Long Term Ecological Research on Biodiversity of Tropical Rainforest in South-East Asia

WILDLIFE RESPONSE TO PHENOLOGY PATTERN OF KEYSTONE TREE SPECIES IN NATURAL AND URBAN AREA

FACULTY OF FORESTRY AND ENVIRONMENT
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Long Term Ecological Research on Biodiversity of Tropical Rainforest in South-East Asia

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Final Three-Year Research Report

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PREFACE

Long-term study on the relationship of wildlife and their habitat is very lacking in Indonesia, and thus we have been very lucky to have a research project on the the long-term study on the wildlife species and their habitat. Of many groups of trees that has been known to be a keystone food resources in the tropics are Ficus spp. Through this project, we want to show that fig trees are actually 'everywhere' – in the natural forest, in peri-urban, even in residential urban area - and whenever the Ficus are, they have a big role for wildlife. To be specific, we would like to know the phenological pattern of the fig trees and the wildlife species associated with them.

Many friends, colleagues and students have been assisted us during preparation of the study, data collection, data analysis and report writing. We would like acknowledge and thank the National Institute of Ecology (Korea) for providing funding to carry out this project, of which without it would not be possible. Special thanks also to the staffs of National institute of Ecology Korea for their valuable assistances and advice, especially to Dr. Gilsang Jeong, Dr. Yena Kim and Ms. Hye Jin-Kang. We also would like to thank the research site managers: Sentul City Management Team who have given us permission to work in the residential areas, Darmaga Campus IPB University, and Mount Halimun Salak National Park Management Team especially the Head of National Park (Mr. Ahmad Munawir) who have given permission to work in the Cikaniki Resort areas.

Three-year research seemed long, but actually very short to understand the phenological cycles of the fig trees, and how wildlife response to it. The change of climate pattern and cycles actually demand a longer and more intensive study. Despite the climatic challenge, we managed to finish our research presented in this report. Some of the topics related to ficus and wildlife has been presented in international conference and published in the international proceedeings. Surely more papers would be written in the future, based on the data we collected though this project.

We do hope that this report will be useful for anybody who need it. We would be more than happy when many researchers would use our data and information presented in this report.

Mid-November 2022

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I. INTRODUCTION

Figs (Ficus, Moraceae) have been considered as keystone species for the persistent of many plant and animal species in the tropical forest. Figs occur in different life forms: from trees, shrubs to hanging roots. Lok et al. (2013) described the habitus of figs in Singapore as shrubs and trees, hemiepiphytes (strangler), climbers and scramblers, holoepiphytes, and rheophytic shrubs. There are at least 830 fig species (http://www.theplantlist.org/browse/A/Moraceae/Ficus/#statistics), 252 species of them can be found in a variety of habitats in Indonesia, including in disturbed habitats (Yusuf 2011). Based on the habitus, it is identified that most of figs in Indonesia grow as tree (179 species), shrubs (62 species), and hanging roots (42 species).

As a result of their asynchronous fruiting, figs seem to be a comparatively constant source of food whereas other species of fruit are distinctly seasonal (Lambert & Marshall, 1991, Shanahan 2001) and reserve food supply during periods of general food scarcity. Many studies have been done to reveal the importance of figs for wildlife (Dominy et al 2016, Kinnaird et al 1999, Wendein and Runkie 2000), but only few examined the role of fig trees in urban areas (e.g. Corlett 2006; Caughlin et al. 2012; Walther et al. 2018; Peabotuwage et al. 2019). Urban habitats are also distributed across climatic and geographical zones, therefore by studying in urban habitat we can make comparison among regions (Corlett 2006).

It is expected that we can understand the role of figs as keystone species in sustaining wildlife in urban ecosystem. The scope of our proposed study includes description of general features of fig and wildlife in urban area, fig phenology and its interaction with wildlife in urban area, and a comparison of wildlife-fig interaction between urban and non- urban site. Therefore, our specific objectives are 1) identifying fig species and describing fig phenological characteristics, 2) mapping their distribution and abundance, and 3) identifying use by vertebrate wildlife species, namely mammals, birds, reptiles, and amphibian.

Our research was proposed to be conducted for 3 phases, which started in July 2020 until end of September 2022. The first-year study (2020) was conducted in Bogor (IPB campus and Sentul City Residential Area) to represent urban areas, with the objectives were to identify and map the distribution of fig tree in two urban sites and conduct a preliminary observation on wildlife use of fig trees. The second year and third year research were focused in IPB Campus in Bogor for selected trees, with an additional preliminary study in Mount Halimun-Salak National Park, a natural habitat as a representation of a non-urban area. Part of the Mount Halimun-Salak National Park, namely Cikaniki ($\pm$ 72 km from Sentul City and $\pm$ 55 km from IPB campus Darmaga), was selected as additional study area because of the existence of the permanent field station, which has been used for the previous collaborative research between Korea and Indonesian.The objectives of the second phase were observation on wildlife use in urban habitat and start a preliminary study in natural habitat. In the third phase we aimed at comparing the wildlife use in urban and natural habitat to examine the role of fig trees for wildlife in those two habitats (Fig 1)

We have identified 14 species of Ficus spp. between the Citalahab and Cikaniki trails, Mount Halimun Salak National Park. However, the results have not been maximized due to several challenges, such as the difficult terrain and the short time of field work due to the closure of the National Park due to the surge in the Covid-19 Delta variant in the area. Therefore, we carried out intensified sampling on other grids within the selected area in 2022 as well as conducted monthly monitoring of wildlife use in the Ficus spp focal tree in the Cikaniki route. Additional monthly monitoring of wildlife on the IPB Campus were also conducted during the 2022 activity. It is expected that this study can serve as a model to understand the importance of fig species in sustaining wildlife.

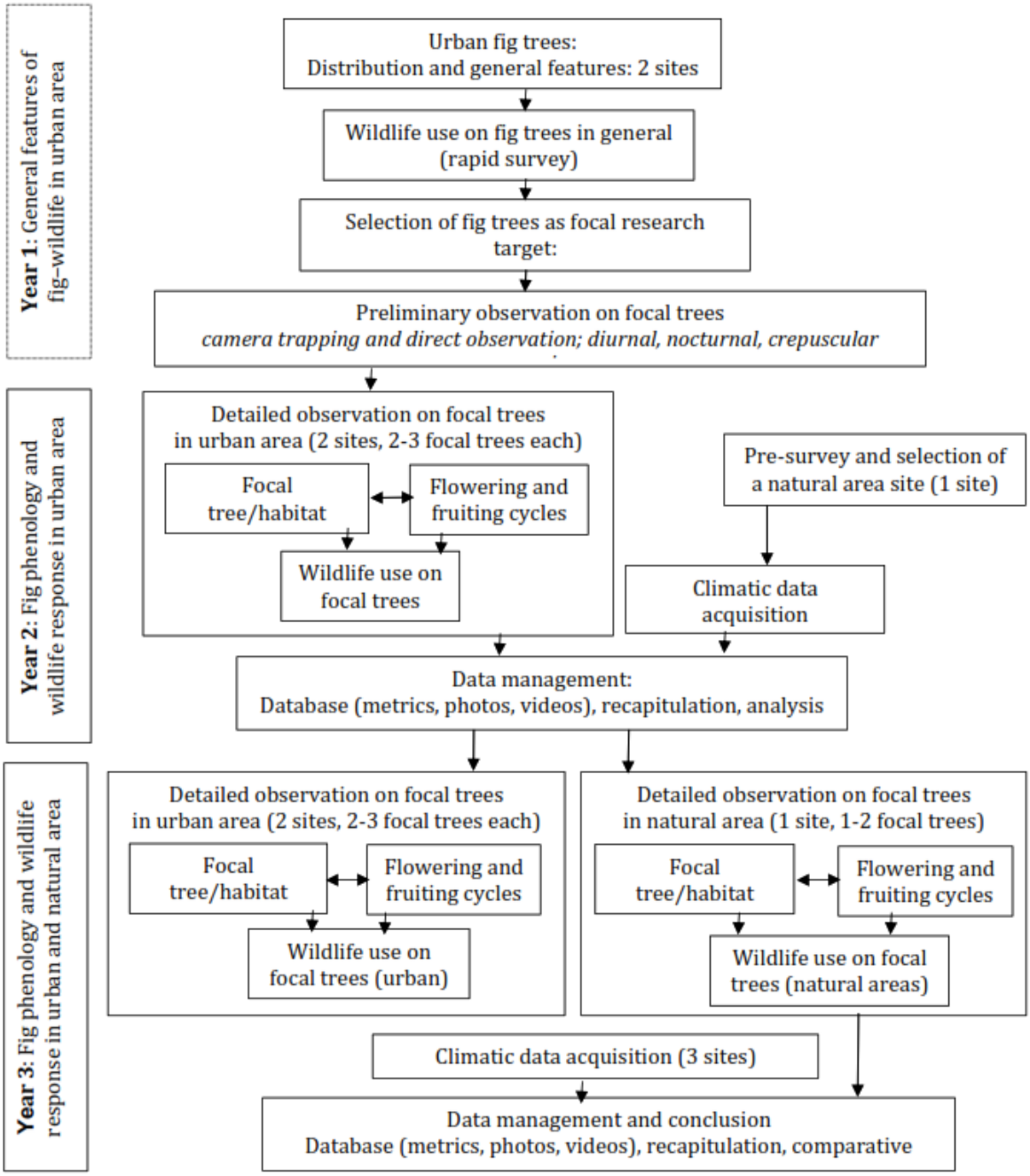

Figure 1 Schematic diagram of proposed study for three years (2020-2022)

II. METHOD

2. 1. STUDY SITES AND TIME OF SURVEY

The urban sites chosen for this study were IPB University Darmaga Campus (total area of 267 Ha), located approximately 12 km west of Bogor City, and Sentul City (total area 3,100 Ha), located approximately 5 km East of Bogor City and 35 km south of Jakarta (Fig 2). The natural sites chosen for the second and third year was in Cikaniki, part of Mount Halimun-Salak National Park, West Java. Surveys were conducted from early July to early August 2020 in IPB University Campus, and from late July to early September 2020 in Sentul City. Survey in Cikaniki-Citalahab trail in Mount Halimun Salak was conducted in June-July 2021 and July-August 2022. Additionally, observation of wildlife using Ficus trees were conducted in IPB Campus until August 2022.

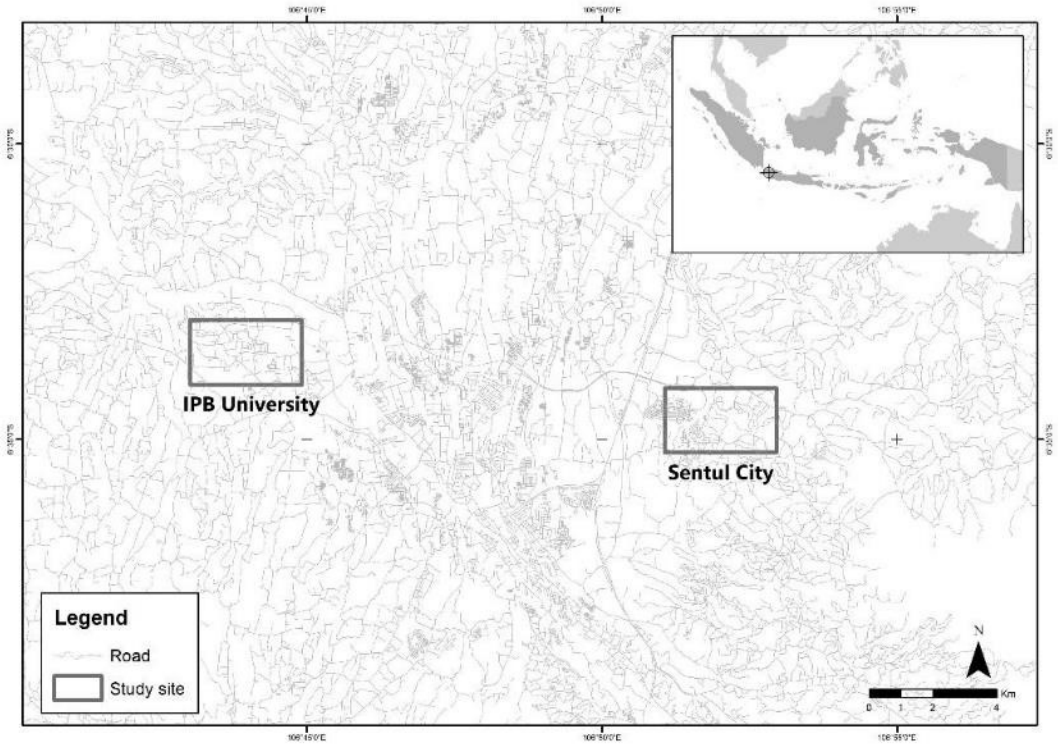

Figure 2 Map of IPB University Darmaga Campus and Sentul City

2.1.1. IPB University Darmaga Campus

The IPB University Darmaga Campus is one of five campus locations of IPB University. It is located 12 Km west of Bogor City (6°32'41" - 6°33'58" S, 106°42'47" - 106°44'07 E), between 145 – 195 m above sea level. The area is located between the tributaries of Cisadane River, i.e. Ciapus River and Cihideung River that makes it bordered by two rivers in the north and west, while in the south it is bordered by provincial road and in the east bordered by settlement (Fig. 3). Bogor is famous as rain city, with high precipitation that could reach an average of 4000 mm per year and nine rainy months per year.

Previously the campus area was covered by rubber plantation. Starting in 1963 various facilities were developed, which included academic facilities such as classrooms, laboratories and offices, and also housings for academic staffs. To accommodate the moving of the campus from Baranangsiang Campus in the City of Bogor to Darmaga Campus the development had been continued to build other buildings and infrastructures. Some green areas were also built, replacing parts of old rubber plantation with forest trees (arboretum, plantation forest), and agricultural plants especially in areas allocated for experimental field.

By the end of 2005 all academic services for undergraduate and graduate students have been moved from Baranangsiang Campus to Darmaga Campus. More rubber and forested areas have been converted into other facilities, although garden and ornamental plants were planted along roadside and in the parks. Physical developments have been going on, causing significant changes in landscape, however, based on 2013 IPB Master Plan there should be 15,68% buildings, 10.31% road and parking while 74.01% will be retained as green belt (IPB 2013).

Settlements around the campus to facilitate off campus student housings have also been growing fast, that makes the area more and more resembles to urban area. However, due to the availability of green open spaces and a variation of habitats in the campus, the IPB Darmaga Campus is considered a refugee for wildlife in the area. Several studies showed the area held high diversity of birds (Kurnia 2003; HIMAKOVA 2012, Mulyani et al 2013)

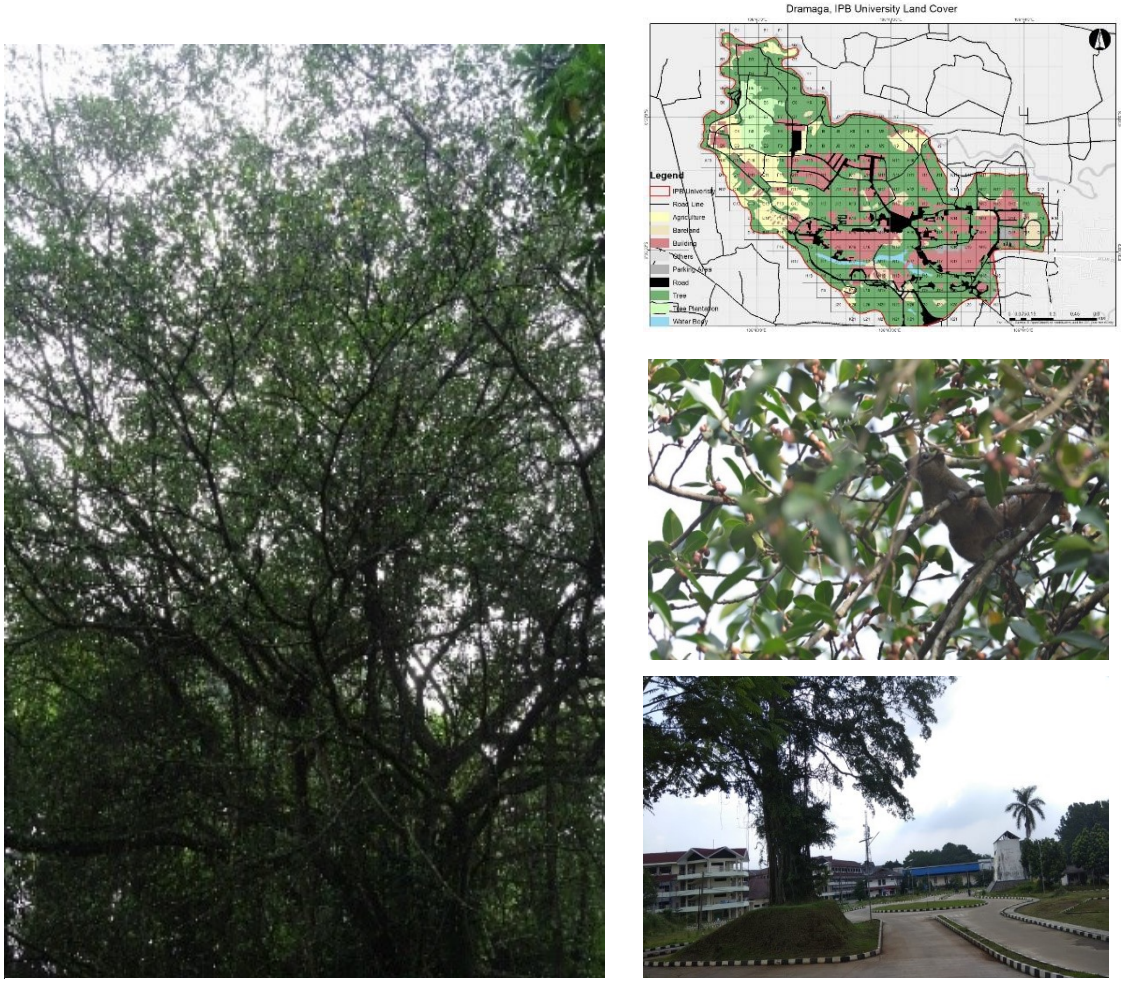

Figure 3 Map of IPB Campus (top right) and a variety of Ficus in IPB Campus Darmaga. Pictures by Rahayu Oktaviani and Mirza D. Kusrini

The university campus was established in 1963 and previously covered by rubber plantation and patches of forest-species tree plantation; however, rapid development that had started in late 1980s/early 1990s to facilitate academic processes have converted the habitat into more buildings and other infrastructures. Some forested areas were also converted into educational agricultural farm (experimental field) and other facilities. Settlements around the campus to facilitate off campus student housings have also been growing fast, that makes the area more and more resembles to urban area. In campus area we have recognized four free standing and hemiepiphytic fig trees located in IPB University: *Ficus benjamina*, *Ficus septica, Ficus hispida, and Ficus racemosa* with height is around 12-15 m and the crown diameter around 5-6 m (Fig. 3).

2.1.2. Sentul City

Sentul City (Fig. 4) is a satellite township, with a big complex of residential areas. It is located in the outskirt of the city of Bogor, about 5 km to the north of Bogor, connected by a toll road to the central Bogor. The toll road has a branch in Sentul City, to the northern city and to Darmaga Campus via an outer ring road. Sentul City was established in 1994. Before transformed into a township, Sentul City was a rubber plantation, managed by state-own company (PTPVIII).

Sentul City (06°33′55′′- 06°37′45′′S, 106°50′20′′- 106°57′10′′ E; 300–600 m above sea level) covers an area of 3,001.4 ha. Administratively, Sentul City is located on 2 subdistricts (Babakan Madang and Sukaraja Subdistrict) and 8 villages (Cipambuan, Babakan Madang, Citaringgul, Bojong Koneng, Sumur Batu, Cijayanti, Kadumanggu, and Cadas Ngampar Village) (Masterplan of Sentul CIty 2011 cited in Suheri et al. 2019). The city of Bogor is surrounded by four mountains: Mt. Salak, Mt. Gede, Mt. Pangrango, and Mt. Pancar. Mt. Pancar is very close to Sentul City. Being in the foothill of a mountain, the average daily air temperature is very pleasant, ranging from 22°C (minimum) and 30°C (maximum) (Arifin & Nakagoshi 2011).

Sentul City has a vast green area, about 65% of its total area. This township is well known for its diverse plants along the 6.2 km green boulevard and streets. Each settlement gate, traffic island, roadside and median road were planted with many trees, totaling 6,518 trees from 49 species, covering 27 ha area, does not include small trees, bushes, herbs, lianas, shrubs, and grasses. This Sentul City's street garden was awarded by the Indonesia's World Record Museum (MURI) as the "Largest Street Garden for Township Development" in November 2008 (Arifin & Nakagoshi 2011).

Currently Sentul City consists of 13 housing complexes, and will be more in the future, as the Developer is still planning to build more housing complex. There are many other facilities that have been built in Sentul City, including 5 hotels (Aston, Harris, Alana, Neo, Watana), convention center (Sentul International Convention Center; seating capacity 11,000 persons, the biggest in the Greater Jakarta Metropolitan Area), offices, apartment, riverside food court, market, malls, hospital, amusement park, mosques and churches, house-shop complex, schools, bus terminal, and 18-hole golf course. Aeon Mall has just recently opened on a 19 ha land.

Considering that Sentul City (about 3,000 ha) is much larger than Darmaga Campus, only a small part of the Sentul City was selected as the study site, in order to make a more or less similar coverage of the study sites. The area purposively selected is three residential clusters and a boulevard which connect the residential clusters, totaling 270 ha. The residential clusters were Victoria, Mediterania 1, and Bukit Golf Hijau. For Mediterania 1 and Bukit Golf Hijau, only a small part was selected as the study area. As for Victoria, the entire area of Victoria Cluster is censused for its fig trees. Based on landsat image analysis, the size of Victoria Cluster is 19.6 ha. The boulevard which included within the study area was named MH Thamrin Boulevard. Only about 2 km (from the total of 6.2 km) of the MH Thamrin Boulevard lied within the study areas.

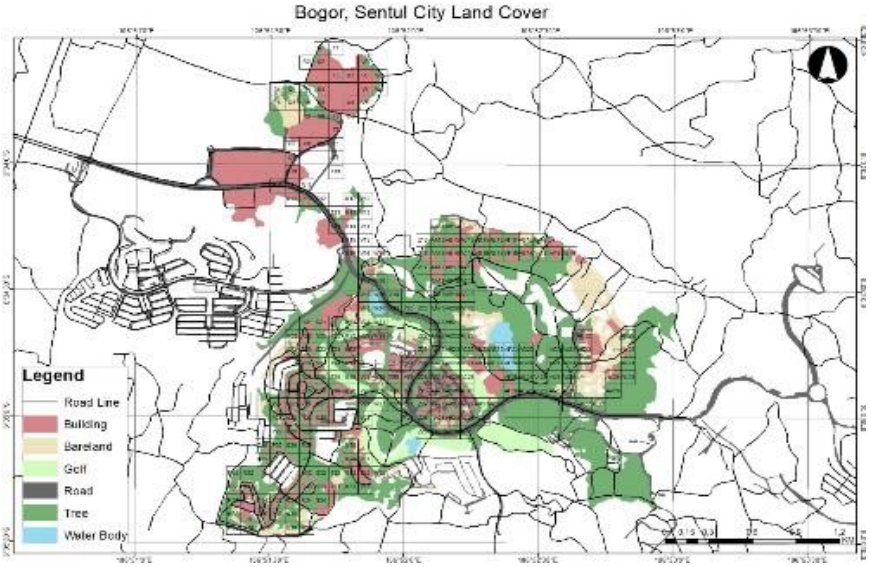

Figure 4 Areal view of Sentul City (top). Photo taken from https://www.sentulcity.co.id/v01/en. Middle: photo of residential area in Sentul City and below: land cover map of Sentul City

2.1.3. Cikaniki-Citalahab Trail, Mount Halimun Salak National Park

The Gunung (or Mount in English) Halimun-Salak National Park (GHSNP) is one of the national park in Java which consisted of tropical montane forest, the other one is Gunung Gede-Pangrango National Park (Fig. 5). The park was established in 2003 with area of 113,357 ha (SK Menteri Kehutanan No.175/Kpts-H/2003) and located in three districts: Sukabumi, Bogor and Lebak. Following the exclusion of 25,220 ha of conflicting land based on regulation of Ministry of Environment and Forestry Number SK.327/Menlhk/Setjen/PLA.2/4/2016, the size of national park is currently 88,137 ha.

The national park could be separated into two cluster of mountains. In the east lies the Mount Salak with the highest peak around 2200 m and in the western park the cluster of Mount Halimun (peak at 1800 m) surrounded by smaller hills, i.e. Gunung (Mount) Kendang and Gunung Botol which is part of the Cikaniki resort. The natural sites chosen for this study are the area between the trail of Cikaniki and Citalahab at Mount Halimun Salak National Park (total area of 312 Ha) (Figure 2.1 and Figure 2.2). The condition of the trail varied, some are steep but a few are gentle. We divided the chosen areas into 78 grids (Fig 6).

The forest in Citalahab areas can be categorized a lower montane forest, having many high trees of 20-30 m high. The highest canopy was dominated by 'rasamala' (*Altingia excelsa*), 'saninten' (*Castanopsis* spp. ex. *Castanopsis javanica*, *Castanopsis tungurrut*, *Castanopsis acuminatissima*), and 'pasang' (*Quercus sundaica*), some are tall trees up to 30 m. The mower canopy is dominated by medium-sezed trees of 20–30 m, including 'beleketebe' (*Sloanea sigun*), 'ganitri' (*Elaeocarpus sphaericus*), *Acer laurinum*, and some species belonging to *Litsea* genus. Meanwhile, some example of the lower canopy with an average height of 10 m area several species of 'jambu hutan' (*Syzygium* spp., *Decaspermum* spp.), 'huru' (*Litsea* spp.), and *Ficus* spp.

The understory was covered by various plant species, including 'tepus' (*Etlingera coccinea*), several members of genera *Begonia* and *Cyrtandara,* as well as plants belonging to Marantaceae family. Climbers and epiphyte, including ferns, orchids, *Rhapidophora* spp., and *Freycinetia* sp. were also abundant.

The topography of the selected site was hilly, with many small valleys. The forest floor was always humid, with a good coverage of humus. The depth of the humus varied, mostly well covered. Most soil have a high clay content.

As for the Ficus in the research site, the distribution of Ficus trees varied from site to site. Many big-sized stranglers (of sub-genus Urostigma) were observed surrounded big trees such as *Schima wallichii*, which can reach 30 m high. The sub-genus of Synoecia (climbers) also often observed attached on trees or even on big rocks. Some Ficus species seemed to have a high association with water, as they often seen along small creeks, such as *Ficus lepicarpa*. Other species, for example *Ficus padana,* preferred a more open area.

Due to the difficulties of the topography, in 2021 we were only able to sample 29 grid (C3, C4, C5, C6, D3, D4, D5, D6, D7, E4, E5, E8, F4, F5, F6, F7, F8, F9, G4, G5, G6, G7, G8, G9, G10, G11, H12, H13 and I12). mostly located not too far from the loop-trail. The total area covered by the visited grids were 37.18%. Information on the grid and their short description was presented in **Appendix 1** and **Appendix 2**, respectively. In 2022, we carried out sampling in 33 grid sized 200 x 200 m (B4, C4, D3, D4, D5, D9, E4, E5, E6, E7, E8, E9, F4, F5, F6, F7, F8, F9, F10, G4, G6, G7, G8, G9, G10, G11, G12, H6, H7, H8, H12, H13, and I12). Within a grid, we divided it into sub grid 100 x 100 m as plot to identified species of Ficus and wildlife that use Ficus.

