Journal of Tropical Biodiversity and Biotechnology
Volume 07, Issue 02 (2022): jtbb68516
DOI: 10.22146/jtbb.68516

Research Article

A Study on Diversity and Distribution of Figs (*Ficus*, Moraceae) in Bogor City, West Java, Indonesia

Peniwidiyanti[1,2], Ibnul Qayim[3]*, Tatik Chikmawati[3]

1) Research Center for Plant Conservation, Botanic Gardens, and Forestry, National Research and Innovation Agency, Jl. Ir. H. Juanda No. 13, Bogor, West Java, 16112, Indonesia.
2) Plant Biology Graduate Program, Department of Biology, Faculty of Mathematics and Natural Sciences, IPB University, Jl. Raya Dramaga, Bogor, West Java, 16680, Indonesia.
3) Department of Biology, Faculty of Mathematics and Natural Sciences, IPB University, Jl. Raya Dramaga, Bogor, West Java, 16680, Indonesia.
* Corresponding author, email: i-qayim@apps.ipb.ac.id

Keywords:
Bogor City
Ficus
Hemiepiphyte
QGIS
Urban Ecology
Submitted:
19 August 2021
Accepted:
20 May 2022
Published:
04 July 2022
Editor:
Miftahul Ilmi

ABSTRACT

Ficus (Moraceae) is a keystone resource species in the tropical region, and it contributes significantly to Bogor City's vegetation composition. *Ficus* spp. provide habitat for urban animals and contribute to providing environmental services for the community. Minimum data distribution and increasing land-use change possibly decrease *Ficus* diversity in Bogor City. This study aimed to analyse the diversity and distribution of *Ficus* spp. in Bogor City. The research was conducted by dividing Bogor City into 128 plots sized 1 x 1 km. Relative abundance and distribution analysis used QGIS version 3.10.2-A Coruña. A total of 37 species of *Ficus* spp. from six subgenera were found in Bogor. The highest distribution is mainly located around the Bogor Botanic Gardens and the Ahmad Yani City Forest in a tree and hemiepiphyte. *Ficus benjamina* and *Ficus septica* were the most common species found and spread throughout Bogor City. The significant land-use change in Bogor City has resulted in *Ficus* spp. generally spread in the northern and central parts. In contrast, in the southern part, they are relatively low. Some *Ficus* can also be bioindicators because they have growing habitats that tend to be specific and spread in certain areas. The presence of the Bogor Botanic Gardens has an important role in increasing the diversity of *Ficus* spp. in Bogor City.

INTRODUCTION

Bogor City was one of the important cities during the Dutch colonial period. It was a cantilever city for Batavia, so schools based on agricultural cultivation (Khoiriyah & Nasution 2014), plant acclimatisation gardens, and various botanical research institutions (Ariati & Widyatmoko 2019) were built in this city. Cultural acculturation, architecture, and high plant species diversity attract domestic and foreign tourists to visit Bogor. The rapid growth development of Bogor city, especially in the 1997–2007 period, converted many land functions that were initially vegetated into settlements and trading centres (Nurwanda & Honjo 2018). To preserve existing nature and history, the local government issued Bogor Mayor Regulation No. 17 (2015) regarding the implementation of Bogor City as a Heritage City in the form of natural and

landscape heritage. Natural and landscape heritage consists of various areas that have the potential as Green Open Space, such as the Ciliwung river boundary, the Cisadane river boundary, forested areas, green belt corridors, and heritage trees. These heritage group trees commonly planted, such as java almond, mahogany, and several species of figs (*Ficus* spp.), are often found in the Bogor Botanic Gardens and Great Post Road (De Groote Postweg Lane) (Akbar & Nurhayati 2018). High adaptability and species distribution of *Ficus* spp. generate it to be commonly found in various areas in Bogor City until now.

The figs (*Ficus*) have various benefits to the environment, animals, and humans. *Ficus* is a genus of the Moraceae that can be a key resource in tropical forests (Kuaraksa et al. 2012). The presence of *Ficus* spp. in urban areas has been widely studied in various big cities (Lok et al. 2013; Ebika et al. 2015; Pradana et al. 2018), leading it to become an environmental indicator (Reyes et al. 2012) and restoration plants (Cottee-Jones et al. 2016). *Ficus* spp. in urban areas has various ecological benefits as a food source and habitat for urban animals (birds, bats, and small mammals), creating a microclimate, and maintaining water conservation (Siswo et al. 2019). Some species also have ethnobotanical potential (Shi et al. 2014).

