of this species.

In most European cities, House Sparrow *Passer domesticus* were among sedentary species, which has been well adapted to urban landscapes via the abundance of food supply and buildings as preferred [41, 42]. House Sparrow's niche in the tropic was replaced by Eurasian Tree Sparrow. This species has a wide distribution in cities of Indonesia and elsewhere in its range, and has been known to be closely linked with buildings and heavy concrete development [12, 13]. This may explain the high occurrence and colonization rates of this species.

4.4. Management implications
Urban and sub-urban area no doubt has been emerged as habitat of birds in Indonesia. Many tropical species have proven to be able to live in cities and its surrounding. In North America, study of [43] suggested that human disturbance and predation from domestic animals might be mitigated by a series of interconnected islands. Increasing vegetative cover in urban areas may increase the number of bird

species, support larger populations of insectivores, and perhaps create suitable habitat for some ground nesters.

For Greater Jakarta Area and other big cities in Indonesia, vegetative cover in urban areas should be increased, not by isolated plantings of landscape shrubs, but by recreating or preserving natural islands of complete habitat profiles consisting of vegetative cover in each layer. A special effort also needed to change the perception of people in Indonesia that a certain bird species are a sign of bad luck and bring death, and therefore, has to be exterminated. Bird species related to this superstitious belief are Barn Owl (a messenger of ghosts and other spirit), Plaintiff Cuckoo (a messenger of sickness and death), and House Crow (a messenger of bad curse).

The synergism of habitat structure and population-suppressing factors in urban areas creates prime habitat for only a few bird species. These species dominate urban communities and often are considered undesirable or pests, for example European Sparrow, reported as pests in Yogyakarta and it surrounding. Manipulating urban habitats so that these species are less favored may be possible.

In big cities of Indonesia, 35.7% of households kept birds, making birds as the most popular pet [40]. The bird keeping hobby could affect the birds' survival, as the birds were an easy target for illegal hunting. Bird species which suddenly has been very popular as cage birds in the Greater Jakarta Area was the Oriental White-eye, one of eight urban exploiters. The intensity of hunting for cage birds needs to be monitored to maintain a viable population of birds in the Greater Jakarta Area.

Acknowledgements

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