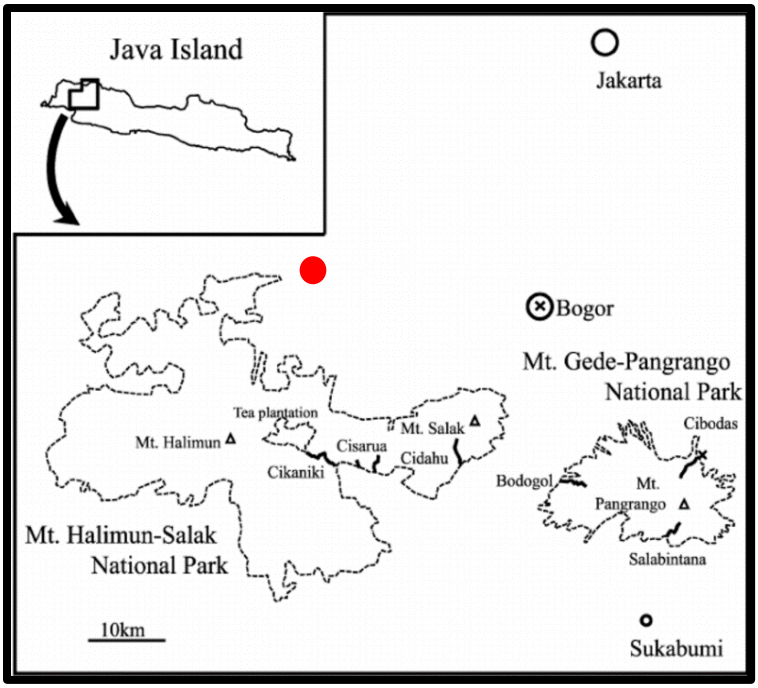

Figure 5 Map of Gunung Halimun National Park and Gunung Gede Pangrango National Park in West Java, Indonesia. The red dot is Cikaniki Resort.

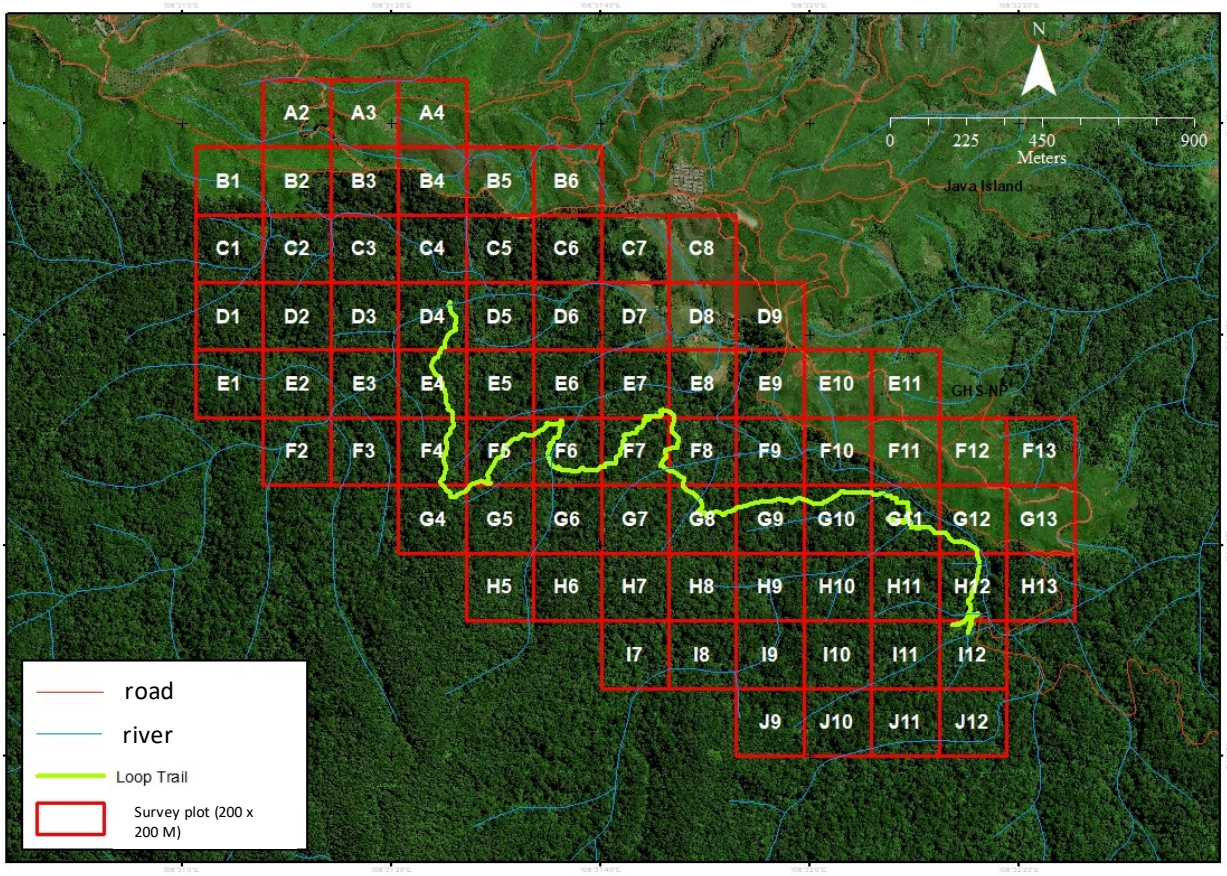

Figure 6 Map of Cikaniki Loop trail and the grid used as study site at Cikaniki, Mount Halimun Salak National Park

2.2. CHALLENGES

During 2020 and 2021, the biggest challenge of research is the COVID-19 pandemic. Timing of filed work has to adjust due to the difference in permit approval to conduct field observation by the area management. Surveys in Cikaniki, Mount Halimun Salak National Park was cut short due to the surge of COVID delta variant. A pre-survey was conducted in late June 2021. Surveys were conducted in June 2021 in Cikaniki. A pre-survey was conducted in late June 2021. Permit approval to conduct field observation by the area management was limited due to COVID-19 pandemic. In July, another lockdown was held by the government, and we were only able to conduct the camera trap study in late October after the ease of mobility by the management of National Park. The data for fig characteristic in Cikaniki is not completed and we decided to conduct another survey in 2022 to increase the sampling site.

Thus, during this study we complied fieldwork to health and safety protocol. A special protocol was prepared and followed by all the researchers and assistants with emphasis to prevent the transmission of COVID-19 by simple mechanism: washing hands, social distancing and using mask. We avoid face-to-face meetings and using zoom for most of our meetings (Fig 7). During field works in 2020, where there is possibility of face-to-face meetings, we required all field personnel to wear masks.

Camera traps were put 5-10 meters above the ground, thus to reduce the possibility of accident, several of field personnel were trained in safety in works at height, and ensure that appropriate equipment were used. In 2021, we requested assistance from the IPB adventure's group, Lawalata, who has personnels trained in working at height and has appropriate equipment.

2.3. FIELD METHOD

2.3.1 General features of fig in urban and natural areas

a. Diversity and General Features

Species identification was done in the field using fig identification guide book (Ng et al. 2005) and with the help of a fig tree identifier (local para-taxonomist). Unidentified samples were taken and brought to Herbarium of Faculty of Forestry IPB University to be identified. The conditions of figs were recorded as full tree, pruning, trimming and cut off tree. Measurements were done on tree diameter (DBH) and height to canopy and height of branchless trunk. Each stem larger than 10 cm in diameter were treated as individual stem, however, trees with compact aerial roots were considered as and measured as one stem (Fig. 8). We also noted fruiting status which include fruiting stage and fruit abundance. Fruiting stage were put into 4 categories: no fruit, early fruiting, full fruiting and late fruiting. Fruit abundance were put into 4 categories: 0-25% full; 25-50% full; 50-75%, 75-100% full. For each species with fruit, we sampled fruits and measured the diameter and coloration of the fruit.

In Cikaniki-Citalahab trail (Fig. 9), we subsampled 100 x 100 m plots from the selected 200 x 200 m grid. We recorded growth rate of fig as seedling (height < 1.5 m), sapling (height > 1.5 m and dbh < 10 cm), pole (height > 1.5 m and 10 cm dbh < 20 cm) and tree (height > 1.5 m and dbh 20 cm). Habitus were recorded as either tree, strangler, shrub, liana, climber, epiphyte, and hemi epiphyte.

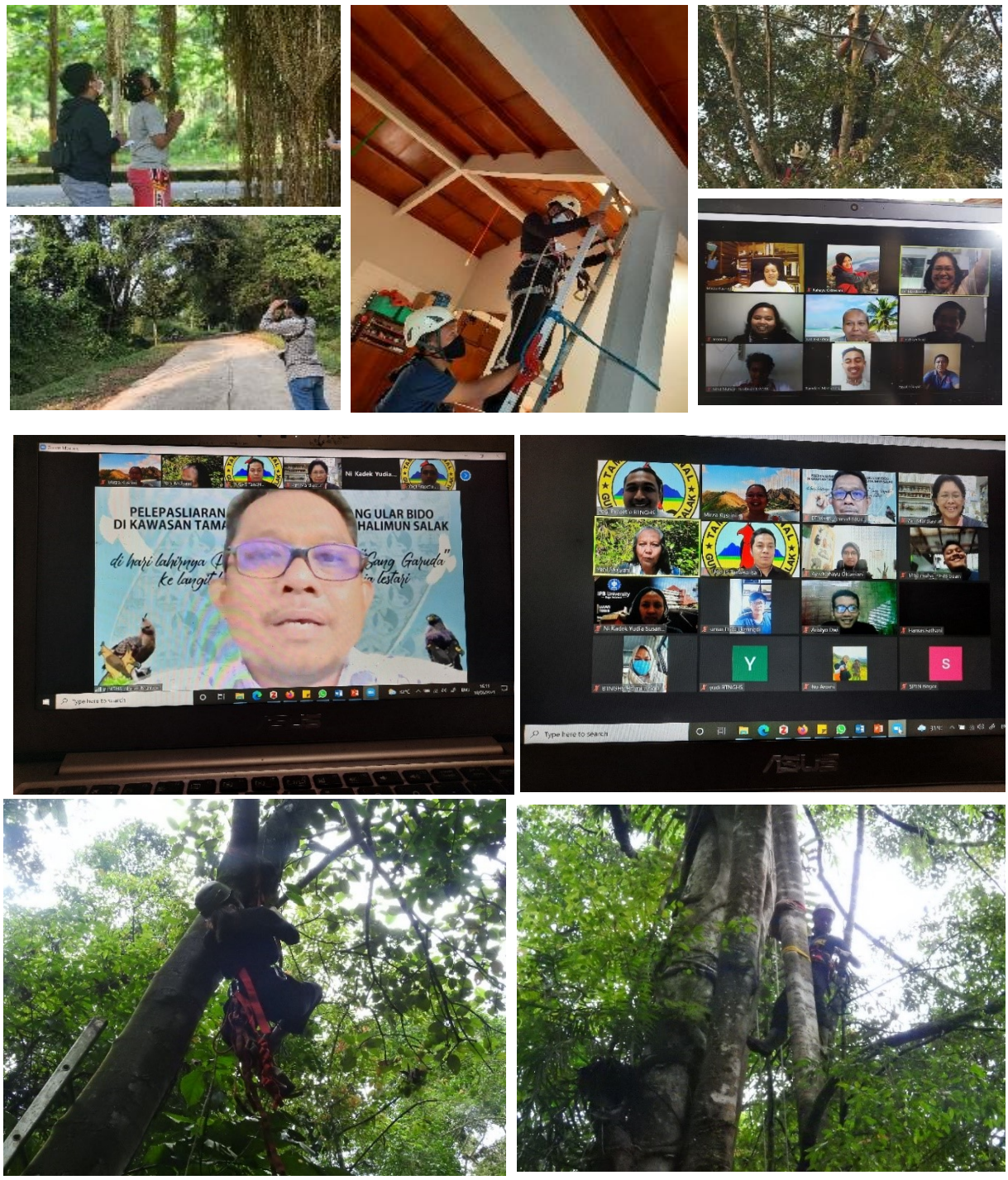

Figure 7 Pre-research activity in 2020 includes several online meetings using zoom and training in working at height safety. During survey, field assistants wear mask to avoid the spread of Covid-19. In 2021, we also conducted online meetings using zoom with the

b. Abundance and Distribution

Number of fig trees in each location were noted. The distribution of fig trees in all locations were mapped using a grid system. Locations of each fig tree was recorded using GPS. We measured two indicators of human disturbance within a 30 m radius around focal trees: neighbourhood tree cover and building cover. We assigned a visual assessment of the area occupied by buildings on a scale of 1–5, where 1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80% and 5 = 81–100% of the area within the neighbourhood covered by buildings. We also recorded the nearest distance to water body (river, creek, pond, spring), distance to nearest building, and distance to road.

2.3.2. Wildlife use of fig trees

A rapid survey was conducted to identify wildlife species using fig trees. Wildlife species observed in fig trees during mapping were recorded, mostly during the day. Based on the result of fig identification we chose four individual trees in each site to be monitored for wildlife use as focal trees. Selection of focal tree species were based on its dominance in the landscape. Observations of wildlife (mammals, birds, reptiles, and amphibians) were only carried out in poles and trees only. Location of Ficus spp. which was used as the observation location was determined based on the results of the identification of Ficus spp. held the previous day. The duration of observation location is about 30 minutes within radius of ±10 meters. Observations were made from morning to evening and only when the weather was sunny. Additional pbservation at night was carried out to observe nocturnals amphibians and reptiles. Identification of bird species refers to "Birds of Sumatra, Java, Bali and Kalimantan" (MacKinnon et al. 2010) and "Birds of the Indonesian Archipelago: Greater Sundas and Wallacea" (Eaton et al. 2021). The nomenclature of bird species refers to "Birds in Indonesia: List and Status 2021" (Junaid et al 2021). The data recorded in the observations included species and number of individuals, time of discovery, activity of animals, canopy strata of the presence of animals, type and distance of substrate if animal species were found in substrates other than Ficus spp., and weather conditions.

To examine the use of fig tree by vertebrates, a 3-day observation was conducted in each focal tree. Observation was conducted in intervals of 05.00-08.00, 11.00-14.00, 16.00-19.00, and 21.00-24.00 to record activities of diurnal, nocturnal, and crepuscular animals. Camera traps Bushnell Cam Trophy HD were set up in two of focal trees, two in each tree, 5-10 m above the ground. The result will be used to evaluate the effectiveness of camera traps vs direct observation in obtaining information about relationship between figs and wildlife.

2.3.3. Wildlife response to fruiting of Ficus tree in urban and natural areas

We observed wildlife use on two focal trees in IPB Darmaga Campus monthly from September-November 2020 and February to August 2021 to get the information on seasonal variation. We had to cease observation in December 2020 and January 2021 due to very limited access to campus area during pandemic. We continued the observation from November 2021 to August 2022 except in March 2022 due to logistic problem. The focal tree used were similar to those in the first year. At least 2h of nocturnal observations and 6h of diurnal observations in the first year were conducted on each observation to determine which animals utilize the fig trees by observers watching at a location from which most of the tree crown is visible. Based on the result of previous year observation in 2021-2022 where night activity of wildlife was minimal, the observation was only conducted during the day. The occurrence of Ficus fruit was also recorded during the observation. Similar activities (observation and fig measurement) was conducted in natural habitat in Cikaniki-Citalahab trail, Mt Halimun-Salak National Park in October 2021 until September 2022 (Fig 9-10).

Figure 8 Taking measurement of fig tree with compact aerial roots in urban areas during 2020 survey

Figure 9 Taking measurement of fig tree in Cikaniki and conducting rapid wildlife survey during 2021 survey

Figure 10 Field team during 2022 survey

III. RESULTS

3. 1. GENERAL FEATURES OF FIG IN URBAN AND NATURAL AREAS

A. Urban Areas

A.1. Diversity of Fig Trees

There were total of 20 Ficus species identified in the urban area, with 17 species occur in IPB Darmaga Campus and 10 species in Sentul City. Seven species were found in both study sites (Darmaga Campus and Sentul City) (Table 1**;** short description on each species is in **Appendix 3**). Darmaga Campus had more species compared to Sentul City, although in term of the number of fig trees, Sentul City had more individual number fig trees. In Sentul City alone, the number of fig trees found were 10 species, almost all were purposively planted by the Developer.

Table 1 Fig tree species found in the urban sites and its relative abundance, listed in alphabetical order

No	Species	Common Name	Darmaga Campus	Sentul City
1	*Ficus ampelas*	-	+	-
2	*Ficus benghalensis*	Indian banyan	+	-
3	*Ficus benjamina*	Weeping fig, benjamin fig, ficus tree	++	+++
4	*Ficus binnendijkii*	'Alii' long leaved fig	-	+
5	*Ficus callosa*	Kadaplavu [Malayam name]	+	-
6	*Ficus caulocarpa*	Stem-fruited fig	-	+
7	*Ficus elastica*	Rubber fig, Indian rubber bush	+	+
8	*Ficus fistulosa*	Common Yellow Stem-fig	+	-
9	*Ficus fulva*	Stinging Fig	+	-
10	*Ficus hispida*	Roug-leaf Stem-fig	++	-
11	*Ficus kurzii*	Burmese banyan	-	++
12	*Ficus lyrata*	Fiddle-leaf fig, banjo fig	++	++
13	*Ficus maclellandii*	Alii fig, banana-leaf fig	+	+
14	*Ficus microcarpa*	Chinese/Malayan banyan, Indian laurel, curtain fig	++	++
15	*Ficus racemosa*	Cluster-fig , Indian Fig tree	+	-
16	*Ficus septica*	White-veined fig	++	++
17	*Ficus variegata*	Common red stem fig, green fruited fig, variegated fig	+	+
18	*Ficus cf. kerkhovenii*	Johor Fig	+	-
19	*Ficus cf. sundaica*	Sunda Fig	+	-
20	*Ficus cf. virens*	Grey Fig	+	-
		Total number of species	17	10

+++: abundant (>100), ++: common (10-99), +: rare (<10)

Of the 20 fig trees found in both study site, two species were non-native species, namely *F. binnendijkii* (originated from Africa, South America and the south of the USA), and *F. lyrata* (tropical western and central Africa). These non-native species were specifically planted for certain purposes, for example *F. lyrata* that has been planted along the boulevard for shading and ornamental purposes (Fi.g 11).

Figure 11 Left: F. binnendijkii originated from Africa, South America and the south of the USA; Right: Ficus lyrata, originated from tropical western and central Africa

A.2. General Features of Fig Trees

Fig trees are mostly big trees, except for *Ficus septica.* Several species are strangler. All strangler figs that still have host tree were found in IPB Darmaga Campus. The host trees were present and could be identified only on four individuals Ficus, i.e one tree in *F. benjamina* (*Roystonea regia)* and three trees on *F. macrocarpa* (*Acacia mangium, Caesalpinia pulcherima,* and *Syzygium malaccense).* Most fig trees in Sentul City are planted by the Developer, that might explain no host tree even for small size fig trees.

The largest fig tree found in IPB Darmaga campus was *F. benjamina* (dbh 420.38 cm, total height 27.8 m), whilst in Sentul City the largest tree was also *F. benjamina* (dbh 150 cm, total height 13.18m). Average heights and diameter of fig trees can be seen below (Table 2).

Table 2 Mean heights and diameter of Ficus species in urban area

No	Species	Total Height (m)		Clear Bole (m)		DBH (cm)	
		IPB Campus	Sentul City	IPB Campus	Sentul City	IPB Campus	Sentul City
1	*Ficus ampelas*	10.25 ± 2.61 (n=5)	-	3.51 ± 0.68 (n=5)	-	27.58 ± 8.20	-
2	*Ficus benghalensis*	13.9 (n=1)	-	1.7 (n=1)	-	65.92 (n=1)	-
3	*Ficus benjamina*	15.0± 5.83 (n=43)	9.06± 3.25 (n=194)	2.96 ± 1.43 (n=36)	2.66±1.63 (n=166)	93.0± 77.19	54.69±32.03 (n=136)
4	*Ficus binnendijkii*		4.30± 1.39 (n=4)		0.76(n=1)		61.46±13.50 (n=5)
5	*Ficus callosa*	16.95 ± 4.40 (n=5)	-	8.72 ± 3.39 (n=5)	-	37.21 ± 18.99	-
6	*Ficus caulocarpa*		9.53 (n=1)		2.57 (n=1)		25.48 (n=1)
7	*Ficus elastica*	14.99 ±2.68 (n=5)	10.56±2.65 (n=5)	2.57 ± 1.18 (n=5)	1.95±0.56 (n=5)	126.18 ± 96.31	44.0±17.86 (n=5)
8	*Ficus fistulosa*	3.52 (n=1)	-	-	-	-	-
9	*Ficus fulva*	4.1 (n=1)	-	-	-	-	-
10	*Ficus hispida*	7.70 ±1.69 (n=23)	-	2.83 ± 1.56 (n=17)	-	20.53 ± 7.10 (n=17)	-
11	*Ficus kurzii*		6.85± 3.30 (n=37)		1.67±0.60 (n=32)		37.09±15.77 (n=39)
12	*Ficus lyrata*	8.94 ± 1.74 (n=25)	7.81± 1.56 (n=25)	2.03 ± 1.12 (n=25)	1.88±0.55 (n=23)	22.89 ± 8.81	27.59±5.88 (n=24)
13	*Ficus maclellandii*	13.8 (n=1)	2.11±0.21 (n=3)	3.2 (n=1)	0.44±0.11 (n=3)	26.43 (n=1)	20.91±0.97 (n=3)
14	*Ficus microcarpa*	16.42 ± 4.28 (n=12)	8.89±3.26 (n=7)	3.34 ±1.48 (n=12)	1.90±0.39 (n=6)	111.18 ± 60.44	28.49±4.71 (n=8)
15	*Ficus racemosa*	11.38 ± 2.46 (n=3)	-	3.47 ± 1.48 (n=3)	-	77.05 ± 74.44	-
16	*Ficus septica*	5.03 ± 2.08 (n=21)	-	2.78 ± 1.18 (n=8)	-	16.64 ± 10.71 (n=8)	-
17	*Ficus variegata*	12.71 ± 1.75 (n=4)	6.8(n=1)	6.26 ± 0.97 (n=4)	1.5(n=1)	33.64 ± 24.39	15.29(n=1)
18	*Ficus cf. kerkhovenii*	15.3 (n=1)	-	1.9 (n=1)	-	15.3 (n=1)	-
19	*Ficus cf. sundaica*	14.4 (n= 3)	-	2.09 ± 0.40 (n=3)	-	31.42 ± 1.21(n=3)	-
20	*Ficus cf. virens*	29.7 (n=1)	-	8.7 (n=1)	-	409.87 (n=1)	-

Trees in the study area were mostly maintained by the area management; therefore, 60% of individual Ficus tree had undergone some maintenance such as trimming. About 60% of fig trees in Darmaga Campus were pruned and the rest are in full tree form. There is no trimming or cut off of trees. Fig trees in Darmaga campus were pruned, especially if they are located nearby roads. In Sentul cities, several trees are cut off, especially those that grow near houses (Table 3).

Table 3Ficus species based on maintenance stage in IPB Darmaga Campus and Sentul City

No	Ficus Species	Darmaga Campus				Total	Sentul City				Total
		Full tree	Pruning	Trimming	Cut off		Full tree	Pruning	Trimming	Cut off	
1	*F. ampelas*	1	2	0	0	3	0	0	0	0	0
2	*F. benghalensis*	0	1	0	0	1	0	0	0	0	0
3	*F. benjamina*	12	25	0	0	37	134	37	35	32	238
4	*F. callosa*	5	0	0	0	5	0	0	0	5	5
5	*F. cf. kerkhovenii*	1	0	0	0	1	0	0	0	0	0
6	*F. cf. sundaica*	0	3	0	0	3	1	0	0	0	1
7	*F. cf. virens*	0	1	0	0	1	0	0	0	0	0
8	*F. elastica*	2	2	0	0	4	0	0	0	0	0
9	*F. hispida*	7	2	0	0	9	0	0	0	0	0
10	*F. lyrata*	4	11	0	0	15	6	0	0	0	6
11	*F. maclellandii*	0	1	0	0	1	0	0	0	0	0
12	*F. microcarpa*	2	10	0	0	12	20	13	7	7	47
13	*F. racemosa*	1	1	0	0	2	32	0	0	0	32
14	*F. septica*	3	0	0	0	3	0	0	0	3	3
15	*F. variegata*	2	1	0	0	3	6	2	0	0	8
	Grand Total	40	60	0	0	100		0	0	0	0

Only 14 species were fruiting during the survey. The timing of fruiting seems differs between location and species. For instance, in Sentul City, most of *Ficus benjamina* has no fruit, where as in Darmaga campus were all in fruiting stages. All of fig trees in Darmaga Campus were in sort of fruiting stage, whereas only *F. lyrata* has all trees in fruiting stage. Data on fruiting stage is presented on Table 4, whereas data of 14 species that produce mature fruit during the study period is presented in Table 5. All fruits are preserved in alcohol and deposited in the Laboratory of Wildlife Ecology in the Faculty of Forestry and Environment, IPB University.

Table 4Fruiting stage of fig tree in urban area between July - September 2020

	IPB Campus				Sentul City			
Species	No Fruit	Early Fruiting	Full Fruiting	Late Fruiting	No Fruit	Early Fruiting	Full Fruiting	Late Fruiting
F. ampelas	0	2	0	3	0	0	0	0
F. benghalensis	0	1	0	0	0	0	0	0
F. benjamina	0	25	11	7	246	5	1	7
F. binnendijkii	0	0	0	0	4	0	0	0
F. callosa	0	4	1	0	0	0	0	0
F. caulocarpa	0	0	0	0	0	1	0	0
F. cf. kerkhovenii	0	0	0	1	0	0	0	0
F. cf. sundaica	0	0	0	3	0	0	0	0
F. cf. virens	0	1	0	0	0	0	0	0
F. elastica	0	5	0	0	7	0	0	0
F. fistulosa	0	1	0	0	0	0	0	0
F. fulva	0	1	0	0	0	0	0	0
F. hispida	0	4	14	6	0	0	0	0
F. kurzii	0	0	0	0	8	0	1	3
F. lyrata	0	4	20	1	0	0	17	0
F. maclellandii	0	1	0	0	3	0	0	0
F. microcarpa	0	10	1	1	3	0	0	0
F. racemosa	0	2	1	0	0	0	0	0
F. septica	0	10	7	0	1	17	0	0
F. variegata	0	3	1	0	0	0	1	0

Table 5 Characteristics of fruit, average width x average height (mm) of fig trees in urban area

No	Species	Description	Darmaga Campus	Sentul City
1	*Ficus ampelas*	Green, turned to yellow and red	6.80 x 6.73 (n=30)	-
2	*Ficus benghalensis*			-
3	*Ficus benjamina*	Green, turned to yellow and red	8.73 x9.73 (n=60)	8.32 x 8.52 (n=221)
4	*Ficus binnendijkii*		7.4 x 8.9	-
5	*Ficus callosa*	Green	20.43 x 21.14 (n=30)	-
6	*Ficus caulocarpa*			-
7	*Ficus elastica*			-
8	*Ficus fistulosa*		16.86 x 14.55 (n=10)	-
9	*Ficus fulva*		11.18 x 10.78 (n=6)	-
10	*Ficus hispida*		35.63 x 26.17 (n=30)	-
11	*Ficus kurzii*			10.51 x 10.54 (n=71)
12	*Ficus lyrata*	Dark green	34.318 x 31.17 (n=38)	34.49 x 34.90 (n=30)
13	*Ficus maclellandii*			-
14	*Ficus microcarpa*	Yellowish green	6.36 x 6.93 (n=6)	-
15	*Ficus racemosa*	Green	27.24 x 23.62	-
16	*Ficus septica*		20.63 x 20.91 (n=30)	13.01 x 10.06 (n=45)
17	*Ficus variegata*	Yellowish green	31.40 x 28.50 (n=30)	19.40 x 16.85 (n=37)
18	*Ficus cf. kerkhovenii*			-
19	*Ficus cf. sundaica*	Reddish yellow	8.46 x 8.10 (n=30)	-
20	*Ficus cf. virens*			-

A. 3. Abundance and Distribution of Fig Trees in urban areas

A total of 626 individuals of 17 Ficus species were identified during the study in IPB University Campus area and Sentul City, comprised of tree growth stages, i.e. tree, poles, and saplings (Table 6**).** Although consisted of different growth stages, life form of figs in both locations are dominated by trees, with *F. benjamina* as the most abundant species in both locations (Fig. 12)

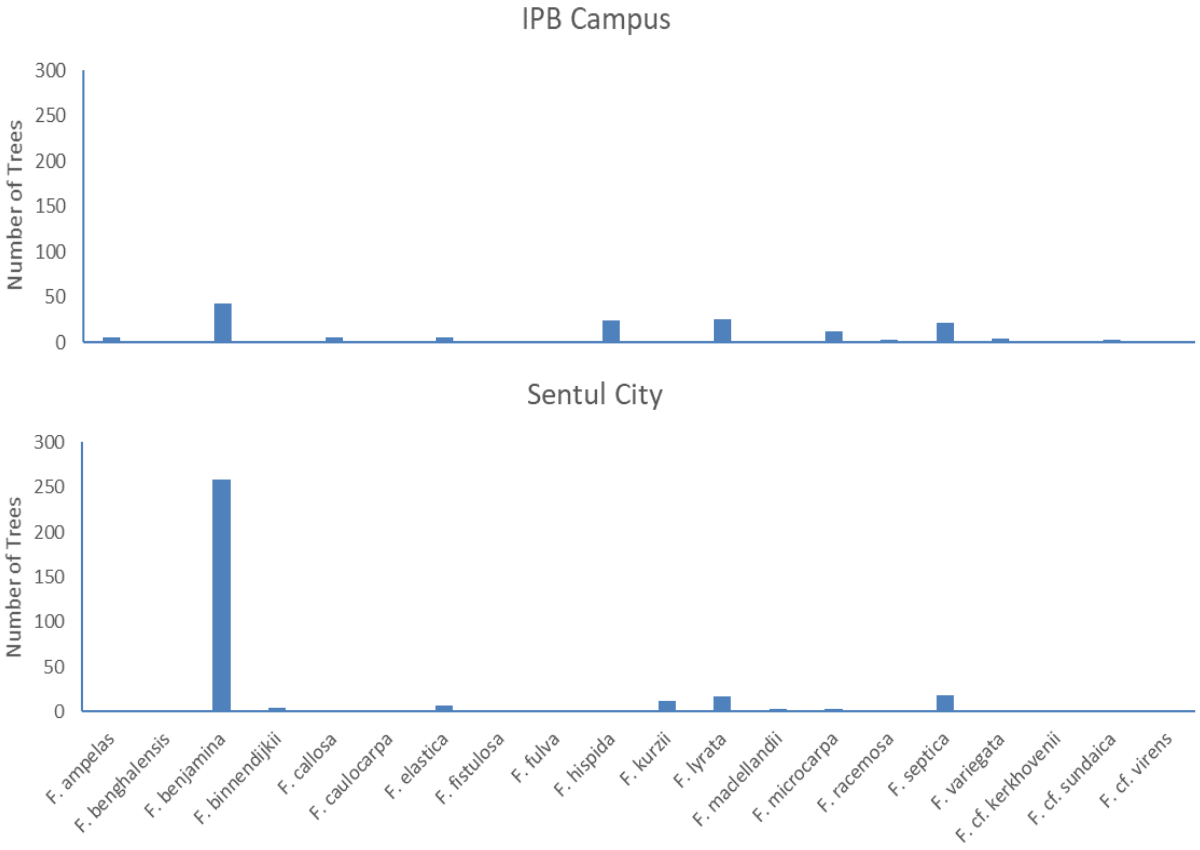

Figure 12 The relative abundance of fig trees in IPB Darmaga Campus and Sentul City.