The high level of landscape change in Bogor City allows for a decrease in plant species diversity, especially native plant species such as *Ficus*. Previous research on plant species diversity in Bogor City was limited to a few green belt corridors and urban forests (Soviyanti 2017; Kalam 2018), while *Ficus* spp. can grow in various habitats in the city. Limited information and data of *Ficus* diversity in Bogor City resulted in a lack of attention to the presence of these figs and the function of *Ficus* as an environmental bioindicator and ecological balancer has not been maximised. Recent studies on the presence and ecological function of *Ficus* in various ecosystems in Java have been published, including studies of diversity *Ficus* in the mountains (Hendrayana et al. 2019), *Ficus* at settlements around springs (Ridwan et al. 2015), and *Ficus* in Sentul City as urban area (Mulyani et al. 2021). The Bogor City, as a satellite town of the capital city, can be a liveable area with sufficient green open space and information on the diversity of *Ficus* in Bogor City can add a list of *Ficus* found on the Java, both native and introduced species. This research aimed to analyse the diversity and distribution of *Ficus* in Bogor City. This research is expected to provide important information in determining plants in green open space and settlements to increase plant diversity and the ecological function of Bogor City.

MATERIALS AND METHODS

Study Site

This research was conducted from August 2020 to May 2021. Observations of *Ficus* spp. were carried out in Bogor City excluding Bogor Botanic Garden, Presidential Palace, the office complex of Environmental and Forestry Instrument Standardisation Agency, and Dramaga-Situ Gede Research Forest.

The next step continued the herbarium identification at the Treub Laboratory and Herbarium Bogor Botanic Gardens (HBO). Bogor City has 11.850 hectares, divided into six sub-districts and 68 urban villages with an average height of 190 – 330 masl (The Central Bureau of Statistics of Bogor 2021). Monthly average temperature is 22° – 32°C, and humidity is 80% (Meteorological, Climatological and Geophysics Agency (BMKG) 2021). Observation of *Ficus* spp. were carried out throughout the Bogor City area, marked by the administrative boundary between Bogor City and Bogor Regency.

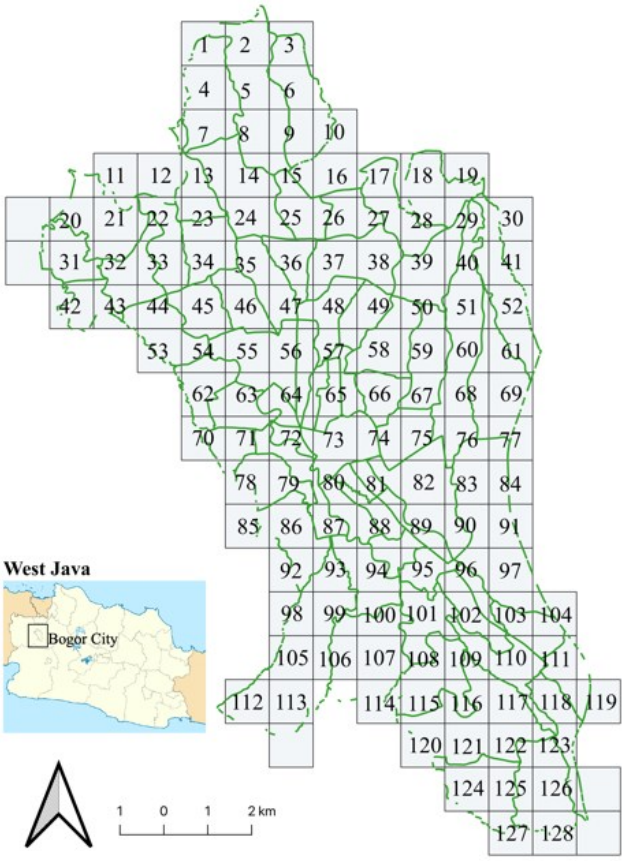

Figure 1. Map of the study area

Material and Methods

Observations of *Ficus* spp. were done by forming observation plots sized 1x1 km (Kent et al. 1999; Serrato et al. 2004), thus there were 128 observation plots in Bogor City (Figure 1). The data collected were location point, species name, number of individuals, habitus based on Berg and Corner (2005) and description habitat. The specimens were documented by taking photograph for habitus, important morphological characters and making description of habitat. After that, specimens were preserved into the herbarium. The next stage was the identification of *Ficus* spp. found, identified host trees, and known distribution status by matching the specimen with the herbarium in HBO, and identification books based on Flora of Java vol 1-3 (Backer & Bakhuizen van den Brink 1963; 1965; 1968) and Flora Malesiana: *Ficus* (Berg

& Corner 2005). Scientific name validation and accepted name updating refers to the Plant of the World Online website (POWO 2021). Information about the sexual system of *Ficus* refers to various references that will mention in the results of this study.