Table 6 Number of Ficus found in IPB Campus area based on growth stages

Species	Darmaga Campus			Sentul City		
	Tree	Poles	Saplings	Tree	Poles	Saplings
F. ampelas	3	2	0	0	0	0
F. benghalensis	1	0	0	0	0	0
F. benjamina	37	0	6	238	58	0
F. binnendijkii	0	0	0	5	0	0
F. callosa	5	0	0	0	0	0
F. caulocarpa	0	0	0	1	0	0
F. cf. kerkhovenii	1	0	0	0	0	0
F. cf. sundaica	3	0	0	0	0	0
F. cf. virens	1	0	0	0	0	0
F. elastica	4	1	0	6	4	0
F. fistulosa	0	0	1	0	0	0
F. fulva	0	0	1	0	0	0
F. hispida	9	8	7	0	0	0
F. kurzii	0	0	0	47	30	0
F. lyrata	15	10	0	32	11	0
F. maclellandii	1	0	0	3	0	0
F. microcarpa	12	0	0	8	7	0
F. racemosa	2	1	0	0	0	0
F. septica	3	5	13	0	0	19
F. variegata	3	1	0	0	1	0
Total	100	28	28	340	111	19

Ficus trees in Darmaga Campus can be found in variation of habitats, including buildings, open agricultural farm, arboretum, and housing complex (Fig. 13). Almost all figs were natural, which differs with Sentul City. Each residential cluster in Sentul City was planted certain species as the 'theme' of the cluster. For Victoria Cluster, the theme is fig trees. Of total number of fig trees in the study area, about half (49.3%) were found in this Cluster (Table 7; Fig 14). Examples of other themes in other clusters in Sentul City are weeping *bottlebrush Callistemon viminalis*, stone apple *Aegle marmelos*, raintree *Samanea saman*, and sea mango Cerbera manghas.

The fig trees in Victoria Clusters were possibly planted in 1994, when the residential area was first developed. The fig trees were planted along the road within the cluster as shading trees, and in the periphery of the Cluster as borders. Victoria Cluster is located at the border of the Sentul City and adjacent residential area. The figs as borders were high and has a large diameter, as they never been pruned or thinned, mostly located in downhill sites. The fig as shading trees, on the other hand, mostly have been undergone thinning or pruning by the residents when the figs get bigger, as the trees might interfere with buildings and streets. Therefore, tree samples selected for further research were border trees, of which their condition are still natural (i.e. free of pruning, thinning, and cutting).

Table 7 Number of fig trees in Sentul City Residential Area

No	Species	Residential Cluster			MH Thamrin Boulevard	Total
		Victoria	Mediterania 2	Bukit Golf Hijau		
1	*Ficus benjamina*	128	21	1	98	248
2	*Ficus binnendijkii*	-	-	-	4	4
3	*Ficus caulocarpa*	1	-	-	-	1
4	*Ficus elastica*	2	-	5	-	7
5	*Ficus kurzii*	49	-	-	7	56
6	*Ficus lyrata*	-	-	-	37	37
7	*Ficus maclellandii*	-	3	-	-	3
8	*Ficus microcarpa*	10	-	-	3	13
9	*Ficus septica*	1	-	-	18	19
10	*Ficus variegata*	1	-	-	-	1
	Total	192	24	6	167	389

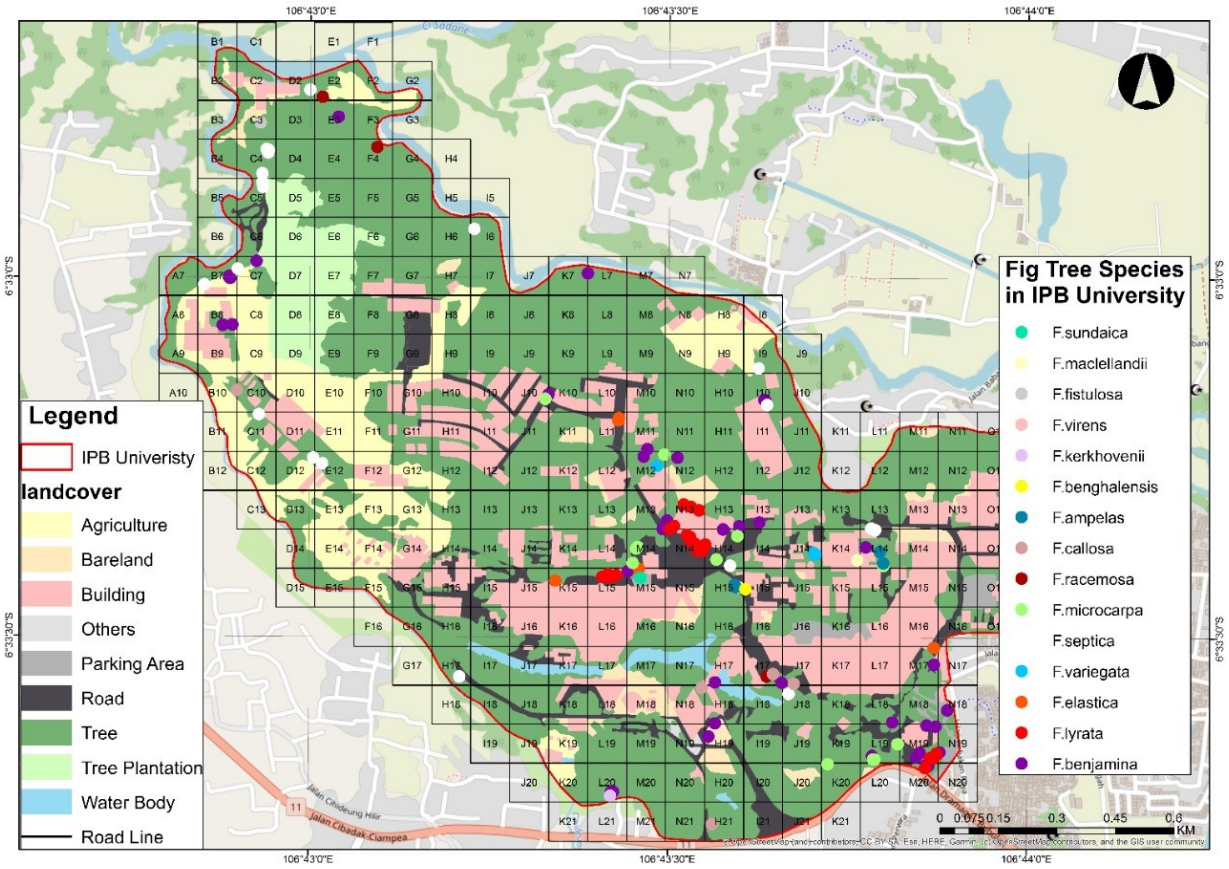

Figure 13 Distribution of fig trees in IPB Darmaga Campus

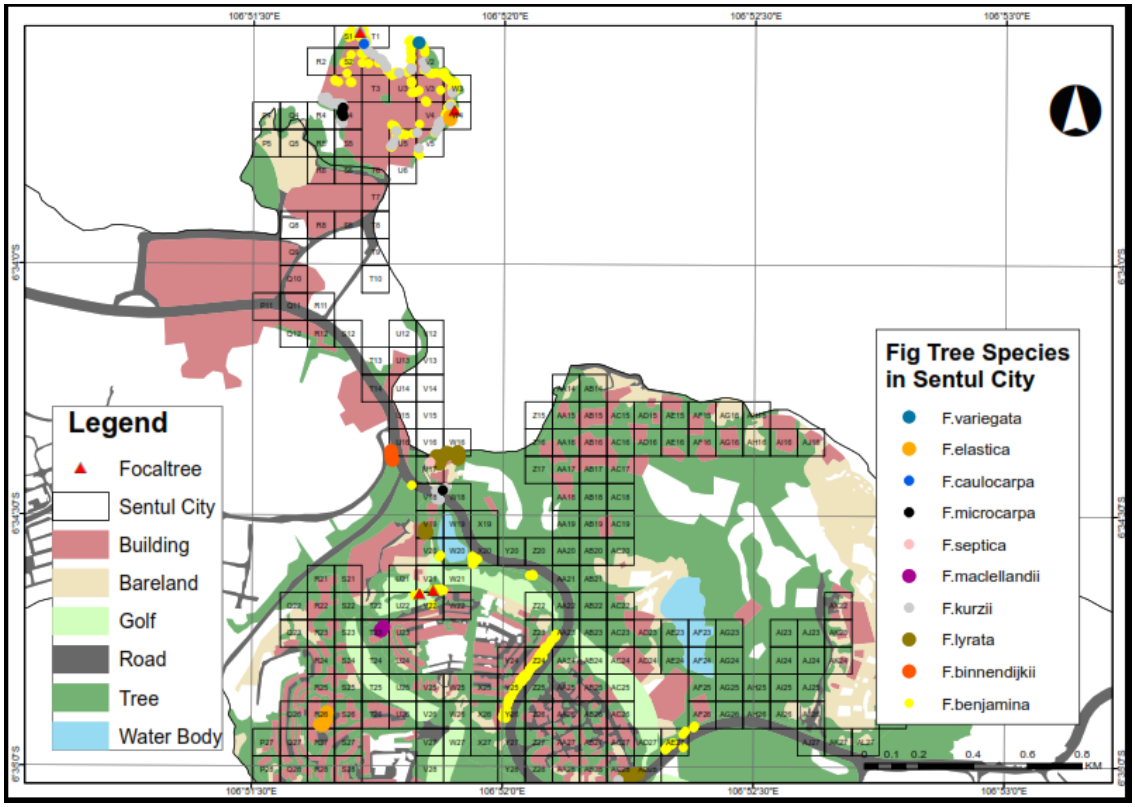

Figure 14 Mapping of the distribution of fig trees in Sentul City

Most of fig trees are not situated near building, although several are really closed, mostly saplings that probably distributed by natural means (Table 8). Most Fig tree species found in IPB Darmaga campus were located close to road, less than 10m from the roadside. However, 26% are located more than 10 m from roads. Only 15% were located less than 1 m from road. In contrast, only 7% of fig trees in Sentul City were located more than 10 m from roads and 41% were located less than 1 m from road (Fig 15). Most of fig trees are located more than 20m from water source (Fig 16)

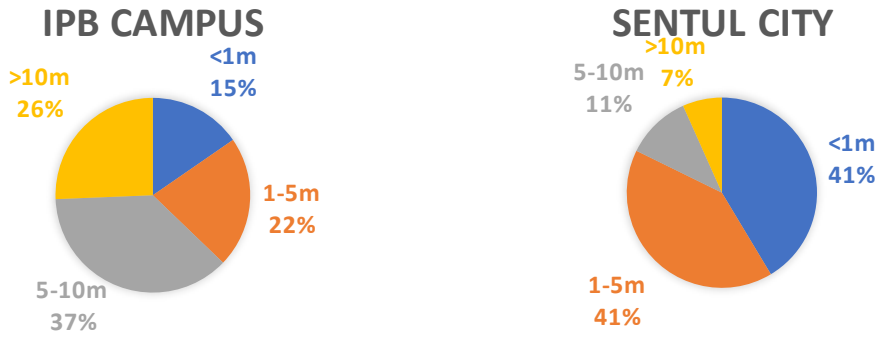

Figure 15 Position of Ficus trees in relation to road in IPB Darmaga Campus and Sentul City

Table 8 Distance from the nearest building (mean+SD) in meters and range (minimum and maximum distance

	IPB Campus		Sentul City	
Species	Mean	Range	Mean	Min
Ficus ampelas	20.94±6.23 (n=5)	10.50-26.00		
Ficus benghalensis	13.50 (n=1)	13.50		
Ficus benjamina	22.94±13.96 (n=43)	1.25-49.10	8.16±7.99 (n=248)	0.00-55.20
Ficus binnendijkii			2.89±0.29 (n=4)	2.45-3.10
Ficus callosa	23.04±13.99 (n=5)	5.20-38.54		
Ficus caulocarpa			0.00	0.00
Ficus cf. kerkhovenii	17.20 (n=1)	17.20		
Ficus cf. sundaica	4.07±0 (n=3)	4.07		
Ficus cf. virens	9.60 (n=1)	9.60		
Ficus elastica	14.22±11.48 (n=5)	1.50-27.84	12.30±9.88 (n=7)	0.00-25.73
Ficus fistulosa	36.60 (n=1)	36.60		
Ficus fulva	32.40 (n=1)	32.40		
Ficus hispida	25.44±15.30 (n=24)	5.00-52.00		
Ficus kurzii			7.78±6.12 (n=56)	0.60-29.04
Ficus lyrata	21.13±13.12 (n=25)	4.20-50.00	15.43±7.01 (n=37)	5.33-34.57
Ficus maclellandii	1.87 (n=1)	1.87	0.00 (n=3)	0.00
Ficus microcarpa	25.87±13.71 (n=12)	7.65-42.53	8.05±6.92 (n=13)	0.00-28.46
Ficus racemosa	12.80 (n=3)	12.80		
Ficus septica	25.07± 14.32 (n=21)	4.30-51.00	0 (n=19)	0.00
Ficus variegata	9.45±5.48 (n=4)	3.40-15.20	0.50 (n=1)	0.50
Grand Total	21.62±13.47 (n=156)	1.25-52.00	8.81±7.92 (n=389)	0.00-55.20

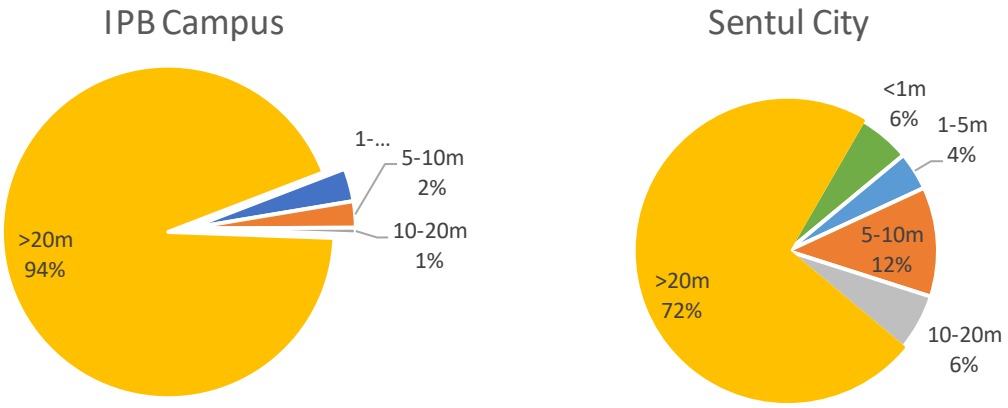

Figure 16 Position of Ficus trees in relation to water source IPB Darmaga Campus and Sentul City

B. NATURAL AREAS

B.1 Diversity of Fig Trees

A total of 28 Ficus species identified in the Citalahb-Cikaniki Trail with *Ficus lepicarpa* as the most abundant species (Table 9).

Table 9 Fig tree species found in the study sites and its relative abundance, listed in alphabetical order

No	Species	Common Name	Citalahab-Cikaniki Trail
1	*Ficus allutacea*	Ki sigung (Sundanese	+
2	*Ficus annulata*	kiara koneng (Sundanese), Ficus pohon	+
3	*Ficus asperiuscula*	Amis mata	+
4	*Ficus cf. sumatrana*	Kiara	+
5	*Ficus consociata*	Brown-Scurfy Fig, Ficus kebo	+
6	*Ficus cuspidata*	Ficus oren kecil	++
7	*Ficus deltoidea*	Ki centong	++
8	*Ficus fistulosa*	Beunying darat	++
9	*Ficus glaberrima*	Ki ara	+
10	*Ficus grossularioides*	Sehang	+
11	*Ficus heteropleura*	Ficus bintik	+
12	*Ficus laevis*	Ficus daun bulat	+
13	*Ficus lanata*	Ki sigung	++
14	*Ficus lepicarpa*	Beunying cai	+++
15	*Ficus obscura*	Ficus oren palsu	+
16	*Ficus padana*	Hamerang	++
17	*Ficus pisifera*	Ficus totol	+
18	*Ficus punctata*	Liana fiucs besar	++
19	*Ficus ribes*	Walen	++
20	*Ficus sinuata*	Ficus oren besar	++
21	*Ficus subulata*	Ficus oren	+
22	*Ficus sumatrana*	Kiara	+
23	*Ficus sundaica*	Kiara beas	++
24	*Ficus tricolor*	Kondang kecil	++
25	*ficus variegata*	Kondang besar	+
26	*Ficus vasculosa*	Ficus kendeng bawah	+
27	*Ficus villosa*	Ki sigung Besar	+
28	*unknown*	Darandan	+
	Total number of species		28

+++: abundant (>100), ++: common (10-99), +: rare (<10)

B.2. General Features of Fig Trees

About a third of the fig tree in Citalahab-Cikaniki trail were coiled or strangled lianas with host tree still visible (Table 10). The highest number of ficus with host tree are Ficus lanata (n=58), Ficus cuspidata (n=51) and Ficus deltoidea (n=28). The highest number of host tree is Rasamala (Altingia excelsa, n=87), followed by Pasang (*Quercus sundaica, n = 41) and Puspa (*Schima wallichii, n = 30).

Table 10 Dominant form of Fig tree in Citalahab-Cikaniki Trail

Species	Sole tree	Coiled liana <50%	Strangled liana >50%
Ficus allutacea	1		
Ficus annulata	2		
Ficus asperiuscula	2		
Ficus cf. sumatrana	2		
Ficus consociata	1		2
Ficus cuspidata	4	51	
Ficus deltoidea		28	
Ficus fistulosa	82		
Ficus glaberrima	2		1
Ficus grossularioides	1		
Ficus heteropleura		7	
Ficus laevis		1	
Ficus lanata		58	
Ficus lepicarpa	196		
Ficus obscura		1	
Ficus padana	31		
Ficus pisifera		4	
Ficus punctata		50	
Ficus ribes	55		
Ficus sinuata	1	25	
Ficus subulata		1	
Ficus sumatrana			3
Ficus sundaica	7		4
Ficus tricolor	49		
ficus variegata	6		
Ficus vasculosa	1		
Ficus villosa		1	
unknown	2		
Grand Total	**445**	**227**	**10**

The largest fig tree found in Citalahab-Cikaniki Trail was *Ficus sundaica* (dbh 589.81cm, total height 36.87 m), followed by *Ficus glabberina* (dbh 288.85.81cm, total height 21 m), and *Ficus annulata* (dbh 245.86 cm, total height 35 m). Average height and diameter of fig trees can be seen in Table 11.

Table 11 Mean heights and diameter of Ficus species in Ciatalahb-Cikaniki Trail

Species	Height (m)	Clear bole (m)	Dbh (cm)
Ficus allutacea	25.63 (n=1)	8.08 (n=1)	11.46 (n=1)
Ficus annulata	34.29 ± 1.00 (n=2)	13.41 ± 2.26 (n=2)	197.43 ± 68.49 (n=2)
Ficus cf. sumatrana	21.85 ± 1.98 (n=2)	11.85 ± 7.85 (n=2)	20.655 ± 2.54 (n=2)
Ficus consociata	9.07 ± 15.71 (n=3)	3.07 ± 5.33 (n=3)	66.87 ± 115.84 (n=3)
Ficus fistulosa	8.42 ± 3.61 (n=82)	4.07± 2.19 (n=82)	13.73 ± 5.77 (n=82)
Ficus glaberrima	14 ± 12.12 (n= 3)	6.67 ± 5.77 (n= 3)	6.67 ± 5.77 (n= 3)
Ficus lepicarpa	7.91 ± 3.42 (n=196)	3.21 ± 1.93 (n=196)	15.37 ± 7.53 (n=196)
Ficus padana	10.99 ± 4.36 (n=31)	5.15 ± 2.35 (n=31)	19.88 ± 9.74 (n=31)
Ficus ribes	7.38 ± 4.81 (n= 55)	3.26 ± 2.73 (n= 55)	11.61 ± 6.76 (n= 55)
Ficus sumatrana	13.00 ± 22.52 (n= 3)	7.33 ± 12.70 (n= 3)	23.33 ± 40.41 (n= 3)
Ficus sundaica	17.53 ± 14.68 (n= 11)	7.05 ± 6.31 (n= 11)	169.14 ± 206.82 (n= 11)
Ficus tricolor	9.29 ± 7.29 (n= 49)	5.25 ± 4.52 (n= 49)	11.75 ± 10.80 (n= 49)
ficus variegata	19.39 ± 3.91 (n= 6)	6.07 ± 3.37 (n= 6)	49.21 ± 21.51 (n= 6)
Ficus vasculosa	17.37 (n=1)	13 (n=1)	53.50 (n=1)
unknown	6.14 ± 0.91 (n=2)	2.11 ± 0.15 (n=2)	16.88 ± 1.80 (n=2)

Almost half of the tree have no fruit during survey (n=336 from 682 tree). However, most of the species were seen fruiting either early fruiting to late fruiting (25 out of 28 species). The timing of fruiting seems similar between year (Table 12). Most of the fruits were small, the biggest fruit is Ficus punctata with the dimension of (6.67 ± 1.93) x (5.47 ± 1.03) cm (Table 13).

Table 12 Fruiting stage of several fig trees in Citalahab-Cikaniki Trail during 2021 and 2022 survey

Year/Species	No fruit	Early Fruiting	Full fruiting	Late fruiting
2021	**84**	**97**	**11**	**7**
Ficus allutacea	1			
Ficus annulata				1
Ficus cf. sumatrana	2			
Ficus consociata	1			
Ficus fistulosa	17	15	3	1
Ficus glaberrima				2
Ficus lepicarpa	41	41	1	
Ficus padana	3	13	2	
Ficus ribes	8	18	4	1
Ficus sundaica	2	4		1
Ficus tricolor	5	4	1	
ficus variegata	2	1		1
Ficus vasculosa	1			
unknown	1	1		
2022	**252**	**83**	**36**	**112**
Ficus annulata	1			
Ficus asperiuscula		2		
Ficus consociata	2			

Ficus cuspidata	31	7	4	13
Ficus deltoidea	16	8		4
Ficus fistulosa	16	11	3	16
Ficus glaberrima	1			
Ficus grossularioides		1		
Ficus heteropleura	2	1	2	2
Ficus laevis		1		
Ficus lanata	30	13	2	13
Ficus lepicarpa	76	9	1	27
Ficus obscura			1	
Ficus padana	6	1	3	3
Ficus pisifera	2	1	1	
Ficus punctata	16	14	2	18
Ficus ribes	13	2	5	4
Ficus sinuata	16	3	1	6
Ficus subulata			1	
Ficus sumatrana	3			
Ficus sundaica	3	1		
Ficus tricolor	18	7	9	5
ficus variegata			1	1
Ficus villosa		1		
Grand Total	**336**	**180**	**47**	**119**

Table 13 Characteristics of fruit, average width x average height (mm) of fig trees in natural area

Species	Mean Width ± stddev (cm)	Mean Length ± stddev (cm)	Colour
Ficus annulata	1.9 (n=1)	1.65 (n=1)	Black
Ficus asperiuscula	1.2 (n=1)	1.25 (n=1)	Red
Ficus cf. sinuata	1.65 ± 0.07 (n=2)	1.28 ± 0.25 (n=2)	
Ficus cuspidata	0.47 ± 0.05 (n=21)	0.39 ± 0.08 (n=21)	Green, orange, yellow, red
Ficus deltoidea	1.06 ± 0.05 (n-5)	1.34 ± 0.06 (n-5)	Green
Ficus fistulosa	1.84 ± 0.64 (n=51)	2.04 ± 0.68 (n=51)	Green
Ficus grossularioides	1.2 (n=1)	1.1 (n=1)	Yellow
Ficus heteropleura	0.74 ± 0.08 (n=21)	0.66 ± 0.07 (n=21)	Orange
Ficus laevis	3.9 (n=1)	3.4 (n=1)	Green
Ficus lanata	0.6 (n=1)	0.65 (n=1)	Orange
Ficus lepicarpa	1.33 ± 0.56 (n=26)	1.63 ± 0.28 (n=26)	Chocolate, Green
Ficus padana	2.67 ± 0.54 (n=30)	3.25 ± 0.78 (n=30)	Green
Ficus pisifera	1 ± 0.10 (n=27)	0.98 ± 0.10 (n=27)	Green, Orange, Yellow
Ficus punctata	6.67 ± 1.93 (n=3)	5.47 ± 1.03 (n=3)	Red
Ficus ribes	0.82 ± 0.21 (n=51)	0.96 ± 0.28 (n=51)	Green
Ficus sinuata	0.60 ± 0.08 (n=22)	0.57 ± 0.09 (n=22)	Orange, Red, Yellow
Ficus subulata	1.31 ± 0.15 (n=20)	1.23 ± 0.12 (n=20)	Green, Orange, Yellow

Ficus sundaica	1.12 ± 0.17 (n=35)	0.88 ± 0.24 (n=35)	Black
Ficus tricolor	2.15 ± 0.34 (n=26)	1.99 ± 0.53 (n=26)	Green, Orange, Red, Yellow
Ficus variegata	3.6 (n=1)	3.5 (n=1)	Green
Unknown (Damerang)	0.50 ± 0.02 (n=42)	0.49 ± 0.02 (n=42)	

B. 3. Composition, Abundance and Distribution of Fig Trees in natural areas vs urban Areas

A total of 682 individuals of 28 Ficus species were identified during the study in Citalahab-Cikaniki Trail, comprised of tree growth stages, i.e. tree, poles, saplings, seedlings. We did not categorize growth stage of liana (Table 14). Although consisted of different growth stages, life form of figs in both locations are dominated by trees, with *F. lepicarpa* as the most abundant species. Distribution of ficus species is shown in Fig. 17

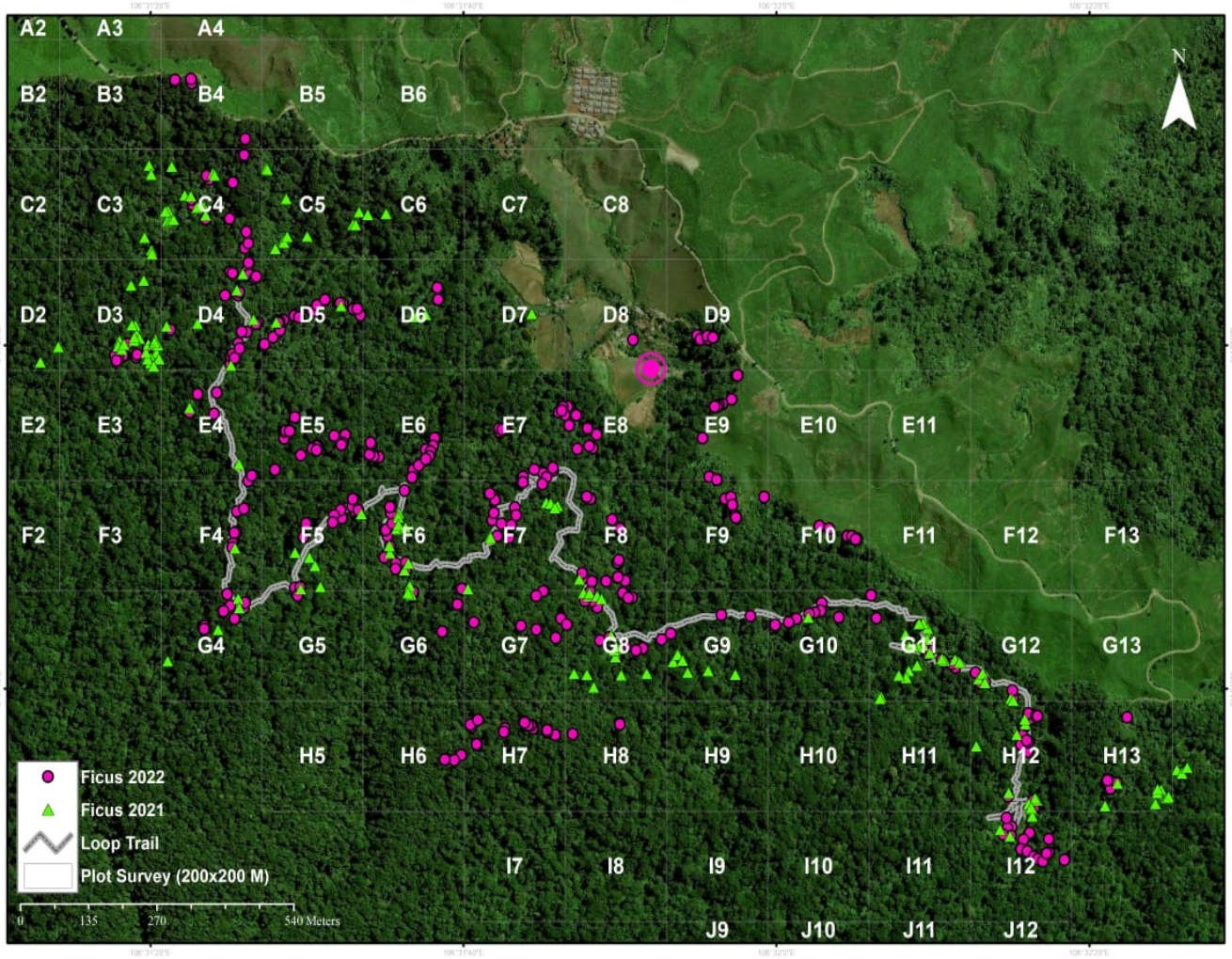

Figure 17 Distribution of Ficus Species in Citalahab-Cikaniki Trail, Mout Halimun Salak National Park

Table 14 Number of Ficus species found during 2021 and 2022 survey in Citalahab-Cikaniki

Species	Liana	Pole	Sapling	Seedling	Tree	Grand Total
Ficus allutacea		1				1
Ficus annulata					2	2
Ficus asperiuscula				2		2
Ficus cf. sumatrana		1			1	2
Ficus consociata	2				1	3
Ficus cuspidata	51			4		55
Ficus deltoidea	28					28
Ficus fistulosa		37	31	7	7	82
Ficus glaberrima	1				2	3
Ficus grossularioides				1		1
Ficus heteropleura	7					7
Ficus laevis	1					1
Ficus lanata	58					58
Ficus lepicarpa		75	76	6	39	196
Ficus obscura	1					1
Ficus padana		13	6		12	31
Ficus pisifera	4					4
Ficus punctata	50					50
Ficus ribes		32	13	8	2	55
Ficus sinuata	25	1				26
Ficus subulata	1					1
Ficus sumatrana	3					3
Ficus sundaica	4				7	11
Ficus tricolor		22	19	2	6	49
ficus variegata					6	6
Ficus vasculosa					1	1
Ficus villosa	1					1
unknown		2				2

The composition of Ficus species between natural areas and urban areas differs. Cluster analysis using single linkage and Morisita indices shows that there are almost no similarities between natural areas and urban area. Ficus species in IPB Darmaga and Sentul formed a cluster with more than 0.5 similarities (Fig. 18).

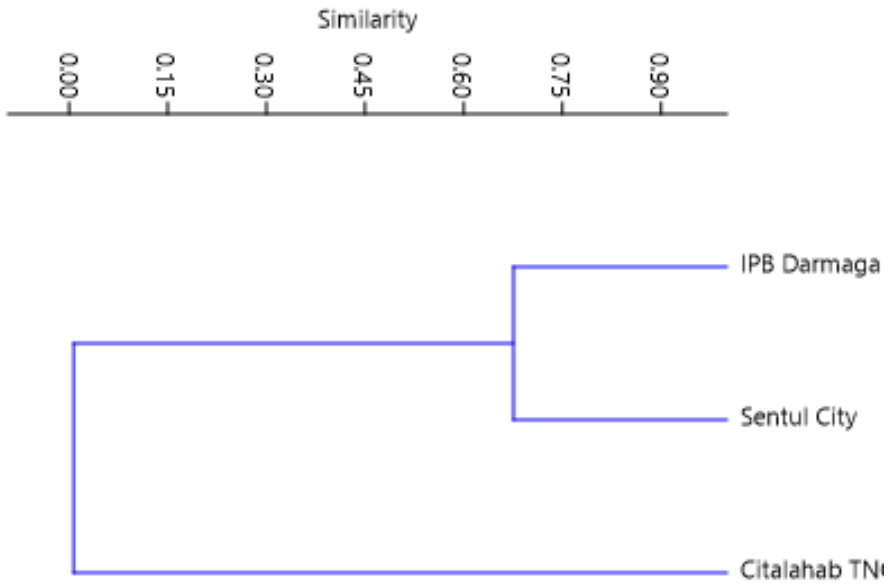

Figure 18 Dendogram of single linkage cluster using Morisita similarities. Data analysed using PAST 4.11

Compared to urban areas, ficus tree in natural areas are not planted. They were found in the forest, far from village (thus far from building) and also far from road. Only a small number is found near building, which is actually the research station of Cikaniki. About half of the Ficus tree is found near water source (about 1-5 m) (Fig. 19)

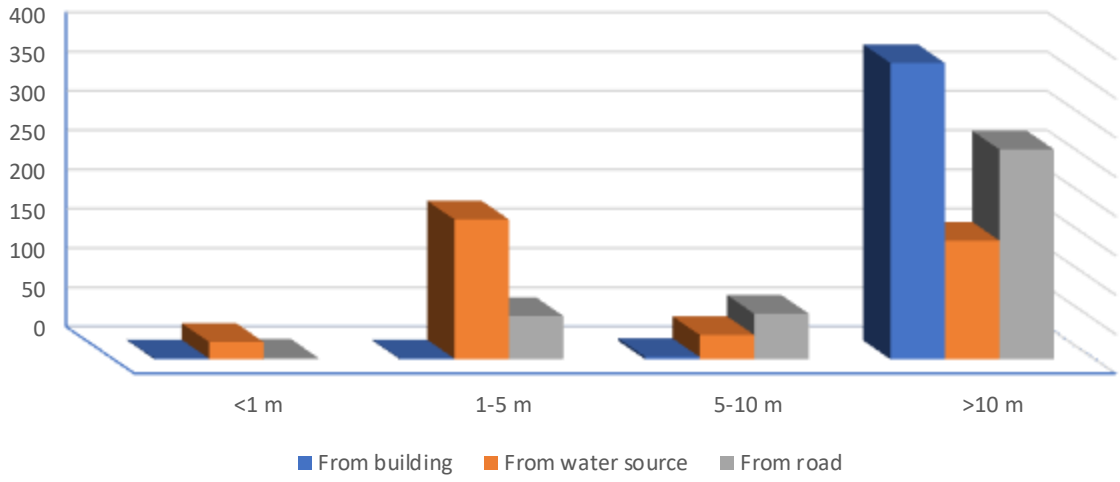

Figure 19 Distance of fig trees from building, water source and road

3.2. WILDLIFE SPECIES

A total of 21 mammal species of 11 families were recorded using fig trees and habitat within radius 20m of the fig trees during the 3-year study (Table 15). However, only 5 mammal species were recorded in urban area, while 17 species were recorded in natural area. The Javan Tree Shrew was the only mammal species found in both habitats. There was one bat species that we could not identify, however we include it as using the fig tree because of its activity feeding inside the canopy. The most frequent species observed using the fig trees in urban habitats were Plantain Squirrel that was recorded in all months of observation. In natural habitat Black-striped Squirrel and Javan Gibbon were the most frequent species that use fig trees.

The number of bird species recorded during the 3-year period was 99 species from 34 families (Table 15). Thirty-three species were recorded in urban habitats while 72 species were recorded in natural habitat in Mt Halimun-Salak National Park. The bird species recorded in both habitats were Spotted Dove, Collared Kingfisher, Sunda Pygmy Woodpecker, Small Minivet, Velvet-fronted Nuthatch, and Scarlet-headed Flowerpecker

There were 16 species of reptiles from 7 families, with 13 species found in urban habitat and only 6 species recorded in natural habitat (see Table 25). Three species were recorded in both habitats, those are Maned Forest Lizard, Common Flying Dragon, and Marbled Bowed-finger Gecko. We observed a total of 9 species of amphibians that belong to 6 families; 7 species were recorded in natural habitat while only 4 species were recorded in urban habitat. Only one species, White-lipped Frog, that was recorded in both habitats.

Table 15 Wildlife species observed at fig trees during the study period (based on rapid survey and observation on focal trees)

Taxa Family	Species	Common Name	IPB Campus (Urban Habitat)	Sentul City (Urban Habitat)	HSNP (Natural Habitat)
MAMMALS					
Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque; Crab-eating Macaque	+		
Cercopithecidae	*Presbytis comata*	Javan Surili			+
Cercopithecidae	*Trachypithecus auratus*	East Javan Langur			+
Cynocephalidae	*Galeopterus variegatus*	Sunda Flying Lemur			+
Hylobatidae	*Hylobates moloch*	Javan Gibbon			+
Mepithidae	*Mydaus javanensis*	Sunda Stink Badger			+
Muridae	*Maxomys sp*	Rat			+
Sciuridae	*Callosciurus notatus*	Plantain Squirrel	+		
Sciuridae	*Callosciuris nigrovittatus*	Black-striped Squirel	-		+
Sciuridae	*Callosciurus sp*	Borneo Black-banded Squirrel?			+
Sciuridae	*Hylopetes Lepidus*	Gray-cheeked flying squirrel	-	+	
Sciuridae	*Nannosciurus melanotis*	Black-eared Squirrel			+
Sciuridae	*Petaurista petaurista*	Red Giant Flying Squirrel			+
Sciuridae	*Ratufa bicolor*	Black Giant Squirrel			+

Taxa Family	Species	Common Name	IPB Campus (Urban Habitat)	Sentul City (Urban Habitat)	HSNP (Natural Habitat)
Suidae	*Sus scrofa*	Wild boar			+
Tupaiidae	*Tupaia javanica*	Javan Tree-Shrew	+		+
Viverridae	*Paradoxurus hermaphroditus*	Asian Palm Civet	-	+	+
Viverridae	*Paguma larvata*	Masked Palm Civet			+
Viveriidae	*Artogalidia trivirgata*	Small-toothed Palm Civet	-		+
Pteropodidae	*Cynopterus bracchyotis*	Leser Short-nosed Fruit-bat	+		
? Sub order Microchiroptera	-	(insectivorous bats-un identified)			+
BIRDS					
Accipitridae	*Spilornis cheela*	Crested Serpent Eagle			+
Phasianidae	*Arborophila javanica*	Chestnut-backed Partridge			+
Columbidae	*Treron vernans*	Pink-necked Green Pigeon	+		
Columbidae	*Treron gricseicauda*	Grey-cheeked Green Pigeon	+		
Columbidae	*Ptilinopus melanospila*	Black-naped Fruit Dove			+
Columbidae	*Ducula aenea*	Green Imperial Pigeon			+
Columbidae	*Spilopelia chinensis*	Spotted Dove	+	+	+
Psittacidae	*Psittacula alexandri*	Red-breasted Parakeet	+		
Psittacidae	*Loriculus galgulus*	Yellow-throated Hanging Parrot			+
Cuculidae	*Phaenicophaeus curvirostris*	Chestnut-breasted Malkoha			+
Cuculidae	*Cacomantis merulinus*	Plaintive Cuckoo	+	+	
Cuculidae	*Cacomantis sepulcralis*	Rusty-breasted Cuckoo			+
Cuculidae	*Surniculus lugubris*	Black Drongo	+		
Tytonidae	*Tyto alba*	Barn Owl			+
Strigidae	*Otus lempiji*	Collared Scops Owl	+		
Caprimulgidae	*Caprimulgus macrurus*	Large-tailed Nightjar	+		
Caprimulgidae	*Caprimulgus affinis*	Savanna Nightjar			+
Trogonidae	*Apalharpactes reinwardtii*	Blue-tailed Trogon			+
Alcedinidae	*Alcedo meninting*	Blue-eared Kingfisher			+
Alcedinidae	*Halcyon smyrnensis*	White-throated Kingfisher	+		
Alcedinidae	*Todirhamphus chloris*	Collared Kingfisher	+		+
Megalaimidae	*Psilopogon armillaris*	Flame-fronted Barbet			+
Megalaimidae	*Psilopogon corvinus*	Brown-throated Barbet			+
Megalaimidae	*Psilopogon haemacephalus*	Coppersmith Barbet	+		
Picidae	*Dendrocopos macei*	Fulvous-brested Woodpecker	+	+	
Picidae	*Dendrocopos moluccensis*	Sunda Pygmy Woodpecker	+		+

Taxa Family	Species	Common Name	IPB Campus (Urban Habitat)	Sentul City (Urban Habitat)	HSNP (Natural Habitat)
Picidae	*Reinwardtipicus validus*	Orange-backed Woodpecker			+
Eurylaimidae	*Eurylaimus javanicus*	Banded Broadbill			+
Pardalotidae	*Pteruthius aenobarbus*	Trilling Shrike-vireo			+
Pardalotidae	*Pteruthius flaviscapis*	*Pied Shrike-vireo*			+
Campephagidae	*Coracina javensis*	Javan Cuckooshrike			+
Campephagidae	*Coracina fimbriata*	Little Cuckooshrike			+
Campephagidae	*Coracina larvata*	Sunda Cuckooshrike			‘+
Campephagidae	*Lalage nigra*	Pied Triller	+		
Campephagidae	*Pericrocotus cinnamomeus*	Small Minivet	+	+	+
Campephagidae	*Pericrocotus miniatus*	Sunda Minivet			+
Campephagidae	*Pericrocotus flammeus*	Scarlet Minivet			+
Aegithinidea	*Aegithina tiphia*	Common Iora	+	+	
Chloropseidae	*Chloropsis cochinchinensiis*	Javan Leafbird			+
Chloropseidae	*Cholopsis sonnerati*	Greater Green Leafbird			+
Pycnonotidae	*Pycnonotus aurigaster*	Sooty-headed Bulbul	+	+	
Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul	+	+	
Pycnonotidae	*Pycnonotus bimaculatus*	Orange-spotted bulbul			+
Pycnonotidae	*Pycnonotus melanicterus*	Black-crested Bulbul	+		
Pycnonotidae	*Alophoixus bres*	Grey-cheeked Bulbul			+
Pycnonotidae	*Ixos virescens*	Sunda Bulbul			+
Turdidae	*Cochoa azurea*	Javan Cochoa			+
Turdidae	*Enicurus leschenaulti*	Whte-crowned Forktail			+
Turdidae	*Enicurus velatus*	Sunda Forktail			+
Turdidae	*Myophonus glaucinus*	Sunda Whistling Thrush			+
Turdidae	*Myophonus caeruleus*	Blue Whistling Thrush			+
Turdidae	*Zoothera citrina*	Orange-headed Thrush			+
Timaliidae	*Malacocincla sepiarium*	Horsfield's Babbler	+		
Timaliidae	*Alcippe pyrrhoptera*	Javan Fulvetta			+
Timaliidae	*Crocias albonotatus*	Spotted Crocias			+
Timaliidae	*Pnoepyga pusilla*	Pygmy Wren Babbler			+
Timaliidae	*Stachyris thoracica*	White-bibbed Babbler			+
Sylviidae	*Cettia vulcania*	Sunda Bush Warbler			+
Sylviidae	*Orthotomus sutorius*	Common Tailorbird	+	+	
Sylviidae	*Orthotomus sepium*	Olive-backed Tailorbird	+	+	
Aegithalidae	*Psaltria exilis*	Pygmy Bushtit			+
Paridae	*Parus major*	Great Tit			+
Sittidae	*Sitta frontalis*	Velvet-fronted Nuthatch	+		+
Sittidae	*Sitta azurea*	Blue Nuthatch			+
Muscicapidae	*Rhynomias olivacea*	Fulvous-chested Jungle Flycatcher			+

Taxa Family	Species	Common Name	IPB Campus (Urban Habitat)	Sentul City (Urban Habitat)	HSNP (Natural Habitat)
Muscicapidae	*Muscicapa dauurica*	Asian Brown Flycatcher	+		
Muscicapidae	*Eumyias indigo*	Indigo Flycatcher			+
Muscicapidae	*Ficedulahyperythra*	Snowy-browed Flycatcher			+
Muscicapidae	*Ficedula westermanni*	Little Pied Flycatcher			+
Muscicapidae	*Cyornis unicolor*	Pale Blue Flycatcher			+
Muscicapidae	*Culicicapa ceylonensis*	Grey-headed Canary-Flycatcher			+
Dicaeidae	*Prionochilus percussus*	Crimson-breasted Fowerpecker			+
Dicaeidae	*Dicaeum trigonostigma*	Orange-bellied Flowerpecker			+
Dicaeidae	*Dicaeum sanguinolentum*	Blood-breasted Flowerpecker			+
Dicaeidae	*Dicaeum trochileum*	Scarlet-headed Flowerpecker	+	+	+
Nectariniidae	*Aethopyga eximia*	White-flanked Sunbird			+
Nectariniidae	*Aethopyga mystacalis*	Javan Sunbird			+
Nectariniidae	*Anthreptes singalensis*	Ruby-cheeked Sunbird			+
Nectariniidae	*Anthreptes sp*	Sunbird			+
Nectariniidae	*Arachnothera longirostra*	Little Spiderhunter			+
Nectariniidae	*Arachnothera robusta*	Long-billed Spiderhunter			+
Nectariniidae	*Arachnothera affinis*	Streaky-breasted Spiderhunter			+
Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	+		
Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbirds	+	+	
Zosteropidae	*Zosterops palpebrosus*	Oriental White-eye	+		
Zosteropidae	*Zosterops montanus*	Mountain White-eye			+
Zosteropidae	*Zosterops melanurus*	Sunda White-eye			+
Zosteropidae	*Heleia javanica*	Javan Heleia			+
Estrildidae	*Lonchura leucogastroides*	Javan Munia		+	+
Estrildidae	*Lonchura punctulata*	Scaly-breasted Munia	+		
Ploceidae	*Passer montanus*	Eurasian Tree Sparrow		+	
Sturnidae	*Aplonis minor*	Short-tailed Starling			+
Sturnidae	*Gracupica contra*	Pied Myna	+		
Sturnidae	*Acridotheres javanicus*	White-vented Myna			+
Oriolidae	*Oriolus chinensis*	Black-naped Oriole	+		
Dicruridae	*Dicrurus macrocercus*	Black Drongo			+
Dicruridae	*Dicrurus leucophaeus*	Ashy Drongo			+
Dicruridae	*Dicrurus remifer*	Lesser Racquet-tailed Drongo			+
Artamidae	*Artamus leucorhynchus*	White-breasted Woodswallow			+
REPTILES					
Agamidae	*Bronchocela jubata*	Maned Forest Lizard	+		+

Taxa Family	Species	Common Name	IPB Campus (Urban Habitat)	Sentul City (Urban Habitat)	HSNP (Natural Habitat)
Agamidae	*Calotes versicolor*	Common Garden Lizard	+		
Agamidae	*Draco volans*	Common Flying Dragon	+		+
Agamidae	*Gonocephalus kuhli*	Chameleon			+
Gekkonidae	*Cyrtodactylus marmoratus*	Marbled Bowed- finger Gecko	+		+
Gekkonidae	*Gekko gecko*	Tokay Gecko	+		
Gekkonidae	*Hemidactylus frenatus*	Common House-Gecko	+		
Gekkonidae	*Hemidactylus platyurus*	Flat-tiled House Gecko	+		
Lacertidae	*Takydromus sexlineatus*	Asian Grass Lizard		+	
Scincidae	*Eutropis multifasciata*	Sun Skink	+		
Scincidae	*Dasia olevaceae*	Olive Tree Skink	+		
Scincidae	*Sphenomorphus sanctus*	Java Forest Skink			+
Colubridae	*Ahaetulla prasina*	Oriental Whip Snake	+		
Colubridae	*Rhabdopis sp*	Keelback Snake			+
Pareidae	*Pareas carinatus*	Keeled Slug-eating Snake	+		
Viperidae	*Trimeresurus albolabris*	White-lipped Tree Viper	+		
AMPHIBIANS					
Dicroglossidae	*Fejervarya limnocharis*	Rice field Frog			+
Megophryidae	*Leptobrachium hasseltii*	Hasselt's Liter Frog			+
Megophryidae	*Megophrys montana*	Javan Horned Frog			+
Microhylidae	*Microhyla achatina*	Javan Chorus Frog			+
Rhacophoridae	*Polypedates leucomystax*	Common Tree Frog	+	+	
Rhacophoridae	*Chiromantis vittiger*	Indonesian Bubble-nest Frog			+
Rhacophoridae	*Rhacophorus margaritifer*	Harlequin Tree Frog			+
Ranidae	*Chalcorana chalconota*	White-lipped Frog, Copper cheeked Frog	+		+
Bufonidae	*Duttaphrynus melanostictus*	Asian common toad	-	+	

3.2.1 Monthly Variation in Wildlife Species and Abundance

Number of wildlife species and records varied during observation period both in urban and natural habitats (Fig 20-21). Mammal use of fig trees was more varied in urban than natural habitat. In general use of wildlife in urban habitat was lower during early rainy season (Nov-Dec), but increase in January, except for herpetofauna. Less variation found in natural habitat.

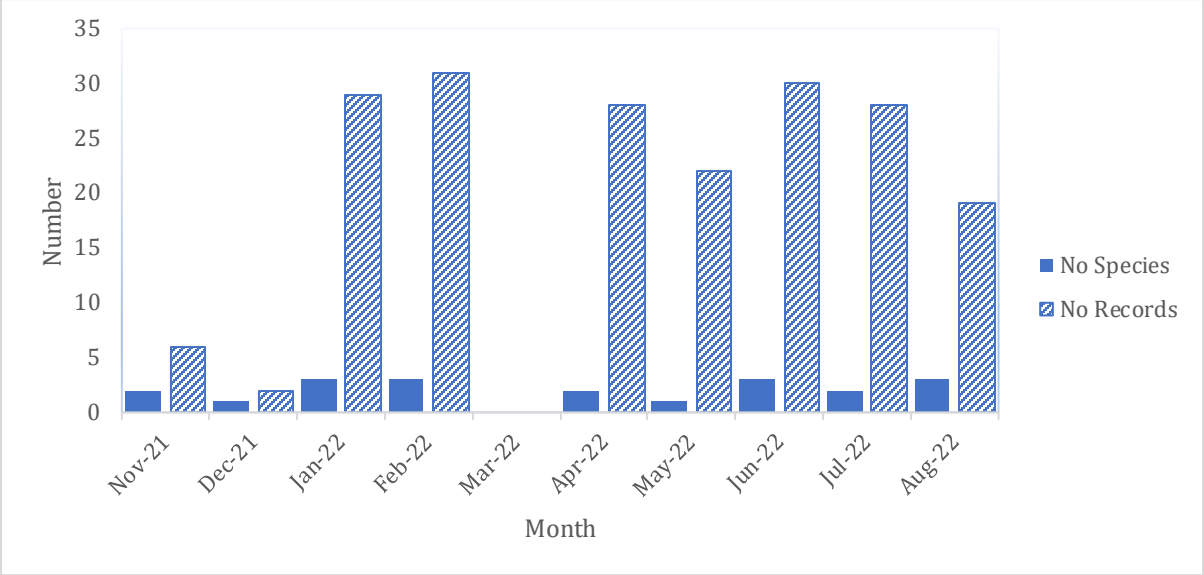

Figure 20 Number of species and records of mammals using fig trees based on observation of focal trees in IPB Dramaga Campus

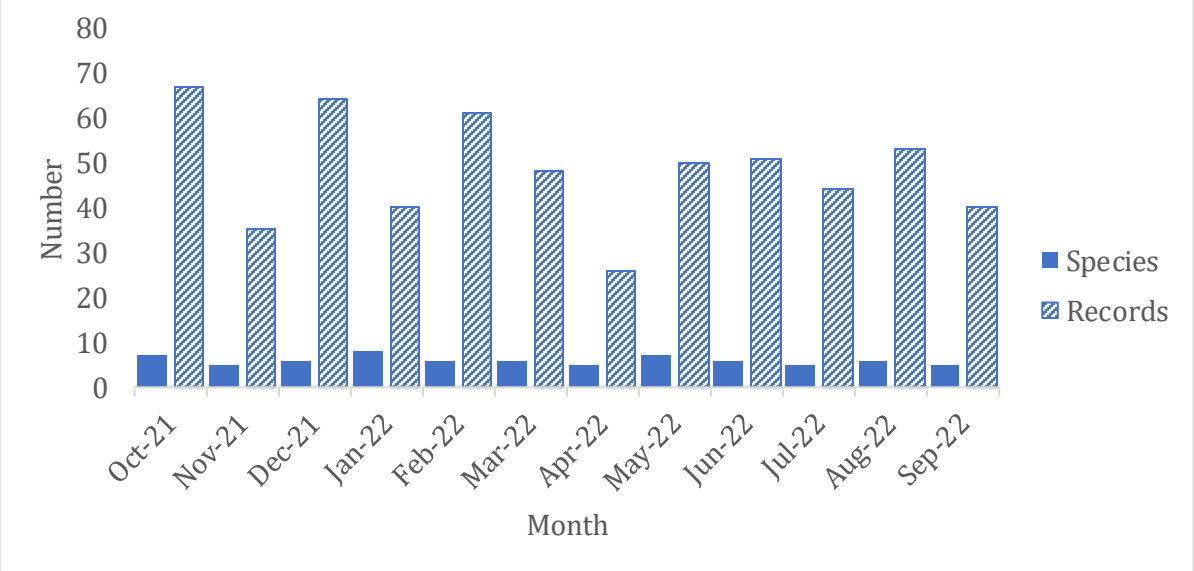

Figure 21 Number of species and records of mammals using fig trees based on observation of focal trees in Halimun Salak National Park

In urban habitat use of fig tree by bird species was lower during November and December and reached the highest during April -May. Use of fig tree by birds in natural habitat seemed to be more varied with abundance fluctuated every other month (Fig. 22-23).