Data Analysis

Observation data were tabulated and analysed using Ms. Excel to classify *Ficus* to subgenus, sexual system, characteristic life form/habitus, and relative frequency of species (%F). The relative abundance of species shows to the percentage of individuals in a location by the following formula:

$$\%F = \frac{nA}{N} \times 100\%$$

Where %F is the relative abundance of species, *nA* is the number of individual species A found in Bogor City divided by *N*, the total individual of all species in Bogor City. The ecological studies were analysed based on distribution data of *Ficus* spp. using QGIS version 3.10.2-A Coruña. The base map for Bogor City is sourced from Ina-Geoportal (2021).

RESULTS AND DISCUSSION

Diversity *Ficus* spp. in Bogor City

Based on the research results in Bogor City, there were 37 species of *Ficus* from six subgenera (*Ficus*, *Pharmacosycea*, *Sycidium*, *Synoecia*, *Sycomorus*, and *Urostigma*) (Table 1, Figure 2). The diversity of *Ficus* species in Bogor City is high compared to other satellite towns such as Sentul city, which recorded 10 species (Mulyani et al. 2021). A total of 877 *Ficus* species have been recorded worldwide (POWO 2021), with 367 species of which can be found in the Malesia to Australasian regions, and 75 species can be found on the island of Java (Berg & Corner 2005). Based on the study, 25 species are native, and 12 species are alien. Native species were found in Bogor City, showing that one-third of the native *Ficus* species on the Java can be found here.

Ficus is divided into six subgenera and has distinctive morphological characteristics, including habitus and reproductive system diversity. A total of 1.726 individuals were observed in Bogor City. Most had a habitus as trees (72%), another habitus is shrubs (14%), hemiepiphytes (10%), and root climber (4%). A total of 25 *Ficus* species (73.76%) have a monoecious reproductive system that positively impacts species conservation, especially for key resource species that can bear fruit year-round. Monoecious figs such as *F. benjamina*, *F. virens*, and *F. racemosa* have more adaptive characteristics (Jim 2014; Krishnan & Borges 2018). The gynodioecious is a reproductive system in which each plant has female flowers and hermaphrodite flowers, perfect flowers (male-female) (Bawa 1980), but functionally the reproductive system of gynodioecious is similar to dioecious (Basso-Alves et al. 2014; Teixeira et al. 2018). There were 2 species of *Ficus* with a gynodioecious (14.25%) and 10 species of dioecious (12.01%).

Table 1. Diversity of *Ficus* spp. in Bogor City.