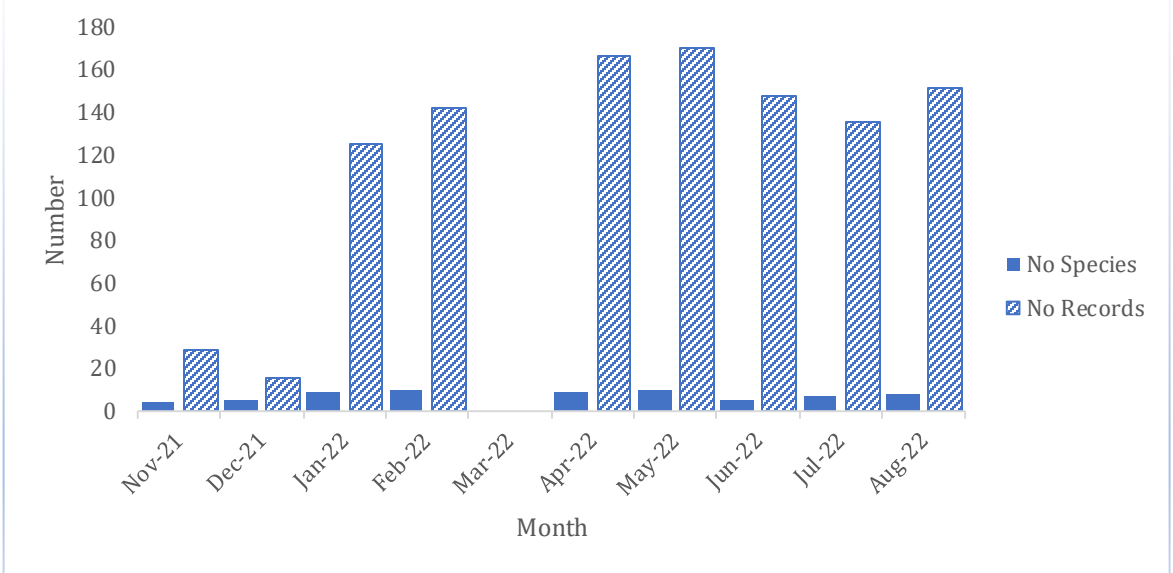

Figure 22 Number of species and records of birds using fig trees based on observation of focal trees in IPB Campus

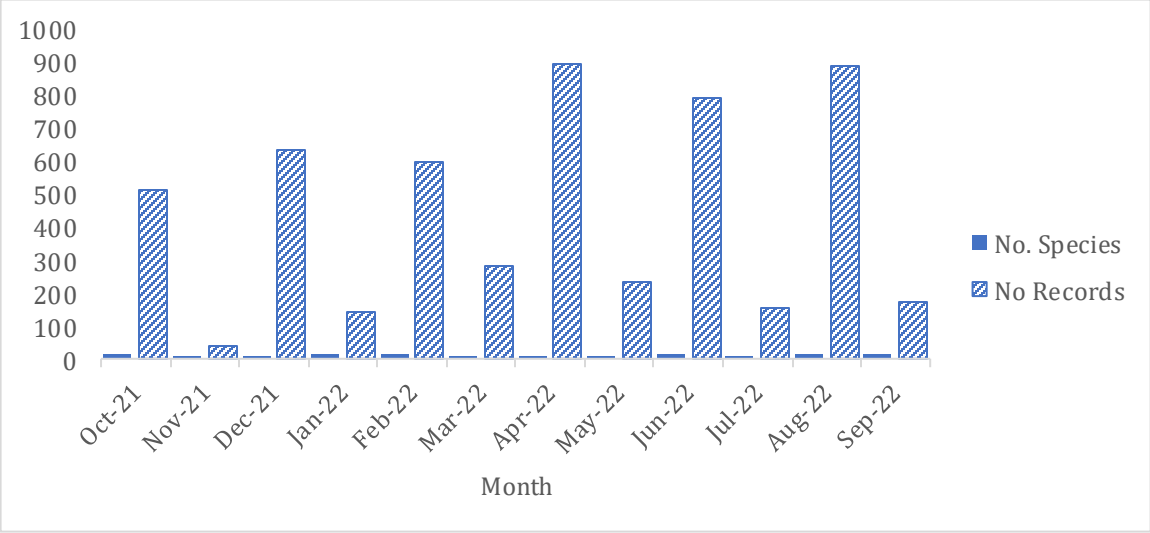

Figure 23 Number of species and records of birds using fig trees based on observation of focal trees in Halimun Salak NP

Use by herpetofauna was observed almost every month in urban habitat but was only observed from October 2021 to January 2022 in natural habitat (Fig 24-25)

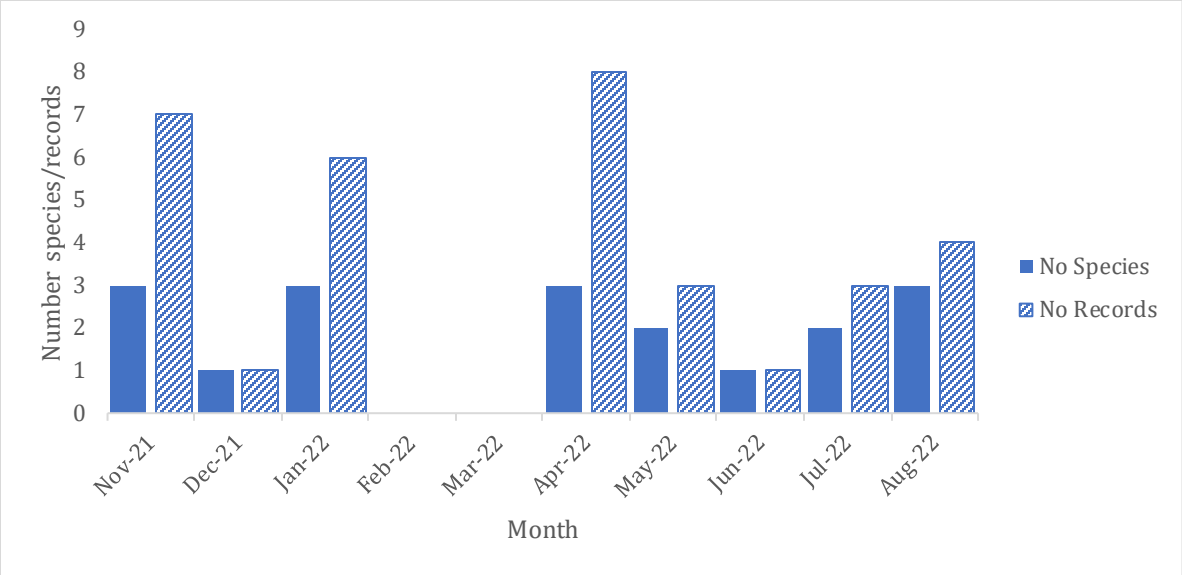

Figure 24 Number of species and records of herpetofauna using fig trees based on observation of focal trees in IPB Dramaga Campus

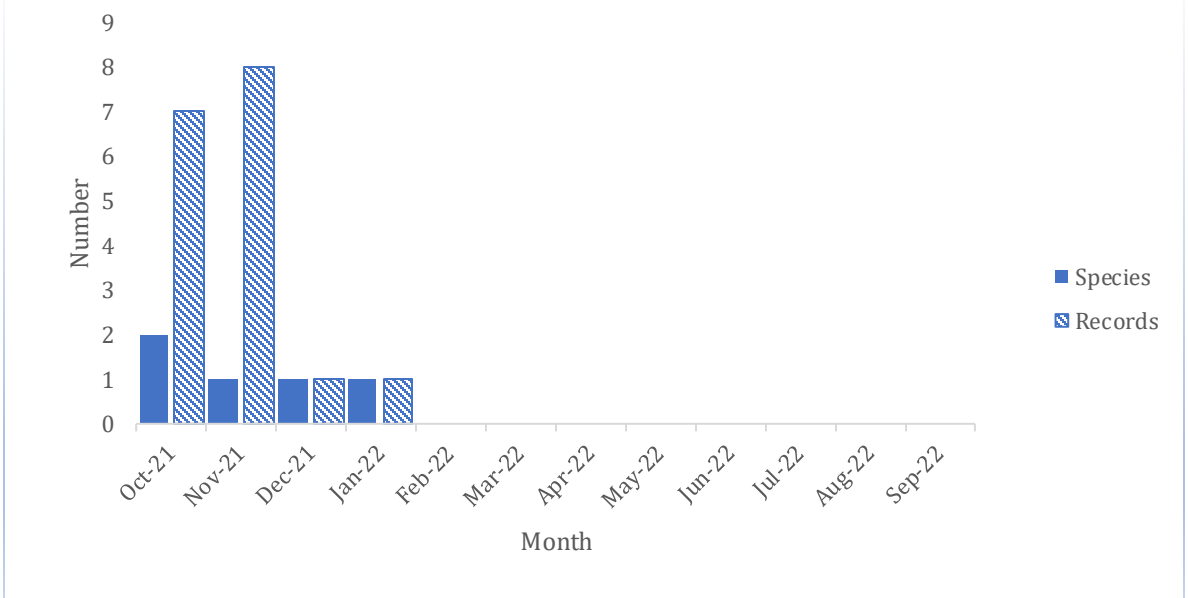

Figure 25 Number of species and records of herpetofauna using fig trees based on observation of focal trees in Halimun Salak NP

Monthly variation in wildlife use of fig trees might be influenced by the availability of other resources in the habitat. Wildlife species use more variation of resources when it is available and use more fig trees when other resources is scarce. In general, use of fig tree by wildlife was relatively constant in natural habitat, while it is more varied in urban habitat.

3.2.2 Wildlife Activities

Mammal activities observed consisted of movement, conflict, resting, grooming, and feeding. In urban habitat the most dominant activity was movement (Fig. 26). Mammals such as squirrel and Long-tailed Macaque used the focal trees to pass through during foraging or other activities. A few was observed feeding on bark of the tree. Feeding was most dominant in natural habitat, with around 60% of records activity contain feeding. For birds, calling was the most dominant activity recorded in urban habitat, folled by foraging (Fig. 27). Foraging was the most frequent activity in natural habitat. Based on monthly observation on focal trees foraging is the most frequent activity observed in natural habitat while calling is the most frequent activity recorded in urban habitat. Observation in urban habitat was conducted only during the day (06.00-18.00), therefore sleeping was never observed, while in natural habitat night observation showed that fig tree was also used by birds to rest (sleeping).

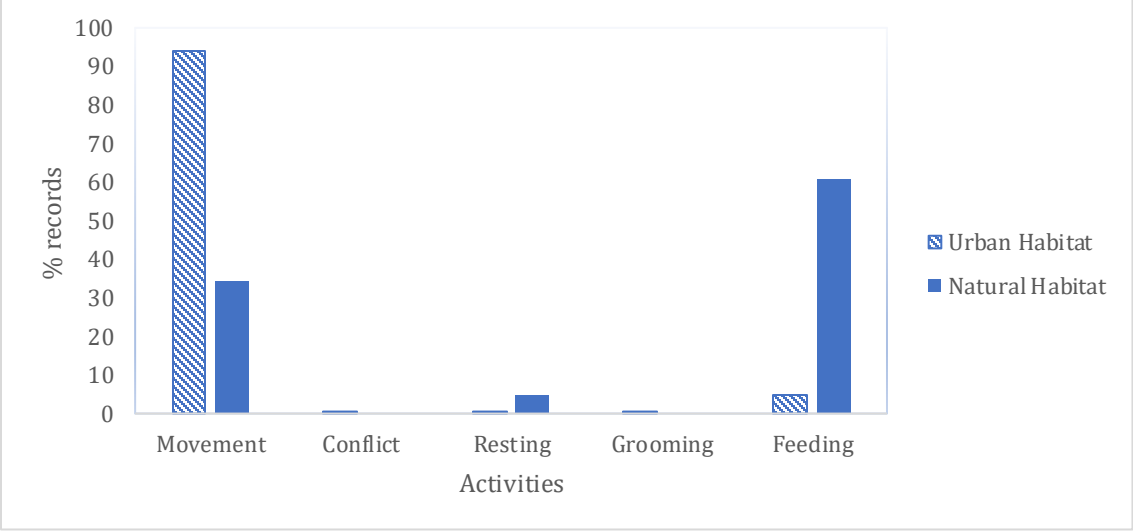

Figure 26 Types of activities of mammals when using fig tree

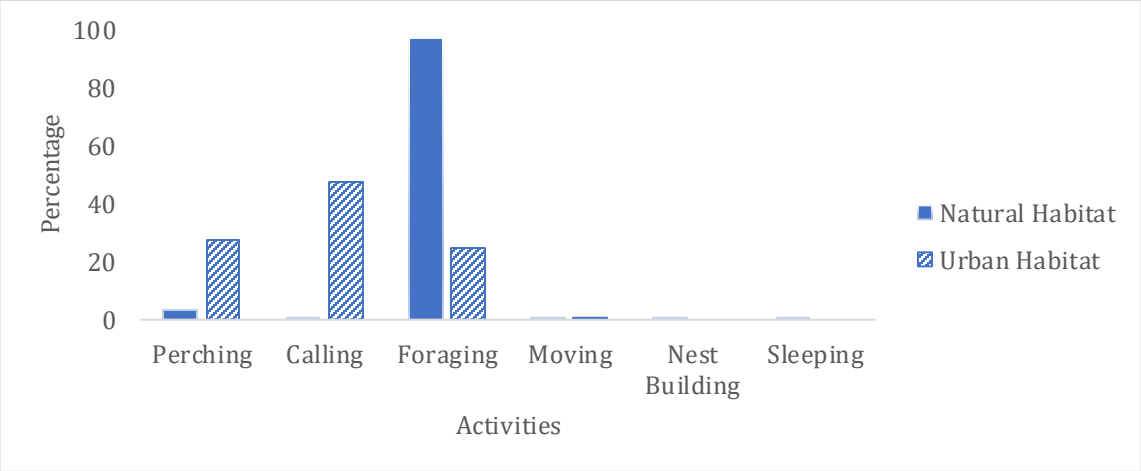

Figure 27 Types of activities of birds when using fig tree

The activities of herpetofauna (reptiles and amphibians) are mostly resting both in urban and natural habitat, although in natural habitat resting seems to be more prominent, no calling activity recorded in natural habitat (Fig. 28).

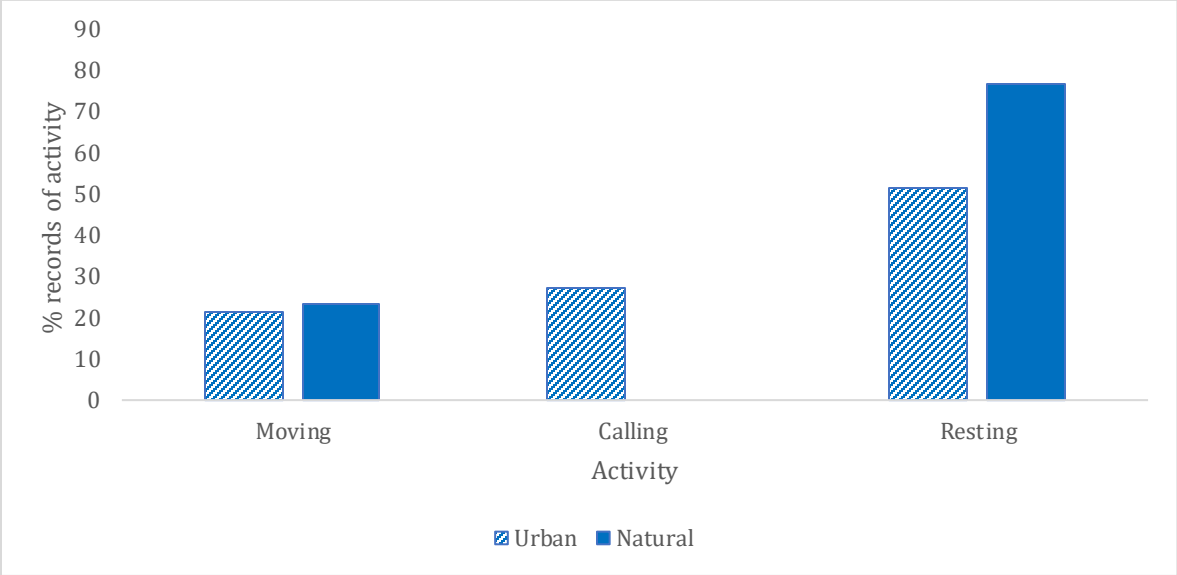

Figure 28 Types of activity by herpetofauna in fig tree in urban and natural habitats

3.2.3 Spatial and Temporal Use of Fig trees by Wildlife

Based on vertical distribution, most wildlife uses the upper canopy in fig trees, especially birds and mammals, both in urban and natural habitats (Fig 29-30). This is consistent with the result for urban habitat in the first year. We speculated that in urban habitat wildlife tend to search for shelter away from human disturbance, therefore they select the upper and middle canopy. Other possible reason of the selection was related to wildlife activity. Most of wildlife uses fig trees for foraging or feeding, and potential food (fruits and insects) are located mostly in the middle and upper canopy. However, this will need further study to confirm it.

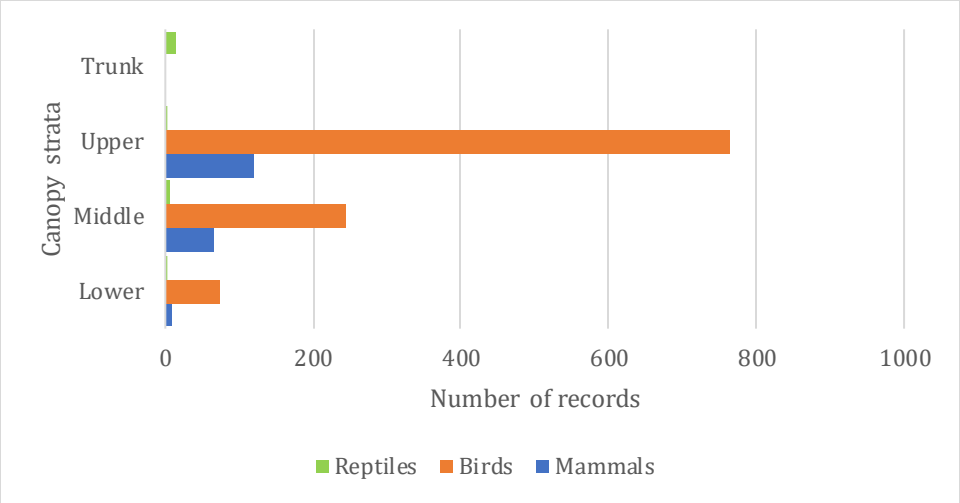

Figure 29 Spatial use of fig canopy by wildlife in urban habitat

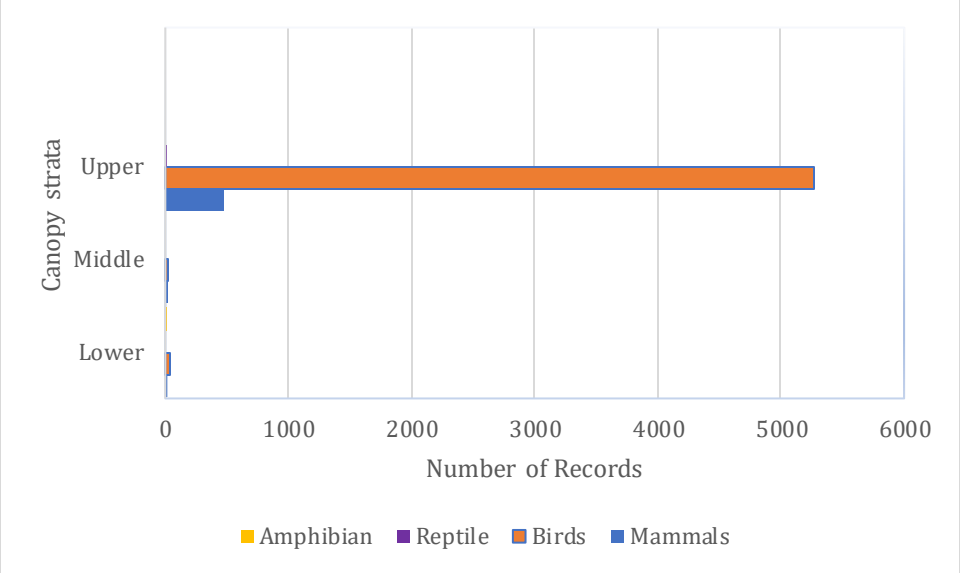

Figure 30 Spatial use of fig canopy by wildlife in natural habitat of HSNP

Based on temporal variation during the day wildlife activity in urban and natural habitats showed similar pattern, where bird activity increase from morning to noon and then decreae in the afternoon (Fig 31- 32). This pattern slightly different from the result of observation in urban area in the first year, in which bird were most active in the morning. The difference might be attributed to weather condition where precipitation was higher during 2021-2022 compared to those in 2020 (https://jabar.bps.go.id/indicator/151/430/1/-curah-hujan-di-stasiun-pengamatan-klimatologi-bogor-menurut-bulan.html). During observation in Mt Halimun -Salak morning rain made birds postponed their activities to later in the day.

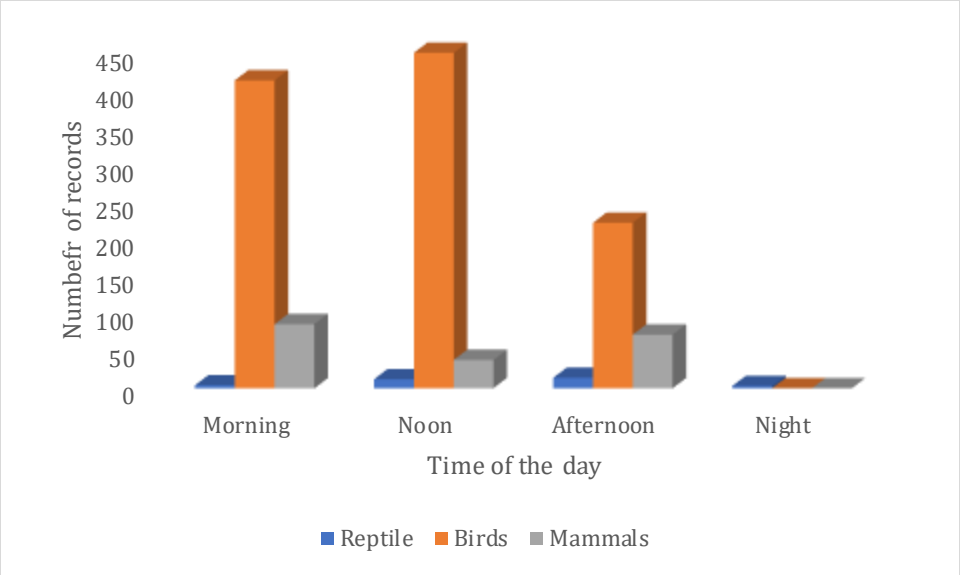

Figure 31 Temporal variation of wildlife activities in urban area of IPB Dramaga Campus based on monthly observation in 2021-2022

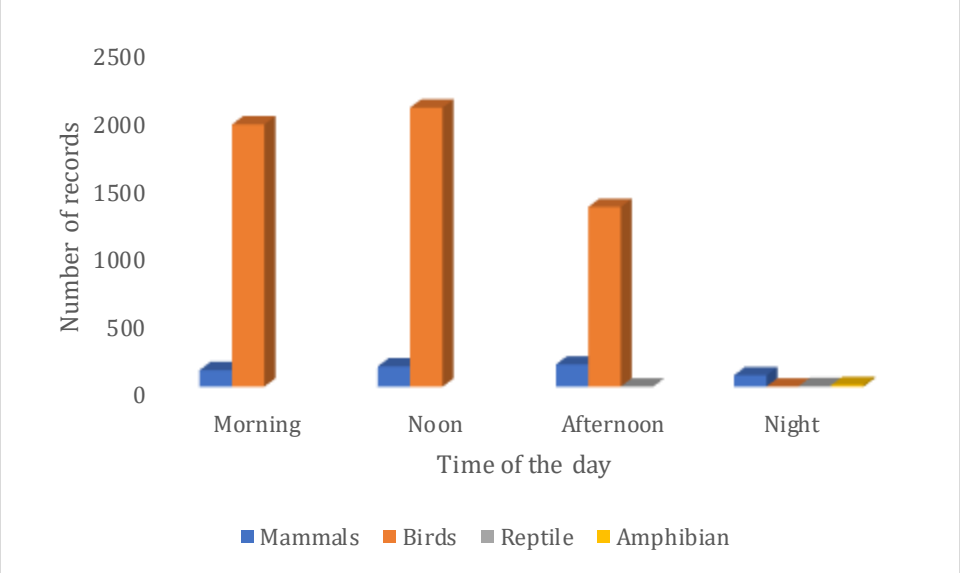

Figure 32 Temporal variation of wildlife activities in natural habitat of Mt Halimun-Salak National Park based on monthly observation in 2021-2022

3.2.4 Wildlife Feeding Activity and Fruiting Stage

The two focal trees in urban habitat (*F. benjamina)* showed fruiting asynchrony, with the highest fruiting score was recorded in January and February 2022 (score 3). No fruiting (score =0) during observation in November-December 2021 (Table 16). Asynchrony in fruiting stage was also observed in natural habitat for two sample trees of different species (Table17).

Table 16 Fruiting stage of two focal trees (Ficus benjamina) in urban habitat in 2022

Focal tree	Jan		Feb		Mar	Apr		May		Jun		Jul		Aug	
	Wk1	Wk3	Wk1	Wk3		Wk1	Wk3	Wk 1	Wk 3	Wk1	Wk3	Wk1	Wk3	Wk1	Wk3
FC1	1	3	0	0	-	0	1	3	0	0	0	2	0	2	2
FC2	1	2	3	0	-	0	1	3	0	0	0	0	0	0	0

Table 17. Fruiting stage of two focal trees *(F. sundaica* and *F, padana*) in natural habitats

	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22
FC1 (Fp)	0	1	0	1	0	1	1	1	1	1	0	1
FC2 (Fs)	2	1	0	2	3	1	0	1	1	1	1	3

To examine whether wildlife feeding activity in fig tree correlates with fruiting stage we plotted the percentage of wildlife feeding per month with fruiting score. The result in urban habitat looks a bit different from the result in natural habitat (Fig 33 - 34). In urban habitat feeding activity was highest in January and February, where the fruiting score reached 3, although the relationship is not clear. In natural habitat percentage of feeding activity does not correlate with the fruiting score. This result is consistent with previous year in urban habitat. We previously hypothesized that feeding activity will increase when the fruit is more abundant. However, that was not the case because not all wildlife feed on fig fruits.

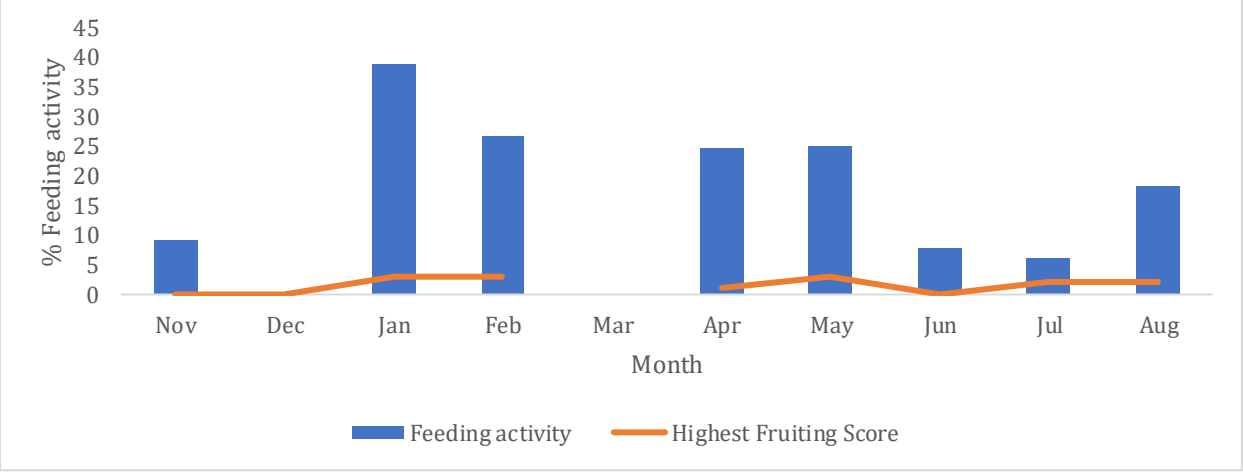

Figure 33 Monthly variation of feeding activity of wildlife in urban habitat

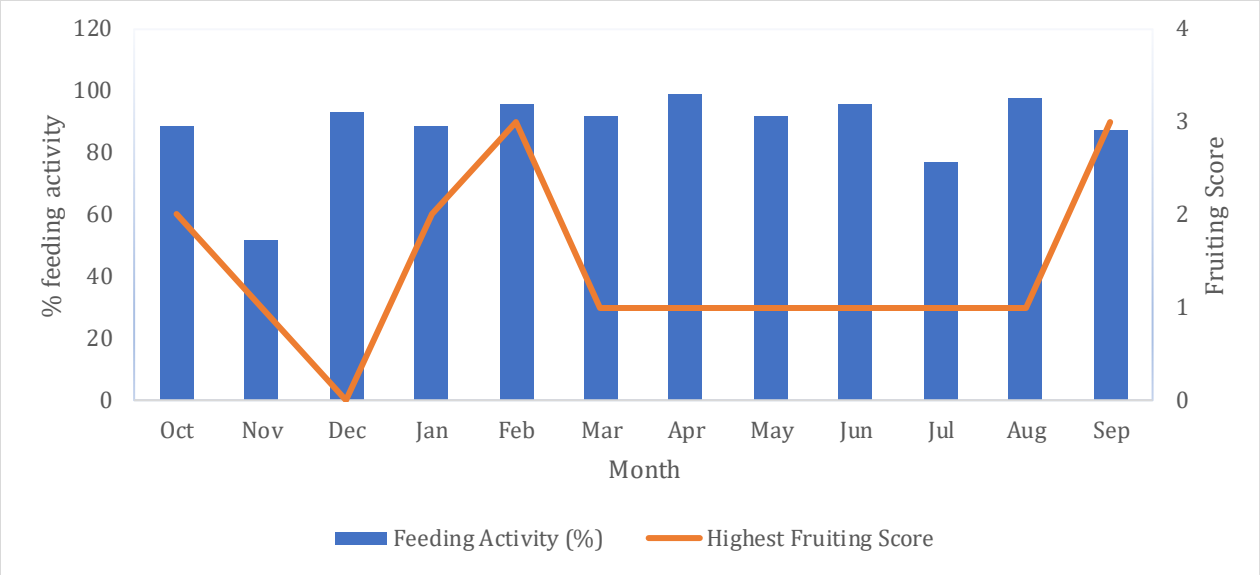

Figure 34 Monthly variation of wildlife feeding in fig tree in natural habitat

IV. CONCLUSION

During the three-year study at least 20 species of Ficus was identified in urban habitat, and 28 species in natural forest, including native and introduced species. This finding verified that ficus group are widespread and easily adapted to the local environment in the tropics.