Species	Sexual System	%F	Habitus
Subgenus *Ficus*			
Ficus fulva Reinw. ex Blume	Gyno[1]	0.46	T
Subgenus *Pharmacosycea*			
Ficus callosa Willd.	Mono[5]	13.15	T
Subgenus *Sycidium*			
Ficus ampelos Burm.f.	Mono[8]	0.93	Sh, T
Ficus heteropleura Blume	Dioe[9]	0.06	Sh, Hm
Ficus montana Burm.f.	Dioe[6]	2.32	Sh
Ficus subulata Blume	Dioe[7]	0.06	T
Ficus tinctoria subsp. *gibbosa* (Blume) Corner	Dioe[7]	0.93	T, Hm
Subgenus *Sycomorus*			
Ficus auriculata Lour*	Dioe[5]	0.52	T
Ficus fistulosa Reinw. ex Blume	Dioe[4]	1.74	T
Ficus hispida L.f.	Dioe[3]	1.80	Sh, T
Ficus racemosa L.	Mono[1]	4.11	T
Ficus septica Burm.f.	Gyno[1]	13.79	Sh, T
Ficus variegata Blume	Dioe[4]	0.64	T
Subgenus *Synoecia*			
Ficus pumila L.*	Dioe[3]	3.24	Rc
Ficus trichocarpa Blume	Dioe[10]	0.70	Rc
Subgenus *Urostigma*			
Ficus altissima 'variegata'*	Mono[4]	3.19	T
Ficus annulata Blume	Mono[7]	0.12	Hm
Ficus benjamina L.	Mono[4]	24.68	T, Hm
Ficus benjamina 'lanset'*	Mono[4]	0.12	T
Ficus benjamina 'variegata'*	Mono[4]	0.81	T
Ficus callophylla Blume	Mono[12]	0.12	T, Hm
Ficus caulocarpa (Miq.) Miq.	Mono[8]	0.06	T
Ficus drupacea Thunb.	Mono[4]	0.41	T, Hm
Ficus elastica Roxb. ex Hornem*	Mono[5]	4.92	T, Hm
Ficus elastica 'abidjan'*	Mono[5]	2.26	T
Ficus elastica 'tineke'*	Mono[5]	0.23	T
Ficus kurzii King	Mono[12]	0.98	T, Hm
Ficus lyrata Warb*	Mono[1]	6.49	T
Ficus maclellandii King*	Mono[5]	2.14	T
Ficus microcarpa L.f.*	Mono[1]	3.94	T, Hm
Ficus microcarpa 'variegata'*	Mono[1]	0.06	T
Ficus natalensis subsp. *leprieurii* (Miq.) C.C. Berg*	Mono[12]	0.23	T
Ficus religiosa L.*	Mono[1]	0.23	T
Ficus retusa L.	Mono[10]	0.06	T
Ficus subcordata Blume	Mono[11]	0.06	T
Ficus superba (Miq.) Miq.	Mono[5]	0.06	T, Hm
Ficus virens Aiton	Mono[2]	4.40	T, Hm

%F is the relative abundance of species; * introduced species, and some naturalized; Gyno: gynoecious; Mono: monoecious; Dioe: dioecious; T: tree; Sh: shrub; Hm: hemiepiphyte; Rc: root climber; (1) Teixeira et al. (2018); (2) Fu et al. (2017); (3) Nazareno et al. (2013); (4) Corlett (2005); (5) Tarachai et al. (2011); (6) Parrish et al. (2003); (7) Zhang et al. (2020); (8) Huang et al. (2019); (9) Harrison & Yamamura (2003); (10) Jeevanandam & Corlett (2013); (11) Harrison (2008); (12) Berg and Corner (2005).

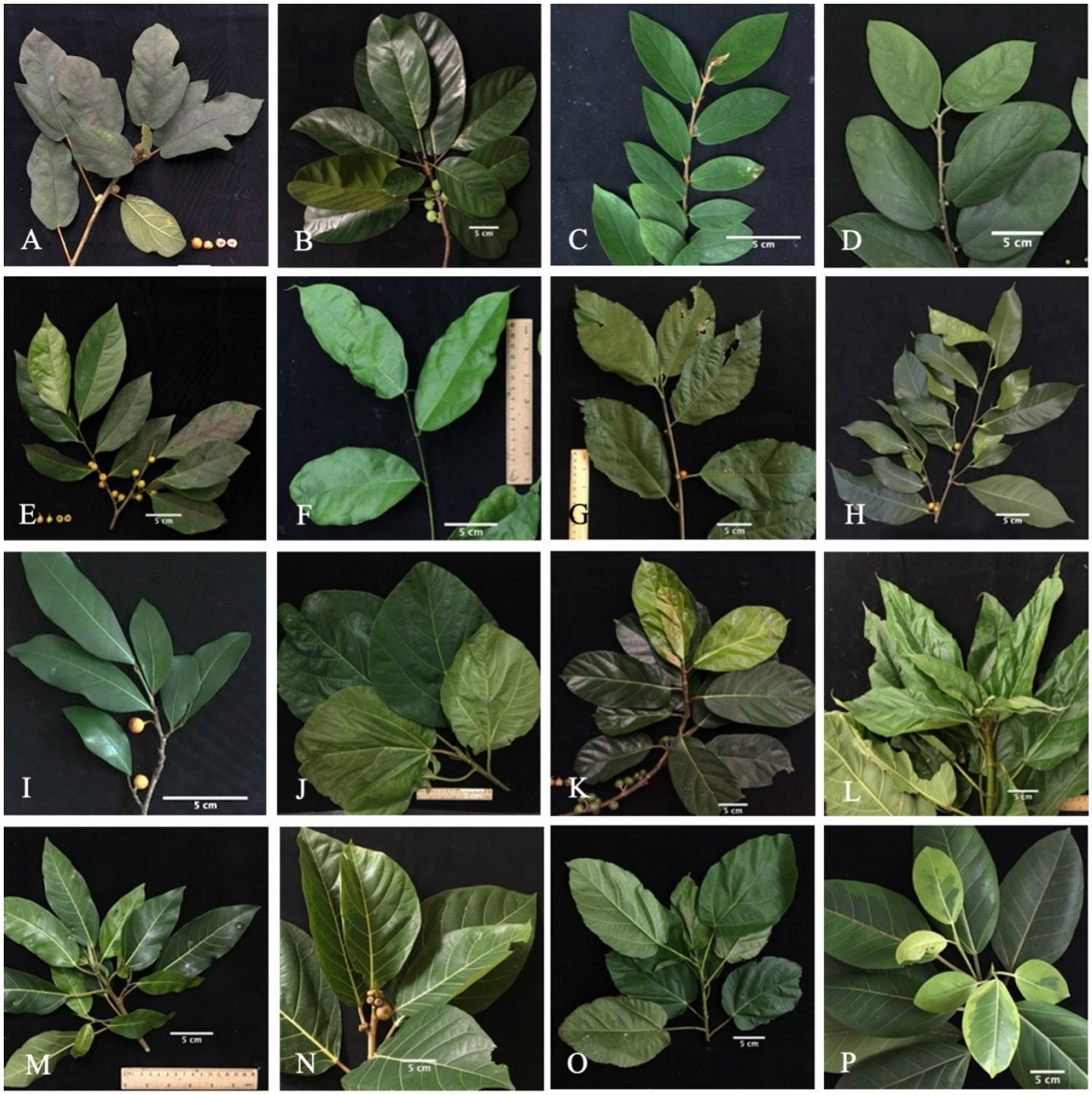

Figure 2. *Ficus* spp. found in Bogor City. A. *Ficus fulva*; B. *Ficus callosa*; C. *Ficus pumila;* D. *Ficus trichocarpa*; E. *Ficus ampelas*; F. *Ficus heteropleura*; G. *Ficus montana*; H. *Ficus subulata*; I *Ficus tinctoria* subsp. *gibbosa*; J. *Ficus auriculata*; K. *Ficus fistulosa*; L. *Ficus hispida*; M. *Ficus racemosa*; N. *Ficus septica*; O. *Ficus variegata*; P. *Ficus altissima* 'variegata'.

All species of *Urostigma* were monoecious trees and hemiepiphytes. *Urostigma* also has the highest number of species (22 species) with the highest relative abundance of 55.56%. Another subgenus with a high relative abundance is the *Sycomorus*, with 22.60% (6 species) with shrubs and tree habitus and generally dioecious. Subgenus *Pharmacosycea* has a high relative abundance of 13.15% (1 species), only *F. callosa* with tree habitus and monoecious. Three other subgenera in Bogor City have relative abundance below 10%. Subgenus *Sycidium* at 4.29% (5 species) with diverse habitus: trees, hemiepiphytes, or shrubs. Subgenus *Synoecia* at 3.94% (2 species) had habitus as root climber, and Subgenus *Ficus* at 0.46% (1 species) had tree habitus. These three subgenera generally have a dioecious.

Native *Ficus* are 25 species (75.64%), and 12 species (24.38%) are introduced or naturalized in Indonesia. Naturalized species such as *F. elastica* and *F. religiosa*, these two species have been naturalized for a long time and are