At least 99 species of birds, 21 species of mammals, 16 species of reptiles, and 7 species of amphibians have been confirmed to use fig trees as food resources and other uses (perching, resting, calling, nesting), and thus suggested that fig trees are indeed important for wildlife species. Fig trees in Cikaniki Loop Trail (natural area) is important for wildlife, especially for primates and birds.

This study showed that not all individual fig trees have simultaneous fruiting time, which benefit to wildlife; sufficient food availability in a larger landscape can be attained from the different fruiting time of each individual tree species. However, it was still difficult to draw a firm conclusion on the phenological cycle of fig trees (especially the focal trees: *F benjamina, F. sundaica and F. padana*) and its relationship with wildlife use. In urban areas there was monthly variation in the number of wildlife species that used Ficus tree but no correlation with fruiting condition. This study also showed that there are many insectivorous birds forage in the canopy and surrounding fig tress, most likely take advantage of the insect that emerge from the fig, but further study is needed to confirm it.

Despite challenge of Covid-19, we have managed to conduct survey to analyze the value of fig tree for wildlife in urban and natural habitats.

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Appendix 1. Number of plots within grid and sub-grid that were visited for observation in natural habitat

Grid	Sub-Grid	Number of Plot
C	C3	5
	C4	16
	C5	10
	C6	3
D	D3	26
	D4	9
	D5	6
	D6	5
	D7	1
E	E4	3
	E5	3
	E8	3
F	F5	3
	F6	13
	F7	6
	F8	2
	F9	2
G	G10	1
	G11	24
	G12	2
	G4	4
	G5	1
	G6	2
	G7	2
	G8	21
	G9	2
H	H12	11
	H13	11
I	I12	2

Appendix 2. Description of research Grids in natural habitat

- Grid C6

This Grid is located in a hilly and steep area, making it difficult to be accessed. This grid is seldom to be visited by national park visitor or staffs, partly due to the heavy topography and slippery as well. Access was also difficult. Shrubs and other lower plants need to be cut off to allow access to this Grid. To the north, this Grid borders with tea plantation belongs to PT Sami Asih. Trees occurred in a high density, creating a dense canopy. Plant species found in the lower canopy were rattan, ferns, 'tepus', and begonias.

- Grid C5

Similar to the other Grid, this Grid is also hilly, with a heavy contour. The trail was slippery to intensive water logged along and nearby the track. The forest floor was covered by many forest litters. The trees were dense, with a dense canopy cover as well. There were many dead, decayed, and fallen logs here and there. Rattan, ferns, 'tepus', and begonias dominated the forest floor. Similar to Grid 6, this Grid is also borders with PT Sami Asih, a tea plantation company.

- Grid C4

This Grid is also hilly and steep. At some spots are extremely steep due to the existence of small creek. The trail was wet and slippery. The forest floor was covered by forest litter and many decayed and dead logs. Rattan, ferns, 'tepus', bamboo and begonias were also dominated the forest floor. Due to the thickness of the lower canopy, some shrubs need to be cut off to make an access to the Grid.

- Grid C3

This Grid is very similar to Grid C4., although the lower canopy was not as thick as Grid C4. The trail was even more humid and wetter, because it received more water from the surrounding. The trail was more or less open, no need to cut off some bushes to walk along the trail. Many decayed and dead logs were also observed. Rattan, ferns, 'tepus', and begonias were also dominated the forest floor.

- Grid E4

This is another heavy contour grid. There is a loop-trail crossing this Grid, and thus the trail is more or less accessible. The trail was humid, with some waterlogged, create some slippery areas here and there. The forest floor was covered by many shrubs and small tree species, creating a dense layer. Dead and decayed logs can be easily found. Rattan, ferns, 'tepus', and begonias were easily found in the forest floor. Epiphytes, including ferns (e.g., *Asplenium nidus)* were abundant.

- Grid F4

Grid F4 is steep and hilly. There is a slippery loop-trail that crossing this Grid. The forest floor was rich with humus and many other species such as rattan, ferns, begonias, and 'tepus'. Many decayed and fallen trees can be found in thus Grid.

- Grid G4

This is another steep and hilly Grid. In this Grid, there is a trail that has been used by the local people to go to Curug Cikudapaeh (a small waterfall). There are many wet and humid spots along the trail. The forest floor was dense and covered by many shrub species and small tree. Dead and decayed logs were abundant. Rattan, ferns, 'tepus', and begonias were easily found in the forest floor. Epiphytes, including ferns (e.g., *Asplenium nidus)* were abundant along the trail.

- Grid G5

  Grid G5 is hilly with steep valleys. Similar to Grid G4, in this Grid, there is a trail leads to a small waterfall of Curug Cikudapaeh (a small waterfall). The trail was humid and wet, with many waterlogged. The trees were dense, with a dense canopy cover as well. There were many dead, decayed, and fallen logs in many areas. Ferns and several orchid species were fund here.

- Grid G7

  Areas in Grid G7 is also hilly, with some very steep valleys. The trail was slippery and wet. There are many litters on the forest floor, as well as fallen logs. Many lianas, rattan, ferns, begonias, 'tepus', and pandans were found in this grid. Orchids and ferns were plenty.

- Grid F5

  Similar to other grids, the Grid F5 was hilly and having steep valleys. There is loop-trail crossing this Grid F5, and thus there was no need to cut off bushes to move around. The trail was wet and slippery. The forest floor was abundant with litter and fallen trees. Tree canopy was dense. Liana, rattan, ferns, begonia, 'tepus', and epiphytes species were abundant.

- Grid F6

  This Grid hold the Focal Tree #1 and the Focal Tree #2. Grid F6 was hilly and having steep valleys as well. There is loop-trail crossing this Grid F5, and movement was easy. and thus, there was no need to cut off bushes to move around. The forest floor was covered by many shrubs and small tree species, creating a dense layer. Dead and decayed logs can be easily found. Rattan, ferns, 'tepus', and begonias were easily found in the forest floor. Epiphytes, including ferns (e.g., *Asplenium nidus)* were abundant.

- Grid F7

Grid F7 was hilly and having steep valley. There is loop-trail crossing this Grid F7, and thus cutting off the bushes to ease movement was unnecessary. The forest floor was covered by many shrubs and small tree species, creating a dense layer. Dead and decayed logs can be easily found. Rattan, ferns, 'tepus', and begonias were easily found in the forest floor. Epiphytes, including ferns (e.g., *Asplenium nidus)* were abundant.

- Grid F9

This Grid is also hilly and steep, seldom visited by others. The trail was wet and slippery. The forest floor was covered by forest litter and many decayed and dead logs. Rattan, ferns, 'tepus', bamboo and begonias were also dominated the forest floor. Due to the thickness of the lower canopy, some shrubs need to be cut off to make an access to the Grid.

- Grid E8

  This Grid is hilly and steep, but sometimes visited by Iavan Gibbon researchers. The trail was slippery and humid. This Grid borders with the agricultural crop owned by the local people of Citalahab. The forest floor was covered by many shrubs and small tree species, creating a dense layer. Dead and decayed logs can be easily found. Rattan, ferns, 'tepus', and begonias were easily found in the forest floor. Epiphytes, including ferns (e.g., *Asplenium nidus)* were abundant.

Appendix 3. Description of Ficus trees found in the sampled grids.

1. ***Ficus allutacea* Blume, Bijdr. (1825)**

Description Root climber which grows on a host tree until it reaches certain height to spread the branches. The twigs have brownish color to blackish with 2-4 mm thick. Leaves spirally spread with stipule length 0.5-1 cm. **Distribution** Widespread across Southeast Asia: Indonesia, Philippines, Malaysia and Thailand. **Habitat** Growing on a host tree in a primary rainforest (Project Noah 2000).

2. ***Ficus annulata* Blume**

Description Evergreen tree growing up to 25-35 m tall, hemi epiphyte or sometimes terrestrial. Stem with white sap. The thickness of the bark is 3-10 mm. Leaves spirally arranged on long and oval shapes with length 12-45 cm and width 4-15 cm, stipules lanceolate 1.5-3.5 cm. Figs places in leaf axils at the end of the branches, green-yellow-orange, fleshy. **Distribution** Myanmar, Southern part of China (Yunnan), Indochina, Thailand, Peninsular Malaysia, Indonesia (Sumatera, Java, Borneo, Sulawesi) and Philippine (Balabac island). **Habitat** Montane Forest up to 1,000 m above sea level (asl), usually found near rivers and streams.

3. ***Ficus consociata* Blume**

Description Mid canopy tree or strangler up to 35 m tall, hemi epiphyte and sometimes terrestrial. Stem with white sap. Leaves alternate, oblong, slightly heart-shaped to elliptic and are 5-27 cm by 2.5-14 cm. Stipulate 15 mm long. Young leaves and twigs have dense brown hair which makes them feel wooly. The figs are small (1-1.5 cm), covered with brown hair. Orange-red when ripe and appear in pairs in the leaf axils. **Distribution** Myanmar, Cambodia, Thailand, Indonesia (Sumatera, Bangka and Belitung Island, Java, Borneo). **Habitat** Lowland to sub montane forest up to 1,000 altitudes. Also, in coastal forests with sandy soils.


4. *Ficus fistulosa* Reinw. ex Blume

Description an evergreen tree can grow up to 10-18 meters tall. Twigs `3-8 mm thick, with hollow young twigs, containing white latex. Large leaves 8-22 cm in size, the leaves are spirally arranged, stalked leaves have leathery leaf blades that are oval to drop-shaped. The stipule has length 0.5 – 2.5 cm, hairy. Medium sized figs (1-3 cm) grow in bunches of the trunk (cauliferous), ripen greenish yellow, fleshy. **Distribution** Northeastern India and southern China to Peninsular Malaysia, Indonesia (Java, Sumatera, Borneo, Sulawesi, Bali, Flores, Alor) to Philippines and New Guinea (single specimen). **Habitat** in sub montane forests up to 2,000 m altitude. Often along streams. Also, often along forested roads in urban areas.


5. *Ficus glaberrima* Blume

Description An evergreen tree growing to 30 meters tall, hemi epiphyte and as it grows older it sends down aerial roots. Branchlets pubescent when young or densely covered with short grayish white pubescence. Stipules caducous, lanceolate, 1.5 cm in size . Figs axillary on leafy branchlets, paired, orange yellow when it ripens, globose, 7-10 mm in diameter. **Distribution** India, Myanmar (Including Andaman Island), Southern part of China (Hainan Island), Indochina, Thailand, Vietnam to Indonesia (Sumatera, Java to Sumbawa). Cannot found in

Borneo, Sulawesi or the Philippines. **Habitat** Sub montane Forest up to 1,700 meters in altitude. Limestone mountains.

6. *Ficus lepicarpa* Blume

Description large shrub to small tree up to 12 mm tall and 25 cm dbh. Leaves alternate, glabrous with length 5-32 cm and width 1.5-14 cm. Twigs ~ 3-4 mm thick, stipules lanceolate. Stem with white sap. The figs grow in the leaf axis towards the end of the branches and ripen green to yellow. **Distribution** Southern part of Myanmar, Peninsular Malaysia (except Singapore), Indonesia (Sumatera, Java, Sulawesi and Moluccas), Philippines (Palawan and Sulu islands only). **Habitat** primary and secondary forest with altitude up to 1,500 m asl, found often near rivers and streams.

7. *Ficus sumatrana* Miq., Ann. Mus. Bot. Lugd. Bat. 3 (1867)

Description Evergreen tree up to 30 m tall, hemi epiphytic, sometime a climber. Internal hairs absent, stem with white sap. Leaves spirally arranged with size 2-6 cm, oblong to lanceolate, and its twigs 1.5-3 mm thick, pale white to pale brown Lateral veins 4-5 pairs, syconia axillary, in pairs. Fig's diameter 9 mm, yellow-orange red, globose figs placed along the twigs. **Distribution** Myanmar, Indochina, Thailand, Peninsular Malaysia, Indonesia (Sumatera, include Bangka Island, Borneo, Java, Sulawesi, Sumbawa) to Philippines. **Habitat** In sub

montane forest up to 1,600 m altitude. Mostly on hillsides and ridges, but also on alluvial sites and along rivers and streams.

8. *Ficus padana* Burm.f.

Description Sparingly branched tree growing to 13 meters tall with umbrella-shaped canopy. Twigs 5-15 mm thick. Large leaves spread spirally, in heart-shaped, ovulate to ellipse 12-25 cm by 6-25 cm (the young leaves can reach up to 50 by 35 cm). Hairy figs, reddish color when ripen. **Distribution** Endemic to Sumatera and Java – Indonesia. **Habitat** Secondary Forest, from the lowland ascending to 1,500 meters in altitude.




9. *Ficus ribes* Reinw. ex Blume

Description Known locally as Walen, a small tree growing up to 15 meters tall. Twigs 1.5-3 mm thick. Leaves spread alternately lancet to oval, 6-29 cm by 5.5-10 cm in size. Thin texture. Ostiole diameter 2-3 mm, figs yellowish to brown when ripen. **Distribution** Thailand to Peninsular Malaysia, Indonesia (Sumatera and Java). **Habitat** Lowland and montane forest, up to 1,600 – 2,000 meters in altitude.

10. *Ficus sundaica* Blume

Description A mid canopy (strangler) tree up to 35 meters tall. Hemi epiphyte, develop a vast spreading crown and it has an aerial root. Twigs grey-brown to dark brown. Leaves alternate with stipules 20 cm long. Glabrous to hairy. Leaves are spirally arranged; stalked leaves have leathery leaf blades that are elliptic and 7.5-22.5 by 3-11 cm with 7-10 pairs of veins. Figs ~18 mm in diameter, yellow-orange to red-purple when ripen, globose figs, placed along the twigs. **Distribution** Myanmar, Indochina, Thailand, Peninsular Malaysia, Indonesia (Sumatera, Java to Borneo), Philippines (Palawan Island). **Habitat** Keranga to coastal forests, peat-swamp forests, sub-montane forests up to 1,100 meters altitude. On alluvial sites along rivers and streams.

11. *Ficus tricolor* Miq.

Description Medium size tree to 20 meters. Twigs 4-16 mm thick, leaves spirally spread, with elliptic to heart-shaped and it has very long petioles. The small figs (1.25 cm) grow in the leaf axils and ripen yellow to orange brown to red. **Distribution** Indonesia (Sumatera, Java, Borneo) and Bornean part of Malaysia, unknown in Singapore. **Habitat** Primary and secondary forests with altitude range from 800 – 1,900 m asl.

12. *Ficus vasculosa* Miq.

Description An evergreen tree up to 20 meters tall. Pale trunk and small buttress. Stem with white sap, stipules 8 mm long, glabrous. Leaves spirally arranged, stalked leaves have thinly leathery leaf blades that are oval with short rounded tips, 3-20 by 1.5-7.6 cm in size. The figs hang from the ends of the branches, ripen yellow to bright red. **Distribution** Myanmar, Indochina, Thailand, Peninsular Malaysia, Indonesia (Sumatera, Java, Borneo). **Habitat** Primary to secondary forests up to 1,300 meter altitude.


13. *Ficus variegata* Blume

Description A deciduous tree with height up to 40 meters. It has conspicuous and spreading buttresses developing from its trunk. Leaves are spirally arranged; long stalked leaves have leathery leaf blades that are egg-shaped to oval to oblong 6-35 by 2-15 cm in size. Its young leaves have larger, toothed leaf blades. The figs are pear-shaped, green with rose-red streaks when ripe, up to 5 cm wide and develop in dense clusters on short twigs, up to 7.6 cm long, arising from the trunk and main branches. **Distribution** India to Myanmar, Southern part of China, Taiwan, Ryukyu Island, Andaman Island, Peninsular Malaysia (including Singapore), Indonesia to Solomon Islands and Australia. **Habitat** Primary and secondary forests with altitude up to 1,200 m asl, often found grows in villages and in open areas.


Appendix 4. Published paper on fig diversity in Sentul

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Diversity of fig trees in a tropical urban residential area of Sentul City, Bogor, West Java

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Abstract. Fig (*Ficus* spp.) trees have been known as keystone species in the tropics and provide food sources for various species. The study aimed to reveal the diversity of fig trees in a tropical urban residential area of Sentul City, Bogor, West Java, as a part of a bigger study on the wildlife-fig relationship. A purposively selected sample (270 ha of housing, boulevard) and all *Ficus* were censused. Data on species diversity, height, diameter, and fruiting stage were taken. There were 389 *Ficus* trees, belonging to 10 species, namely *F. benjamina, F. binnendykii, F. caulocarpa, F. elastica, F. kurzii, F. lyrata, F. maclellandii, F. macrocarpa, F. septica,* and *F. variegata*, of which two species (*F. lyrata* and *F. maclellandii*) were non-native species. *Ficus* were planted as a border, roadsides, shading trees, or ornament. Based on the number of individuals, the most common species was *F. benjamina* (63.75%), followed by *F. kurzii* (14.4%) and *F. lyrata* (9.5%). As the *F. benjamina* can grow big, only about half (56.4%) were in full tree condition, while the rest were pruned (15.5%), trimmed (14.7%), or cut off (13.4%). This study showed that the diversity of fig trees in residential areas of Sentul City, Bogor is affected by the area's management.

1. Introduction

Figs (*Ficus* spp.) belong to the family Moraceae. They are mainly tropical species that are distributed in lowland areas, especially in Asia [1], and occur in different life forms, from trees, shrubs, climbers, hanging roots, hemi-epiphytes (strangler), and holo-epiphytes [2]. Unlike many other fruit bearing trees in the forest that have seasonal fruiting, figs produce fruits at different times of the year (asynchronous fruiting); therefore, they can provide food for wildlife all year long [3, 4] and reserve food supply during periods of general food scarcity. Therefore, figs serve as keystone species that provide food for various animal species thus play an important role in the tropical forest ecosystem

There are 876 accepted species of figs (http://www.plantsoftheworldonline.org), 252 species of which can be found in a variety of habitats in Indonesia, including in disturbed habitats [5], while [6] reported that there are around 350 species of figs in Indonesia. Based on the life form, it is identified that most figs in Indonesia grow as a tree, shrubs, and hanging roots [5]. Several species of figs was identified in more than one life form, such as *F. armitii* that was found as treelet and/or epiphyte, and *F. gracillima* was found as shrub or tree [1, 5].

Figs, especially stranglers, can adapt well in the cities and urban areas [7]. Fig trees have cultural values in some communities, and it is commonly planted for symbolic reasons or ornamental purposes. In Bali, fig trees in urban areas provide ritual and socio-cultural values [8]. Many species of figs can be

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used for various purposes, from food and traditional medicine to simple tools [9], for example, the fruit of *Ficus carica* that is popular as food.

Many studies have revealed the importance of figs for wildlife [10, 11, 12], but only a few examined the role of fig trees in urban areas [13, 14, 15]. The study aimed to reveal the diversity of fig trees in a tropical urban residential area of Sentul City, Bogor, West Java, as a part of a bigger study on the wildlife-fig relationship. Information obtained from this study would benefit the Sentul City management to promote green urban development as stated in their advertisement.

2. Methods

2.1. Study site

Sentul City is a satellite township, with a big complex of residential areas located in the outskirt of the city of Bogor (about 5 km to the north of Bogor) (figure 1) in coordinate 06°33′55′′- 06°37′45′′S, 106°50′20′′- 106°57′10′′ E, and at an altitude of 300–600 m above sea level. It covers an area of 3,001.4 ha [16]. Sentul City has a high rainfall of 3,271.7 mm/year with low permeability soil [17]. The most recent data available for the number of rainy days was 2019, which showed the wet season was from December to April, with the highest rainfall in December (670 mm) and February (568 mm) [18]. Sentul City has a vast green area, about 65% of its total area. Currently, Sentul City consists of 13 housing complexes and will be more in the future, as the developer is still planning to build more housing.

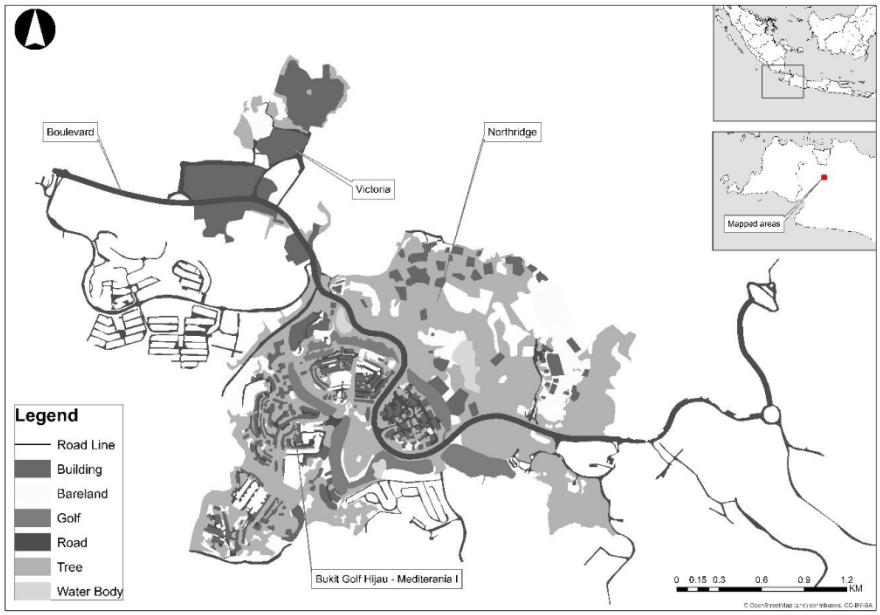

Figure 1. Map of the study area.

This study is a part of a larger study on the use of figs by wildlife in urban and non-urban habitats. To compare with the other area, only a small part of the Sentul City (of the total ± 3000 Ha) was selected as the study site to make a more or less similar coverage of the study sites. The area purposively selected is three residential clusters and a boulevard that connects the residential clusters, totaling 270 ha. The residential clusters were Victoria, Mediterania 1, and Bukit Golf Hijau. Only a small part was selected as the study area for Mediterania 1 and Bukit Golf Hijau (figure 1). As for Victoria, the entire area of

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Victoria Cluster is censused for its fig trees. Based on Landsat image analysis, the size of the Victoria Cluster is 19.6 ha. The boulevard included within the study area was named MH Thamrin Boulevard. Only about 2 km (from the total of 6.2 km) of the MH Thamrin Boulevard lay within the study areas.

2.2. Fig diversity and general features of fig trees

Surveys were conducted from late July to early September 2020 in Sentul City residential complex. Species identification was made with the help of a fig tree identifier (local para-taxonomist). Unidentified samples were taken and brought to the Herbarium of Faculty of Forestry IPB University to be identified. The origin of the trees was assessed based on the research on *Ficus* diversity and distribution in Indonesia [5].

All fig trees within the selected study area were censused and measured. The daily maintenance of the Sentul City landscape was conducted by a management company (PT Sukaputra Graha Cemerlang). Considering the level of maintenance by the management company, fig tree condition was grouped into 4fourcategories: full tree (naturally grown, no maintenance), pruned (overgrown cutting), trimmed (removing unwanted parts, mainly for decorative purposes), and cut-off (cutting some parts of the main trunk).

Tree measurements taken were tree height, the height of branchless trunk (clear bole), and diameter at breast height (dbh). Each stem larger than 10 cm in diameter was treated as an individual stem, although the stems were actually parts of one big tree. Trees with compact aerial roots were considered and measured as one stem. Tree measurement was only done on the tree and pole growth stage. Fruiting status was recorded as well and categorized as no fruit (none), early fruiting, full fruiting, and late fruiting

2.3. Data analysis

Data were analyzed descriptively. A list of species found was made, and the proportion of each species was calculated to obtain the percentage of each species and types of maintenance. Average values of three measurements were calculated to describe the condition of fig trees in the study site.

3. Results

Ten species of Ficus were observed in Sentul City (table 1, figure 2), almost all were purposively planted by the Sentul City Developer/Management. Fig trees were mostly big trees, except for *Ficus septica*, found in seedling and sapling stages. Of the 10 fig trees found, species two were non-native species to Indonesia, namely *F. lyrata* and *F. maclellandii*. These non-native species were specifically planted for certain purposes, for example, *F. lyrata* that have been planted along the boulevard for shading and ornamental purposes. Native species are categorized as those distributed in Indonesia, and non-native species are distributed abroad and introduced to Indonesia. The information on the distribution followed Plants of The World Online (http://www.plantsoftheworldonline.org), while distribution in Indonesia followed [1]. There is no record of the history of *Ficus* in Sentul City, but the planted trees were probably started in 1998, not long after the starting of the development in 1994.

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Table 1. Fig tree species found in the study site, listed in alphabetical order.

No	Species	Habitus	Common Name	Native/ Non-native	Natural Distribution
1	*Ficus benjamina* L.	Tree	Weeping fig, benjamin fig, ficus tree	Native	Tropical and Subtropical Asia, N. Australia [1]
2	*Ficus binnendykii* (Miq.) Miq.	Tree	'Alii' long leaved fig	Native	Peninsular Thailand, W. Malaysia, Sumatra, Java, Borneo[1]
3	*Ficus caulocarpa* (Miq.) Miq.	Tree	Stem-fruited fig	Native	Sumatra, Java, Lesser Sunda Islands, Borneo [1]
4	*Ficus elastica* Roxb. ex Hornem.	Tree	Rubber fig, Indian rubber bush	Native	Nepal to China, N. India to Myanmar, W. Malaysia, Sumatra, Java [1]
5	*Ficus kurzii* King	Tree	Burmese banyan	Native	China (Yunnan) to W Malaysia*Sumatra, Java[1]
6	*Ficus lyrata* Warb.	Tree	Fiddle-leaf fig, banjo fig	Non-native	W. & W. Central Tropical Africa*
7	*Ficus maclellandii* King	Tree	Alii fig, banana-leaf fig	Non-Native	Assam to China (Yunnan) and Peninsula Malaysia (Kedah)*.
8	*Ficus microcarpa* L.f.	Tree	Chinese/Malayan banyan, Indian laurel, curtain fig	Native	Tropical & Subtropical Asia to the Caroline Islands, Tropical & Subtropical Asia to Caroline Islands*, Sumatra, Lesser Sunda Islands Borneo, Sulawesi, Sangihe and Talaud Islands, Moluccas, New Guinea [1].
9	*Ficus septica* Burm.f.	Shrub	White-veined fig	Native	Nansei-shoto to Malesia and Vanuatu, including Indonesia [1].
10	*Ficus variegata* Blume	Tree	Common red stem fig, green fruited fig, variegated fig	Native	E. India to S. China and N. Queensland*, All Malesia region [1]

*Source (http://www.plantsoftheworldonline.org)

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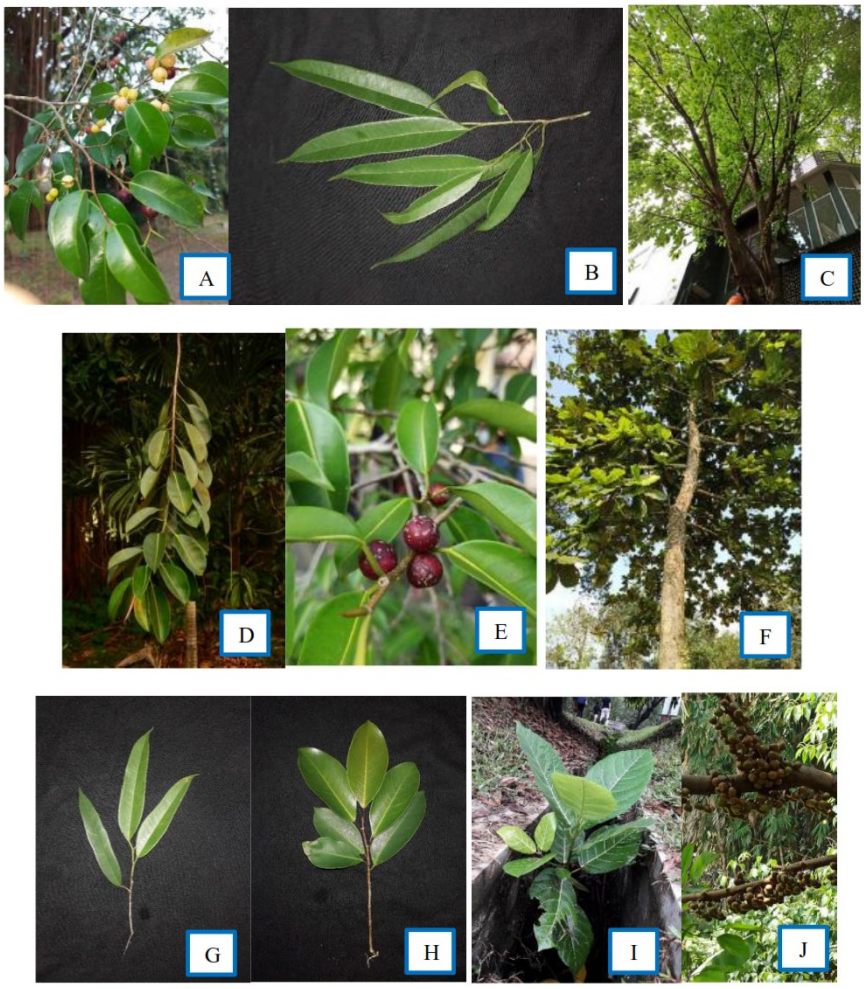

Figure 2. *Ficus* species were found in the study area. (A) *F. benjamina*, (B) *F.binnendykii*, (C) *F caulocarpa*, (D) *F. elastica*, (E) *F. kurzii*, (F) *F. lyrata*, (G) *F. maclellandii*, (H) *F. microcarpa*, (I) *F. septica*, (J) *F. variegata*.

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The total number of trees was 389 individuals, clearly dominated by *F. benjamina* (63.75% (table 2). Another common species were *F. kurzii* (14.40%). *Ficus lyrata* is the non-native species that was relatively more common than other species (9.51%), although the other non-native species, *F. maclellandii,* only constituted a very small percentage (0.77%). Some fig trees, including *F. benjamina*, *F. microcarpa,* and *F. binnendykii,* were regularly maintained by pruning, trimming, or cutting-off. Maintenance of the fig trees mostly happened on trees within housing clusters. According to the management of Sentul, interviews with some house owners in Victoria Cluster revealed that they preferred mid-size of *F. benjamina* along the road-sides, and thus big trees might be pruned, trimmed, or cut-off, either by the management company or by the house owners. In addition, *F. benjamina* also has been linked to some superstitious belief that this species may house some unwanted spirit. *F. benjamina* seemed to be very tolerant to tree maintenance (i.e., pruning, trimming, or cutting-off).

Table 2. *Ficus* species based on maintenance stage in the study site.

No	Species	Full Tree	Pruned	Trimmed	Cut-Off	Total	Percentage (%)
1	*Ficus benjamina* L.	147	39	35	27	248	63.75
2	*Ficus binnendykii* (Miq.) Miq.	0	0	0	4	4	1.03
3	*Ficus caulocarpa* (Miq.) Miq.	1	0	0	0	1	0.26
4	*Ficus elastica* Roxb. ex Hornem	7	0	0	0	7	1.80
5	*Ficus kurzii* King	21	16	9	10	56	14.40
6	*Ficus lyrata* Warb	37	0	0	0	37	9.51
7	*Ficus maclellandii* King	3	0	0	0	3	0.77
8	*Ficus microcarpa* L.f.	11	2	0	0	13	3.34
9	*Ficus septica* Burm.f.	19	0	0	0	19	4.88
10	*Ficus variegata* Blume	1	0	0	0	1	0.26
	Total					389	100.00

Many fig trees were tall and had reached their full grown. The tallest tree was *F. elastica,* which reached more than 10 m on average. Other tall trees (more than 8 m) were *F. caulocarpa, F. benjamina,* and *F. macrocarpa* (table 3). Clear bole was measured from the base of the tree to the first branch. The highest clear bole was found in *F. benjamina*, which was only 2.66 m on average. In addition to being tall, *F. benjamina* trees were also had a big diameter (more than 50 cm on average), although this species was not the biggest. The highest mean diameter was found in *F. binnendykii*. However, because all trees of this species were in cut off condition, the mean height of this species was only 4.30 m (table 3, figure 2). Many *F. benjamina* were planted along the periphery of the Sentul City residential complex in a small gorge, allowing their natural growth without any maintenance.

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Table 3. Mean heights, clear boles, and diameter of *Ficus* species at growth stages of trees and poles.

No	Species	Mean Height (m)	Clear Bole (m)	Diameter (dbh) (cm)
1	*Ficus benjamina* L	9.06 ± 3.25 (n=194)	2.66 ±1.63 (n=166)	54.69 ± 32.03 (n=136)
2	*Ficus binnendykii* (Miq.) Miq	4.30 ± 1.39 (n=4)	0.76 (n=1)	61.46 ±13.50 (n=5)
3	*Ficus caulocarpa* (Miq.) Miq	9.53 (n=1)	2.57 (n=1)	25.48 (n=1)
4	*Ficus elastica* Roxb. ex Hornem	10.56 ± 2.65 (n=5)	1.95 ± 0.56 (n=5)	44.0 ± 17.86 (n=5)
5	*Ficus kurzii* King	6.85 ± 3.30 (n=37)	1.67 ± 0.60 (n=32)	37.09 ± 15.77 (n=39)
6	*Ficus lyrata* Warb	7.81 ± 1.56 (n=25)	1.88 ± 0.55 (n=23)	27.59 ± 5.88 (n=24)
7	*Ficus maclellandii* King	2.11 ± 0.21 (n=3)	0.44 ± 0.11 (n=3)	20.91 ± 0.97 (n=3)
8	*Ficus microcarpa* L.f.	8.89 ± 3.26 (n=7)	1.90 ± 0.39 (n=6)	28.49 ± 4.71 (n=8)
9	*Ficus septica* Burm.f.	*N.A*	*N.A*	*N.A*
10	*Ficus variegata* Blume	6.8 (n=1)	1.5 (n=1)	15.29 (n=1)

Note: different samples (*n*) for each species were due to the condition of the trees, for example, trimmed or cut-off; all *F. septica* were at the sapling stage, so no measurement was taken. N.A= not available because *F. septica* were in saplings and seedling stages, so no measurement was taken

In the study area where planting has been conducted by the management company, tree regeneration obviously depends on the planting plan. Unfortunately, there is no information on the source of seedlings. Most figs (about 70%) (table 4) were already mature, planted when the housing complex was developed in 1994. Saplings were very minimal (about 4%). Poles were mostly stunted trees in less fortunate condition (e.g., heavy shading, constantly inundated), or those were planted quite recently to replace dead trees.

The fruiting stage and fruiting synchrony among all species are important to ensure that the fruits are available at any time of the year. July to September, coincided with late dry season) was not a fruiting time for fig trees in general. Most trees (84%; table 4) were not fruiting, except for *F. lyrata,* which showed the peak fruiting season. For *F. benjamina*, a big proportion (90.44%) of the population was not fruiting. However, the remaining small population was in the early, full, and late fruiting stage, suggesting a fruiting asynchrony pattern.

Looking at the number of trees in the residential clusters and the main boulevard, it was very clear that Victoria Cluster had the highest number of fig trees (almost 50%), closely comparable to the main boulevard (43%) (table 5). Each cluster within Sentul City residential complex was planted by certain species as the theme of the cluster. For Victoria Cluster, the theme happened to be *Ficus,* including *F. benjamina, F. kurzii*, and *F. microcarpa.* Other non-fig trees were very limited, making the fig trees the highly dominant trees. Meanwhile, along both wide sides of the MH Thamrin Boulevard, many other trees were also planted as street trees. Thus, although the percentage of fig trees was also high in this area, the fig trees did not dominate the tree community.

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Table 4. *Ficus* species based on stage and fruiting stage in the study site.

No	Species	Growth Stage			Fruiting Stage			
		Tree	Poles	Sapling	None	Early	Full	Late
1	*Ficus benjamina* L.	238	58	0	246	5	1	7
2	*Ficus binnendykii* (Miq.) Miq.	5	0	0	4	0	0	0
3	*Ficus caulocarpa* (Miq.) Miq.	1	0	0	0	1	0	0
4	*Ficus elastica* Roxb. ex Hornem	6	4	0	7	0	0	0
5	*Ficus kurzii* King	47	30	0	8	0	1	3
6	*Ficus lyrata* Warb	32	11	0	0	0	17	0
7	*Ficus maclellandii* King	3	0	0	3	0	0	0
8	*Ficus microcarpa* L.f.	8	7	0	3	0	0	0
9	*Ficus septica* Burm.f.	0	0	19	1	17	0	0
10	*Ficus variegata* Blume	0	1	0	0	0	1	0
	Total	340	111	19	272	23	20	10
	Percentage (%)	72.34	23.62	4.04	83.69	7.08	6.15	3.08

Table 5. Number of *Ficus* based on residential clusters in the study site.

No	Species	Residential Cluster			MH Thamrin Boulevard	Total
		Victoria	Mediterania 2	Bukit Golf Hijau		
1	*F. benjamina* L.	128	21	1	98	248
2	*F. binnendykii* (Miq.) Miq.	0	0	0	4	4
3	*F. caulocarpa* (Miq.) Miq.	1	0	0	0	1
4	*F. elastica* Roxb. ex Hornem	2	0	5	0	7
5	*F. kurzii* King	49	0	0	7	56
6	*F. lyrate* Warb	0	0	0	37	37
7	*F. maclellandii* King	0	3	0	0	3
8	*F. microcarpa* L.f.	10	0	0	3	13
9	*F. septica* Burm. f	1	0	0	18	19
10	*F. variegata* Blume	1	0	0	0	1
	Total	192	24	6	167	389
	Percentage (%)					

4. Discussion

The condition of fig trees in the study site varied according to maintenance. The maintenance by the Sentul City management is limited to trimming, pruning, cutting, and watering. There was no fertilizer applied for the fig trees. Based on [1], the average height of fig species found in the study site ranging from 10 m (for *F. binnendykii*) to 40 m (for *F. variegata*). The tallest tree found in the study site was *F. elastica* that did not receive cutting or pruning.

Unfortunately, information on the diversity of fig trees in urban areas, specifically in a residential complex, was very limited, apart from a study in Bogor Botanical Garden [6] that reported a higher number of species. Compared to the number of fig species in Bogor Botanical Garden, the study area has a lower diversity. In 2017 [6], at least 97 fig species grew in Bogor Botanical Garden, consisting of 56 identified species and 41 unidentified species. The collection of figs in Bogor Botanical Garden was

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184 individuals [6]. However, since Sentul City is a human-made environment, 389 fig trees consisted of 10 species within 270 ha (density 1.42 trees/ha on average, 9.80 trees/ha in Victoria Cluster) was considered a high number.

Several studies on vegetation diversity in urban areas in Indonesia revealed that only a few *Ficus* species were found [19, 20, 21]. For example, only two species of figs were found out of 58 shading trees in the city parks of Kediri, and those were *F benjamina* and *F. elastica* [19]. In the urban forest of Bandar Lampung, only one fig species was listed in [20], and in Yogyakarta, the only fig species recorded along the main road was *F. elastica* [21]. However, a study in several habitat types in an urban area of Yogyakarta reported a total of six species of figs, with *F. benjamina* distributed in 8 of 10 study sites [22]. On the other hand, study abroad, such as in Singapore (637.5 km^2 or 637,500 ha), an urban city/country in tropical South-East Asia similar to the study site, has 46 fig species [2]. While Hong Kong, located in subtropics, having a size of 1,100 km^2 (equal to 110,000 ha), was reported to harbor 14 *Ficus* species [13].

The need for green open spaces or vegetation cover in residential areas is important; it provides an environmental and social advantage for the urban inhabitants [23]. The diversity and abundance of fig in urban areas will increase the biodiversity of the residential area, which in turn increase the value of the area. Fruiting figs are recognized as food sources for wildlife, especially frugivores, mainly birds such as Pink-necked Pigeon, *Treron vernans,* and mammals, such as Long-tailed Monkey *Macaca fascicularis*. However, fig trees also provide food sources for many insectivorous birds [24]. Among 43 bird species reported in the Sentul City area and might take advantage of fig trees, mostly are insectivores, while only two species (4.75%) are frugivores [25]. Additionally, *Ficus* gives shades and is good in regulating temperature in the cities due to their dense crown [26]. However, because this study was not aimed at examining the effect of trees on temperature, no measurement was taken. Other studies, such as [27], revealed that *F. microcarpa* 'Golden Leaves' has a good cooling effect that can reduce temperature to 10.0 ± 1.6 °C. *Ficus benjamina* L. in Bogor Botanical Garden was reported to have a very high capacity in absorbing CO_2 [28], thus highly effective in regulating microclimate.

The selection of plant species to be planted or kept in residential areas must consider the interest of the people's daily life in the residential area. Species diversity of urban vegetation in residential areas correlated with several factors such as housing prices and other human factors, including preferences [29]. In this study, the Developer used *Ficus* as one of the cluster themes and consequently planted a relatively high number of figs in that cluster. In another cluster, such as in Mediterania II, the developer planted bintaro (*Cerbera manghas*). Unfortunately, no information was available on the reason for species preference or theme by the developer. Although most of the fig plants in the area were planted by the developer, some seemed to grow naturally. Those that grow naturally are observed at the border of settlement. According to [6], figs might regenerate with the help of animal agents that spread the seeds, and then it will grow at the host tree as hemi-epiphyte.

Ficus grow well in tropical areas, predominately in wet areas, although they grow in drier places [1]. Maintenance of fig trees in residential areas is essential, especially because of the capability of figs to adapt to severe environmental conditions The stranglers with their strong roots, such as *F. benjamina* and *F. macrocarpa* [1] are potentially grip human-made structures such as buildings [7, 26], this might be the reason why maintenance in housing complex is essential to avoid conflict between nature and human interest

5. Conclusion

There were 10 fig species in the study site, consisted of eight native species (dominated by *F.benjamina*) and two non-native species to Indonesia. Although no information on the reason for tree species selection planted by the Developer in Sentul City, this study showed that residential areas such as Sentul City are potential habitats for *Ficus* species in an urban environment. The occurrence of figs in the residential area improves the quality of human settlement by providing shades, greenery, and habitats for wildlife. However, maintenance is necessary to keep the balance between fig growth and safety of the buildings and infrastructures.

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Appendix 5. Published paper on the use of fig by wildlife in Dramaga

The 4th International Conference on Biosciences (ICoBio 2021) IOP Publishing
IOP Conf. Series: Earth and Environmental Science **948** (2021) 012012 doi:10.1088/1755-1315/948/1/012012

The use of weeping fig *Ficus benjamina* by wildlife in campus area of Dramaga, Bogor, Indonesia

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Abstract. Figs are recognized as keystone species in sustaining wildlife. Many studies showed that Dramaga Campus (Bogor) provides suitable wildlife habitat but no information available on the use of figs by wildlife in the area. This study aimed at identifying wildlife species and examining the role of weeping fig (*Ficus benjamina)* in the campus area. A rapid pre-survey was conducted to list wildlife species using fig trees in July 2020; observation on sample trees was conducted (September-November 2020) to obtain data on the type, time, and location of wildlife activities. The results showed that fig trees were used by mammals (4 species), birds (26 species), reptiles (12 species), and amphibians (2 species; found nearby the sample trees). Mammals used fig trees primarily as part of locomotion (59%) and feeding (28%), birds mainly were perching (63%) and feeding (29%), and reptiles mainly were found resting (86%). Mammals were active during day and night; birds were most active in the morning. Lizards were found during the day, while snakes were mainly observed during nighttime. Birds and mammals used lower to top strata, while reptiles used lower strata and trunk. Weeping figs have essential roles as wildlife habitats in peri-urban areas.

Keywords: amphibians, birds, *Ficus benjamina,* mammals, reptiles

1. Introduction

Weeping fig or *Ficus benjamina* is a member of the family Moraceae that is recognized to have many uses in human life. The trees are planted and used for shades in city parks, and in Jakarta, this species was frequently planted in green belts [1]. Genus *Ficus* are known to function as keystone species in the forest because they bear fruit all year round, making them beneficial for wildlife as a reserve food supply [2, 3]. Ficus might be considered the most important tree for wildlife in tropical forests [4]. The species can grow well in different conditions, including shade, drought, and other kinds of soil such as karst and even rocks [5].

IPB University Campus in Dramaga Sub-District of Bogor City has been recognized to have high biodiversity due to the availability of green open spaces [6-9]. The university campus was established in 1963 and was dominated by rubber plantations. However, since the early 1980s, the rapid development of the campus to provide academic facilities has changed its land cover. In addition, the increase in student intake of IPB University has been affecting the high development of off-campus

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housings and business around the campus, especially to the East and south parts of the campus, created a peri-urban area.

Most studies conducted on wildlife in the campus area showed that the area harbors a high wildlife diversity that includes mammals [8-10], herpetofauna [11], butterflies [12], and especially birds [6, 7, 13]. The high wildlife diversity was attributed to a variety of habitats occurring in the campus area. Many studies found a positive correlation between habitat diversity or heterogeneity with vertebrate diversity [14]. A preliminary survey as a part of a more extensive study on wildlife and fig trees in urban areas revealed 17 species in the campus area, dominated by weeping fig (*Ficus benjamina*). This study aimed to identify wildlife using weeping figs and examine its role in supporting wildlife biodiversity in the campus area.

2. Materials and methods

2.1. Study sites

The study was conducted in the campus area in Dramaga, approximately 12 km West of Bogor, West Java. The study site is located in the tributaries of the Cisadane River; those are Cihideung and Ciapus Rivers that border the area to the North and West, while provincial road borders the campus to the South, and settlement bordered the campus the East. This area occupies ± 267 Ha land with various land covers consisted of patches of vegetation (arboretum, parks, experimental agricultural field, side roads), academic buildings (classes, laboratories, offices), and staff housing (figure 1). Construction to provide facilities for academic activities is still ongoing.

2.2. Characteristics of weeping fig in the study areas

The survey was conducted to locate weeping figs in the study site. The survey aimed to discover and describe weeping figs at growth stages of trees, poles, and saplings only. Measurements on trees and poles consist of the height and diameter at breast height (dbh), while for saplings, measurement was only taken for its height. Additionally, the general condition of trees was also recorded, including the type of maintenance, fruiting condition, and occurrence of epiphytes. The fruiting stage was put into four categories: no fruit, early fruiting, full fruiting, and late fruiting.

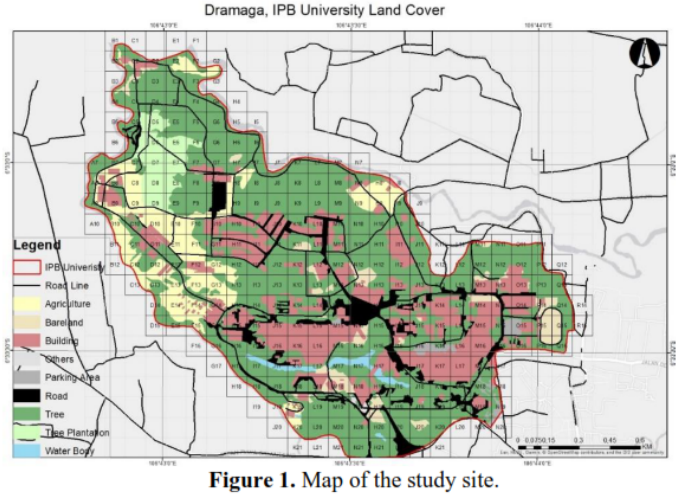

Figure 1. Map of the study site.

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2.3. Wildlife identification and use of fig trees

Identification of wildlife was conducted by a rapid survey simultaneously with locating the distribution of fig trees in July 2021. Wildlife species observed in fig trees were recorded. All vertebrate species seen on fig trees were identified and recorded. Based on the result of fig tree identification, we chose four individual trees to be monitored for wildlife use as focal trees. Observation of wildlife use on fig trees was conducted on those focal trees from September to November 2020, entering the rainy season. However, due to logistic reasons, observations on four focal trees were only conducted in September, while in October and November, observations were done on two focal trees. The selection of focal or sample trees was based on several criteria, i.e., tree growth stage and location (not located in the center of human activities, not completely isolated from other vegetation). Because some of the trees on the campus undergo maintenance, such as pruning, we selected trees that were not maintained by the management to minimize human influence.

One to three days of observation was conducted to examine the use of fig trees by vertebrates in each focal tree per month from September to November 2020. The observation was conducted ad libitum in intervals of 05.00-08.00, 11.00-14.00, 16.00-19.00, and 21.00-24.00 to record activities of diurnal, nocturnal, and crepuscular animals. The total length of observation was 216 hours**.** During the first month (September), we set up two camera traps in two focal trees to capture wildlife species that might visit the trees outside our observation time. However, the result did not match our expectations. Therefore, we stopped using them in the following months. Wildlife activities were categorized into feeding, resting (or perching for birds), locomotion, including moving, calling, basking (for lizards), preening (for birds), and calling. In addition, one category was added for bats that fly through the canopy, i.e., flying through, considering the possibility of the bat searching for food in the canopy.

3. Results

3.1. Description of F. benjamina in campus area

The survey recorded a total of 43 stands of *Ficus benjamina* consisted of 37 trees and 6 saplings. Fig trees in Dramaga Campus can be found in various habitats, including buildings, open agricultural farms, arboretum, and housing complex. The height of trees ranging from 2.9 to 23.4m, with an average of 15.0 $\pm$ 5.83m (n=43), and the diameter ranges from 19.1 to 255 cm with an average of 93.0$\pm$ 77.19 cm (n=37).

The area management mostly maintained trees in the study area. Only 12 out of 37 stands were a complete tree that did not receive any pruning or cutting as maintenance by the campus management. Fig trees in the Dramaga campus were pruned, mainly if they were located nearby the road. During the study, the weeping figs were in different stages of fruiting condition: early (58%), mid (26%), and late (16%).

3.2. Wildlife species

The wildlife species (vertebrates) that use *Ficus* trees are comprised of four taxa, i.e., mammals (4 species), birds (29 species), reptiles (12 species), and amphibians (2 species). The rapid survey only recorded 7 bird species and 1 mammal species, while camera traps only captured 2 mammal species (*Macaca fascicularis* and *Callosciurus notatus)* and 1 bird species (*(Pycnonotus aurigaster)*. Camera traps did not capture nocturnal or cryptic species as expected; therefore, the use of camera traps was abandoned. Mammals consisted of 4 families, birds consisted of 19 families, reptiles consisted of 5 families, and amphibians 2 families. None of the species found is protected by Indonesian law, although two species, i.e. Long-tailed Macaque and Red-breasted Parakeet (*P. alexandri*), are listed in CITES Appendix II.

Among the mammalian species, only one species found is insectivorous, i.e., Javan Tree-Shrew (*Tupaia javanica*), while others feed on plant parts. Based on major diet birds using fig trees can be categorized into insectivores (48.28%), frugivores (10.34%), frugivore-insectivores (13.79%), nectarivores (10.34%), carnivores (10.34%), and granivores (6.90%). On the other hand, most

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herpetofauna species found during the study feed mainly on insects, and only three species were carnivorous (table 1).

Table 1. List of wildlife species using *Ficus benjamina* in the study sites.

Order/Taxa Family	Species	Common Name	Major diet	Recorded from		
				Rapid survey	Camera Trap	Sample trees
MAMMALS						
Sciuridae	*Callosciurus notatus*	Plantain Squirrel	Plant parts (leaves, fruits)	+	+	+
Tupaiidae	*Tupaia javanica*	Javan Tree-Shrew	Insects			+
Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque; Crab-eating Macaque	Fruits, leaves, small animals		+	+
Pteropodidae	*Cynopterus brachyotis*	Dog-faced Fruitbat	Fruits			+
BIRDS						
Columbidae	*Treron vernans*	Pink-necked Green Pigeon	Fruits			+
Columbidae	*Spilopelia chinensis*	Spotted Dove	Grains			+
Psittacidae	*Psittacula alexandri*	Red-breasted Parakeet	Fruits			+
Cuculidae	*Centropus bengalensis*	Lesser Coucal	Insects			+
Cuculidae	*Cacomantis merulinus*	Plaintive Cuckoo	Insects			+
Cuculidae	*Surniculus lugubris*	Black Drongo	Insects			+
Strigidae	*Otus lempiji*	Collared Scops Owl	Insects			+
Caprimulgidae	*Caprimulgus macrurus*	Large-tailed Nightjar	Insects			+
Alcedinidae	*Halcyon cyanoventris*	Javan Kingfisher	Meat			+
Alcedinidae	*Halcyon smyrnensis*	White-throated Kingfisher	Meat			+
Alcedinidae	*Todirhamphus chloris*	Collared Kingfisher	Meat			+
Picidae	*Dendrocopos macei*	Fulvous-breasted Woodpecker	Insects			+
Picidae	*Dendrocopos moluccensis*	Sunda Pygmy Woodpecker	Insects			+
Campephagidae	*Lalage nigra*	Pied Triller	Insects			+
Campephagidae	*Pericrocotus cinnamomeus*	Small Minivet	Insects			+
Aegithinidea	*Aegithina tiphia*	Common Iora	Insects	+		+
Pycnonotidae	*Pycnonotus aurigaster*	Sooty-headed Bulbul	Fruits, insects	+	+	+

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Order/Taxa	Species	Common Name	Major diet	Recorded from		
Family				Rapid survey	Camera Trap	Sample trees
Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul	Fruits, insects			+
Timaliidae	*Malacocincla sepiarium*	Horsfield's Babbler	Insects			+
Sylviidae	*Orthotomus sutorius*	Common Tailorbird	Insects			+
Sittidae	*Sitta frontalis*	Velvet-fronted Nuthatch	Insects			+
Dicaeidae	*Dicaeum trochileum*	Scarlet-headed Flowerpecker	Fruit, insects	+		+
Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	Nectar			+
Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbirds	Nectar	+		+
Nectariniidae	*Arachnothera longirostris*	Little Spider-hunter	Nectar	+		
Zosteropidae	*Zosterops palpebrosus*	Oriental White-eye	Insects			+
Estrildidae	*Lonchura punctulata*	Scaly-breasted Munia	Grains	+		+
Sturnidae	*Gracupica contra*	Pied Myna	Fruits, insects,			+
Oriolidae	*Oriolus chinensis*	Black-naped Oriole	Fruits			+
REPTILES						
Agamidae	*Bronchocela jubata*	Maned Forest Lizard	Insects			+
Agamidae	*Calotes versicolor*	Common Garden Lizard	Insects			+
Agamidae	*Draco volans*	Common Flying Dragon	Insects			+
Gekkonidae	*Cyrtodactylus marmoratus*	Marbled Bowed-finger Gecko	Insects			+
Gekkonidae	*Gekko gecko*	Tokay Gecko	Insects			+
Gekkonidae	*Hemidactylus frenatus*	Common House-Gecko	Insects			+
Gekkonidae	*Hemidactylus platyurus*	Flat-tiled House Gecko	Insects			+
Scincidae	*Eutropis multifasciata*	Sun Skink	Insects			+
Scincidae	*Dasia olevaceae*	Olive Tree Skink	Insects			+
Colubridae	*Ahaetulla prasina*	Oriental Whip Snake	Meat			+
Pareidae	*Pareas carinatus*	Keeled Slug-eating Snake	Snail			+

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Order/Taxa	Species	Common Name	Major diet	Recorded from		
Family				Rapid survey	Camera Trap	Sample trees
Viperidae	*Trimeresurus albolabris*	White-lipped Tree Viper	Meat			+
AMPHIBIANS						+
Rhacophoridae	*Polypedates leucomystax*	Common Tree Frog	Insects			+
Ranidae	*Chalcorana chalconota*	White-lipped Frog, Copper cheeked Frog	Insects			+

3.3. Use of fig tree by wildlife

Types of activities recorded varied according to taxa. Mammals used fig trees primarily as part of locomotion (59%) and feeding (28%) (figure 2a). The locomotion by mammals includes movement from one tree to another and movement within the tree canopy. Plaintain Squirrel (*C. notatus*) was the most frequent mammal species recorded using weeping fig tree, followed by Long-tailed Macaque (*M. fascicularis*). However, mammals' most frequent feeding activity was observed in Dog-faced Fruit-bat (*C. brachyotis*) followed by Plaintain Squirrel. Long-tailed Macaque was observed feeding on only three occasions.

Bird activities were mostly perching (63%) and feeding (29%) (figure 2b). The most frequent species observed using the tree was Sooty-headed bulbul (*P. aurigaster*), followed by Common Iora (*A. tiphia*), Scarlet-headed Flowerpecker (*D. trochileum*), and Common Tailorbird (*O.sutorius*). Feeding activity was observed primarily on Sooty-headed Bulbul and Common Iora. Sooty-headed Bulbul feeds on a mixed diet comprising fruit and insects, while Common Iora is mainly insectivores. Frugivores such as Pink-necked Green Pigeon (*Treron vernans*) and Black-naped Oriole (*Oriolus chinensis)* were observed on the weeping fig tree but never fed its fruit.

The least active group found in fig tree was herpetofauna, with the highest percentage of activity was resting (86%) (figure 2c). Basking was observed on one species, i.e., Common Flying Dragon (*Draco volans)*, while calling was observed on Tokay Gekko (*Gekko gecko*).

3.4. Temporal and spatial use of Ficus by wildlife

Wildlife activities in fig trees could be observed all day long, with birds were active during the daytime, especially in the morning. Mammals were also most active during the daytime, while herpetofauna, especially snakes, were most active during nighttime, while lizards were primarily active during the period 11.00-14.00 (figure 3).

Most bird activities were observed in the top canopy, while mammals seemed to prefer the middle canopy. Herpetofauna was found using a lower and middle canopy. One species reptile, i.e., *Gekko gecko* observed on the trunk (figure 4).

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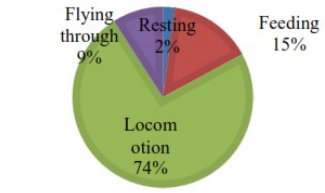
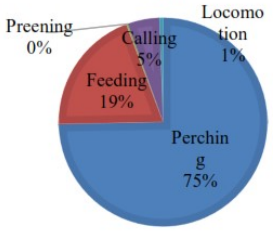


(a)



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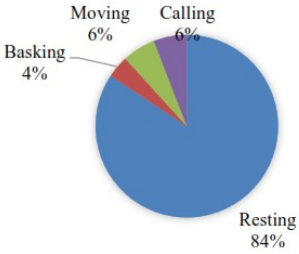

(c)

Figure 2. Frequency of wildlife activities according to taxa (a) mammals, (b) birds), (c) herpetofauna.

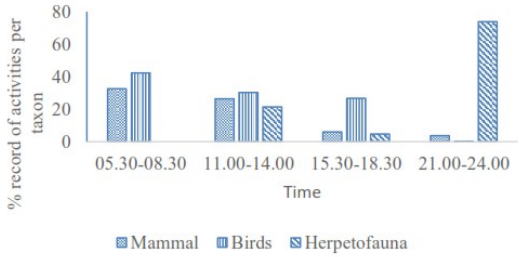

Figure 3. Temporal use of *F. benjamina* by different taxa of wildlife in the study area.

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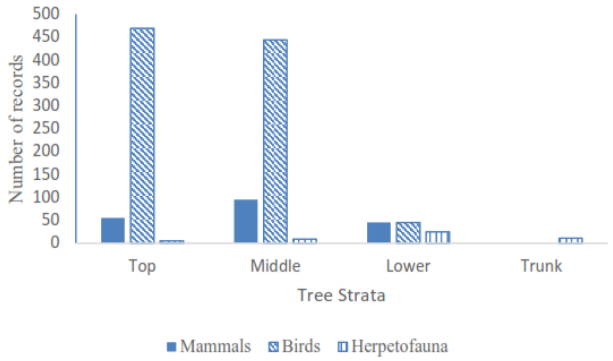

Figure 4. Use of tree strata in *F. benjamina* by different taxa of wildlife in the study area.

4. Discussion

The number of mammalian species reported in a previous study in the area was 14 species of 11 families [8], while this study found that 4 species of 4 families used *F. benjamina* (28%). Among those 4 families, Pteropodidae, Cercopithecidae, and Sciuridae had been reported to feed on fig fruits [3]. Long-tailed Macaque is primarily frugivorous [15]; therefore, it was expected to see them feeding on fig fruits. However, during the observation, Long-tailed Macaque was rarely seen feeding on fig trees, probably because they used other potential food. This species was also reported to widen their diet during fruit scarcity to include other food such as stem, flower, and even insects [15]. In a human-induced environment, such as recreational areas and urban habitats, Long-tailed Macaque was reported to have a broad diet that includes natural and artificial (or human) food [16, 17]. Smaller-sized mammals such as squirrels have been reported to consume *Ficus benjamina* in Sabah, Borneo [18]. In addition, the Plantain Squirrel also include insects in their diet [19].

Studies on the diversity of birds in the area showed that the number of bird species per survey ranging from 18 to 72 species depended on the length of survey, methods, and area [7]. The cumulative number of bird species in the Dramaga campus area was 99 species [9]. This 3-month study found 29 bird species that used the *F. benjamina*, which means that at least 29% - 40% of birds in the area use *F.benjamina* to fulfill their needs. Compared to other studies on bird diversity in the campus area, this fact shows the importance of weeping figs for birds. The importance of *F. benjamina* for birds in urban areas was also reported in the urban area of Depok [20]. The high proportion of insectivorous birds might correlate with fig pollinators than insect availability in the canopy [21]. However, because no insect sampling was conducted during this study, this assumption cannot be proven.

A total of 38 species of reptiles and 12 species of amphibians are reported to occur in the Dramaga campus area [9]. This study found 12 reptile species (31.5%) and two species of amphibian (16.7%). Although no feeding activity was observed, it was shown that *Ficus benjamina* provides habitat requirements for that wildlife.

5. Conclusion

Various wildlife utilized weeping figs (*Ficus benjamina)* to obtain their needs, including food and shelters. Fourteen mammal species, 29 bird species, 38 reptile species, and 12 amphibians visited weeping figs in the study area. Figs are beneficial for wildlife for providing food and shelter all year round. In addition, weeping figs provided food not only for frugivorous animals but also for insectivores; therefore, they have essential roles as wildlife habitats in the peri-urban area.

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Appendix 6. Published paper on the bird visit to Ficus.

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Bird visit to *Ficus benjamina* in two urbanization gradients in the tropics

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Abstract. Fig trees area believed to be important bird habitat in the tropics, including in urban areas. The research objective was to reveal the bird species that visited *Ficus benjamina* in the low and high urbanization gradients in the tropics. Data were obtained in IPB University Darmaga Campus (low urbanization) and Sentul City (high urbanization) in Bogor (West Java, Indonesia), through direct observations of four trees per site in the morning, midday, late afternoon, and night, totalling 276 observation hours. Total of 29 bird species visited *F. benjamina* trees (26 species in low urbanization, 12 species in high), mainly insectivores, nectarivores, and frugivores birds. Nine species were common in both sites, i.e., Spotted Dove, Plaintive Cuckoo, Fulvous-breasted Woodpecker, Small Minivet, Common Iora, Sooty-headed Bulbul, Yellow-vented Bulbul, Common Tailorbird, Scarlet-headed Flowerpecker, and Olive-backed Sunbirds. Nocturnal birds (Collared Scops Owl, Large-tailed Nightjar) were present in low urbanization, but absent in high urbanization site, so did kingfishers (White-throated Kingfisher, Collared Kingfisher) and some other urbanization-prone species. The high urbanization site was characterized by the presence of Eurasian Tree Sparrow at the fig tree. This study showed that *F. benjamina* has an important role for diurnal and nocturnal birds, even in the high urbanization site.

Keywords: Darmaga Campus, fig trees, high urbanization, IPB University, low urbanization, Sentul City

1. Introduction

Fruits of *Ficus* in the tropics have been recognized as important keystone food resources for many wildlife species, as they provide continuous amounts of food all year round [1, 2]. A field study in Lambir Hills National Park, Sarawak [3] reported that up to 42% of bird species and 73% of mammals have been recorded feeding on figs. A more intensive literature reviews worldwide [4] have shown that the *Ficus* was the most widely consumed plant genus, utilized by more than 10% of the world's birds and 6% of mammals.

In a natural forest habitat, tree species bearing soft fruits with many small seeds have been known to be visited by diverse frugivore species [5, 6]. A recent study on Ficus trees in Australia [1] revealed *Ficus* trees provide a valuable food resource (i.e., stingless fig wasps) for insectivorous birds as well. The birds were presumed to feed on emerging fig wasps [7, 1]. Fig wasps are insects (family Agaonidae, superfamily Chalcidoidea) that spend their larval stage inside figs. The figs (syconia) are pollinated exclusively by specific wasps, which reproduce by laying eggs within the fig's flowers, where the larvae

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eventually feed and develop [8].

Ficus benjamina are widely distributed in Indonesia [9] and many other tropical and subtropical countries [10]. In Indonesia, this tree species is highly adaptable and can be found in many habitat types, including in primary forest, secondary forest, agricultural land, and even in urban areas, in the lower altitude up to 1,500 m [9]. Previous studies on the birds visit to *Ficus benjamina* in Indonesia's urban areas was conducted in Jakarta [11].

The research objective was to reveal the bird species that visited *F. benjamina* in the urban area, specifically low and high urbanization gradients in the tropics. This information could be useful for further management by the urban planner, especially when birds and other urban wildlife would be used as an indicator for environmental quality.

The study sites selected to represent the low and high urbanization areas were Darmaga Campus and Sentul City. The bird community in Darmaga Campus has been surveyed from time to time, and the latest survey in 2020 [12] reported that there were 52 bird species in the campus area. Although data on cumulative birds were available (99 species), current bird sighting was used instead. Meanwhile, in Sentul City, the total bird species based on 2017 survey was 35 species, and the cumulative bird number was 51 species [13].

By selecting and comparing the low and high urbanization gradients hopefully would better understand the role of the *F. benjamina* in urban areas, as this species is often used as regreening activities in many green open spaces in Indonesia due to its remarkable adaptation to the urban environment. This research is part of a bigger study on Long-Term Ecological Research (LTER) on the fig-wildlife relationship in the tropics.

2. Materials and methods

Two sites having different urbanization gradients were selected for this study. The low urbanization site was Darmaga Campus (6º32'41"- 6º33'58"S, 106º42'47"-106º44'07"E; total area 267 ha), located in a sub-urban area of Bogor, approximately 12 km west of Bogor City. In addition to buildings and field laboratories, there were some areas contained *F. benjamina* that have been less visited by human, created a suitable low urbanization habitat.

The second research area, the high urbanization site, was Sentul City Residential Complex (6°33′55"-6°37′45"S, 106°50′20"-106°57′10"E; total area 3,100 ha), located approximately 5 km East of Bogor City and 35 km south of Jakarta. Currently Sentul City has a vast green area, about 65% of its total area. Before transformed into residential areas, Sentul City was covered by a rubber plantation. Along with the development of the residential areas started in 1994, *F. benjamina* trees (along with many other trees) were planted as street trees. *F. benjamina* also planted to border the residential complex with its neighbouring areas.

In each site, four mature similar trees were selected as focal trees. All trees were mature (more than 10m high), healthy (i.e., no sign of dying, defoliation), and in a natural condition (e.g., no previous cutting or trimming). Some variation on the tree diameter, tree height and height of branches trunk, however, were inevitable. For the focal trees in the high urbanization gradient, the trees were far away (more than 20m) from housing or other buildings to ensure a minimal human disturbance. Tree characteristics were recorded, including tree height, diameter, and height of branchless trunk (table 1). Phenological features (fruiting stage and relative fruit abundance) were also documented accordingly, and presented in ordinal scales. Fruiting stages and fruit abundance were carefully recorded, as these parameters could lead to a bias in the number of bird visit in both study sites.

Field observation on the visit of birds to *F. benjamina* trees were conducted in July to September 2020. Three-day observations per month was conducted in each focal tree, totalling 144 observation hours in Darmaga Campus (low urbanization) and 132 hours in Sentul City (high urbanization). The slightly differed in total observation time was mostly due to the weather condition. No observation was performed when showering and raining.

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Table 1. Characteristics of sampled trees in low (Darmaga Campus) and high urbanization sites (Sentul City; n=4 for each site).

Tree Characteristics	Low Urbanization				High Urbanization			
	1	2	3	4	1	2	3	4
Height (m)	13.0	23.4	16.4	17.0	11.8	10.6	14.0	12.3
Diameter (cm)	39.49	131.5	129.3	86.94	84.08	110.83	78.34	68.15
Branchless trunk (m)	4.28	3.64	3.12	1.98	2.03	1.74	2.57	2.85
Fruiting stage*	1	1	2	3	0	2	0	0
Fruit abundance**	1	1	1	2	0	2	0	0

* 0: no fruit, 1: very early, 2: early, 3: full, 4: late
** 1: 0-25%, 2: 26-50%, 3:51-75%, 4: 76-100%

Observations were conducted four times in a day: morning (5-8am), noon (11am-2pm), late afternoon (4-7pm) and at night (9pm-midnight). Morning and late afternoon observations are standard timing for bird research. In addition to the standard observation time, two other timing at noon and at night were also added. Observations were conducted simultaneously at both study sites by two different teams, three persons for each team. Observers' posts were about 10 m from the focal tree in different directions to ensure non-overlapping views. Bird sighting was aided by using binoculars (8x30). Data collected were mainly bird species and number of individuals. Identification, nomenclatures and sequence follows a widely-used field guide [14]. Observation on bird behavior or duration of perching were excluded in this research, as it required a more intense timing and equipments.

Data (cumulative and percentage) were collated for each study site. Time preference of the bird visit was tested by using a Chi-square test. Food guild of each bird was also assessed, mainly from literature [14] and through direct observation. Only major food guilds were used, namely frugivores, insectivores, granivores, nectarivores, and bird of prey (meat eater).

3. Results

There were 1,037 individual birds observed visiting *F. benjamina* trees in both locations.The low urbanization site was visited by more than twice birds compare to the high urbanization site (table 2). As for the number of bird species, 26 species have visited *F. benjamina* in low urbanization, and 12 species visited high urbanization site, totalling 29 species. Ten species were common in both sites, namely Spotted Dove, Plaintive Cuckoo, Fulvous-breasted Woodpecker, Small Minivet, Common Iora, Sooty-headed Bulbul, Yellow-vented Bulbul, Common Tailorbird, Scarlet-headed Flowerpecker, and Olive-backed Sunbirds. Meanwhile, nocturnal birds (Collared Scops Owl, Large-tailed Nightjar) were present in low urbanization, but absent in high urbanization site, so did kingfishers (White-throated Kingfisher, Collared Kingfisher) and some other urbanization-prone species. The high urbanization site was characterized by the presence of Eurasian Tree Sparrow at the fig tree.

As for timing of visit, the fig trees were visited by birds mostly in the morning, consistently diminishing throughout the day in both sites (table 3). In the late afternoon, at the time when birds usually active, the visit surprisingly became lower. Statistical tests revealed that there was a time preference in the birds' visiting time (χ^2=297.72; df=3; P<0.001 for low urbanization; χ^2=227.18; df=3; P<0.001 for high urbanization). When the night observations were excluded, there was still a strong preference on the timing of the bird visit (χ^2=27.38; df=2; P<0.001 for low urbanization; χ^2=110.99; df=2; P<0.001 for high urbanization). Nocturnal species that visited the *F. benjamina* were Collared Scops Owl and Large-tailed Nightjar.

Based in food guilds, birds that visited *F. benjamina* trees (table 4) were mainly insectivores (59%), as well as frugivores (17%), and granivores (17%). Despite the fact that the *F. benjamina* trees produced fruits, apparently it was insectivorous bird that visit *F. benjamina* the most. Some nectar-feeding birds and fish-eaters also observed visited the trees, most likely did not searching for food. These species were observed perching and resting on the *F. benjamina.*

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Table 2. Number of birds that visited *Ficus benjamina* trees in low and high urbanization gradients; species in bold were observed in both study sites (n: nocturnal species).

No	Family	Scientific Name	Common Name	Low	High
1	Columbidae	*Treron vernans*	Pink-necked Green Pigeon	22	0
2		*Streptopelia chinensis*	**Spotted Dove**	12	1
3	Psittcidae	*Psittacula alexandri*	Red-breasted Parakeet	2	0
4	Cuculidae	*Cacomantis merulinus*	**Plaintive Cuckoo**	3	2
5		*Surniculus lugubris*	Drongo Cuckoo	1	0
6	Strigidae	*Otus lempiji*[n]	Collared Scops Owl	3	0
7	Caprimulgidae	*Caprimulgus macrurus*[n]	Large-tailed Nightjar	1	0
8	Alcedinidae	*Halcyon smyrnensis*	White-throated Kingfisher	1	0
9		*Todirhamphus chloris*	Collared Kingfisher	2	0
10	Picidae	*Dendrocopos macei*	**Fulvous-breasted Woodpecker**	2	5
11		*Dendrocopos moluccensis*	Sunda Pygmy Woodpecker	1	0
12	Campephagidae	*Lalage nigra*	Pied Triller	2	0
13		*Pericrocotus cinnamomeus*	**Small Minivet**	18	6
14	Aegithinidea	*Aegithina tiphia*	**Common Iora**	54	19
15	Pycnonotidae	*Pycnonotus aurigaster*	**Sooty-headed Bulbul**	456	45
16		*Pycnonotus goiavier*	**Yellow-vented Bulbul**	40	105
17	Timaliidae	*Malacocincla sepiarium*	Horsfield's Babbler	2	0
18	Sylviidae	*Orthotomus sutorius*	Common Tailorbird	59	0
19		*Orthotomus sepium*	Olive-backed Tailorbird	0	22
20	Sittidae	*Sitta frontalis*	Velvet-fronted Nuthatch	1	0
21	Dicaeidae	*Dicaeum trochileum*	**Scarlet-headed Flowerpecker**	52	41
22	Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	4	0
23		*Cinnyris jugularis*	**Olive-backed Sunbirds**	46	7
24	Zosteropidae	*Zosterops palpebrosus*	Oriental White-eye	1	0
25	Estrildidae	*Lonchura leucogastroides*	Javan Munia	0	6
26		*Lonchura punctulata*	Scaly-breasted Munia	1	0
27	Ploceidae	*Passer montanus*	Eurasian Tree Sparrow	0	25
28	Sturnidae	*Gracupica contra*	Pied Myna	1	0
29	Oriolidae	*Oriolus chinensis*	Black-naped Oriole	2	0
			Total number of individuals	789	284
			Number of individuals per observation hour	5.48	2.15
			Total number of species	26	12
			Percentage of the total bird community	50.0	34.3
			Number of common species in both sites	9	

4. Discussion

4.1. The role of Ficus benjamina for urban birds

Compare to the total bird species, high percentage of birds in the study sites were visited *F. benjamina* trees, averaging 42.2% for both sites. In spite of some possible biased due to the different fruiting stage of the two study sites (see table 1), this research reinforced other previous studies that *Ficus* in the urban areas was indeed important for bird community. The high gradient of urbanization selected in this study area was rather unique, because all *F. benjamina* trees were purposively planted by housing management of Sentul City. Results of this research showed that despite the strong anthropogenic influences, *F. benjamina* remained important for birds in urban areas.

As predicted, compared to the low urbanization area, the number of birds visited the *F. benjamina* trees in the highly urbanized area was lower, both in species richness and population number. The European Tree Sparrow that often used as an indicator species for urbanization level [15] was observed only at the high urbanization area in this research, but not in the low urbanization area.

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Table 3. Number of birds that visit *Ficus benjamina* trees in low (Darmaga Campus; n=4) and high (Sentul City; n=4) urbanization gradients at different times of the day.

Observation Time	Low	Percentage	High	Percentage	Both Sites	Percentage
Morning	335	42.46	173	60.92	508	47.34
Noon	240	30.42	72	25.35	312	29.08
Late afternoon	211	26.74	34	11.97	245	22.83
Night	3	0.38	5	1.76	8	0.75
Total	789	100.00	284	100.00	1,073	100.00

Table 4. Main food of birds that search for food at *Ficus benjamina* trees in low (Darmaga Campus) and high (Sentul City) urbanization gradients.

No	Common Name	Main Food Types				
		Fruit	Insect	Seed	Nectar	Meat
1	Pink-necked Green Pigeon	x				
2	Spotted Dove			x		
3	Red-breasted Parakeet			x		
4	Plaintive Cuckoo		x			
5	Drongo Cuckoo		x			
6	Collared Scops Owl[n]		x			X
7	Large-tailed Nightjar[n]		x			
8	White-throated Kingfisher					X
9	Collared Kingfisher					x
10	Fulvous-breasted Woodpecker		x			
11	Sunda Pygmy Woodpecker		x			
12	Pied Triller		x			
13	Small Minivet		x			
14	Common Iora		x			
15	Sooty-headed Bulbul	x	x			
16	Yellow-vented Bulbul	x	x			
17	Horsfield's Babbler		x			
18	Common Tailorbird		x			
19	Olive-backed Tailorbird		x			
20	Velvet-fronted Nuthatch		x			
21	Scarlet-headed Flowerpecker	x			x	
22	Brown-throated Sunbird				x	
23	Olive-backed Sunbirds				x	
24	Oriental White-eye		x			
25	Javan Munia			x		
26	Scaly-breasted Munia			x		
27	Eurasian Tree Sparrow			x		
28	Pied Myna		x			
29	Black-naped Oriole	x				
	Total	5	17	5	3	3
	Percentage*	17.24	58.62	17.24	10.34	10.34

n: nocturnal species
*Sum of the percentage would be more than 100%, as some birds have several food types

Previous research on bird visit to *F. benjamina,* however, was limited. This could be due to the limited distribution of *F. benjamina* in a low elevation in the hot tropics [9]. Therefore, most research have used several *Ficus* species within a certain landscape as focal trees, or selected the most dominant *Ficus* in the study site. In addition, very few (e.g., [11]) conducted research specifically in an urban area at *F. benjamina* trees, the same species used in this study. Further, most study on the visitation of birds to

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various species of *Ficus* trees, either in Indonesia or outside Indonesia, were conducted in a natural habitat, and only a few was located in urban areas, for example at a campus in Jakarta [11], at a fragment forest in Singapore [16], and all green open space in Hong Kong [6], and in forest parks and campus in Taipei [17].

A study in the southwest China on birds visiting several fig trees [10] showed that *F. benjamina* was one of the most visited species, along with two other fig tree species, *F. tinctoria* and *F. altissima*. Thus, when *F. benjamina* present, this species has important roles for bird community, either frugivorous birds, or insectivorous birds. Fig fruits of *F. benjamina* and others are suitable for consumption by most bird, because of the soft fruits with numerous tiny seeds inside [10].

4.2. Bird guild and bird species that visit Ficus

Based on food guild, of the list of birds that visited *F. benjamina* in this study, about 59% were insectivores, while frugivores constituted 17% of the bird community (both sites combined). Although most member of genus *Ficus* has been known to produce mass fruit [7], it was insect-eating bird that dominated the visitation to the *F. benjamina* in this study, both in the low and high urbanization areas. In fact, many other researchers (e.g., [1, 2, 11]) also showed the same results.

There were two reasons of the domination of insectivorous birds that visited *F. benjamina*: (a) in general, the bird community in the study sites was dominated by insectivores, based on previous studies in Darmaga Campus [12] and in Sentul City [13], reinforcing the finding of previous study [10] that bird species visit fig trees often were those with the highest abundances within the study sites, (b) fig trees produced insect wasps that emerged from the fig's ripe fruit. Study in fig wasp at *F. pertusa* in Monteverde [7] revealed that there were 11 bird species (mostly warblers) predating on emerging fig wasps, gleaning insects from the branches, fruits, and also the undersides of leaves, suggested that *Ficus* trees also have attracted insectivorous birds, as well as frugivorous birds. A study in East Java [18] reported a flock of Cave Swiftlet *Collocalia linchi* at certain times continuously flying in a circle above a fig tree, searching for aerial insects.

Small-sized passerines, mainly bulbuls (Pycnonotidae family), were dominant visitors of *F. benjamina*, as also reported in Jakarta [11]. This group of species actually was also dominant visitors of other fig tree species elsewhere. Outside Indonesia, other field studied in tropical and sub-tropical Asia also revealed that small passerines were the dominant birds to visit fig trees, as reported in Malaysia [2], Thailand [5], the Philippines [19], Hong Kong [6], China [10], Japan [20] and India [21]. Based on habitat types, members of Pynonotidae family were always dominated as fig visitors, either in the natural pristine forest area [2], or in urban area [16, 11].

In Singapore, however, the most common bird species seen feeding on the figs (*F. fistulosa* and *F. grossularoides)* was the Pink-necked Green Pigeons, followed by Yellow-vented Bulbul [16], both species were present in this study. In other studies, it was found that large birds might not feeding on the *Ficus* tree because energetically it may be less efficient to feed on small sized figs [2]. In this research, the largest bird that visit *F. benjamina* was Pink-necked Green Pigeon and Spotted Dove. The Pink-necked Green Pigeon is an exclusive fruit eater, and it seemed that in urban areas the opportunity to find fruits was very limited. The fruit of *F. benjamina* could be one of the food sources for this pigeon, even though the fruits were small and less efficient in term of energy cost. As for the Spotted Doves, basically they are seed eaters, which might opportunistically take advantage in the fruiting fig.

In the study areas, other than *F. benjamina,* many tree species nearby the focal trees could aso produce food for birds. In this study, observations were focused only on the *F. benjamina* trees. This study can be extend to a more intensive observations related to the bird behavior, phenology in annual basis, as well as food source from other trees as complement to the *F. benjamina* fruit.

4.3. Daily temporal dynamics

In this research, the birds visited *F. benjamina* trees was more frequent during the early morning, and decreased in the afternoon and evening, very similar to the finding in the natural forest of Maliau Basin in Malaysia, most likely coincided with the production of new ripe fruit in the morning [2]. A study on

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bird diversity in Darmaga Campus (i.e., low urbanization; [12]) comparing morning and evening surveys has noted that the bird community were basically the same, both in species richness and in number of individuals. This means that the bird indeed had a preference on the morning visit compared to other times, although it has been widely known that late afternoon also a preferred time for food searching.

Two nocturnal bird species were also spotted visiting the *F. benjamina* in this study, namely Collared Scops Owl and Large-tailed Nightjar. As both species are known to be insectivorous [14], these species might forage for nocturnal insects, or used the *F. benjamina* tree as a vantage to look for food, especially for the Collared Scops Owl as a nocturnal raptor. Unfortunately, there was no other published information regarding the visitation of nocturnal birds to fig trees, and thus comparison with other research results cannot be conducted at this point.

5. Conclusion

Many bird species (42.2% of the total bird community, mostly small-sized passerines) were observed visited *F. benjamina* trees in an urban area, indicating that *F. benjamina* indeed is very important as a habitat component of the bird community in urban environment. Although *Ficus* group has been known to produce mass fruits, bird food guild that dominated the visit was insectivores. The peak visit time was in the morning, coincided with the new ripe fruit time. Nocturnal birds were also visited the *F. benjamina* trees.

In the urban areas, *F. benjamina* often planted in various purpose sites, including along street trees (i.e. planted in rows), in pocket parks, traffic island, and many other green urban space. In addition to provide many environmental services, *F. benjamina* trees also have important roles in maintaining or increasing bird diversity in the urban tropics.

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