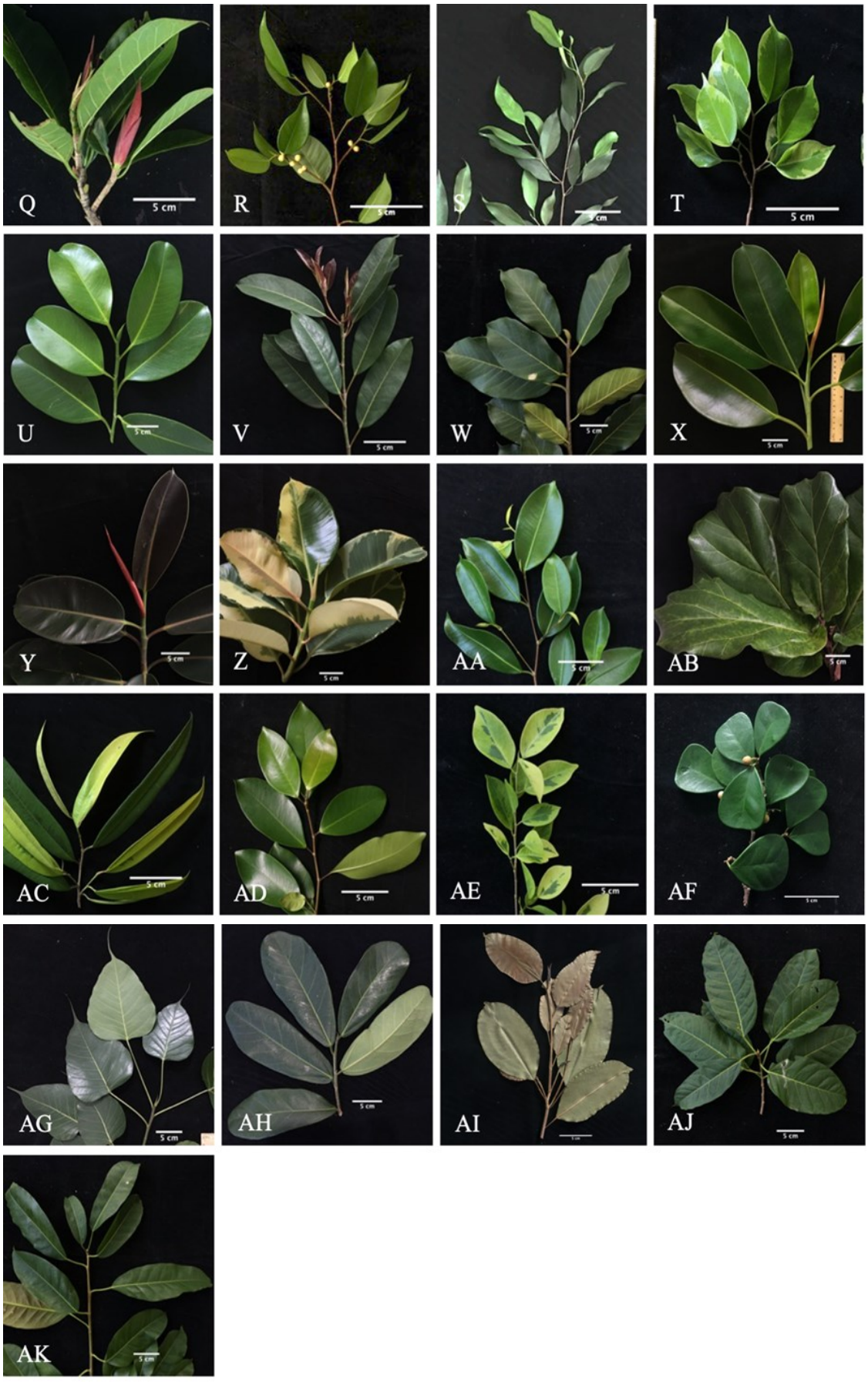

Figure 2 (continued). *Ficus* spp. found in Bogor City. Q. *Ficus annulata*; R. *Ficus benjamina*; S. *Ficus benjamina* 'lanset'; T. *Ficus benjamina* 'variegata'; U. *Ficus callophylla*; V. *Ficus caulocarpa*; W. *Ficus drupacea*; X. *Ficus elastica*; Y. *Ficus elastica* 'abidjan'; Z. *Ficus elastica* 'tineke'; AA. *Ficus kurzii*; AB. *Ficus lyrata*; AC. *Ficus maclellandii*; AD. *Ficus microcarpa*; AE. *Ficus microcarpa* 'variegata'; AF. *Ficus natalensis* subsp. *leprieurii*. AG. *Ficus religiosa*; AH. *Ficus retusa*; AI. *Ficus subcordata*; AJ. *Ficus superba*; AK. *Ficus virens.*

widely used by people in Indonesia. In the Lalitavistara relief at Borobudur temple, *F. elastica* and *F. religiosa* (bodhi tree) are found together with *F. benjamina*, *F. microcarpa*, and *F. racemosa* as species that have important values and have been known by the community as food, wood, and sacred (Metusala et al. 2020). Introduced *Ficus* are generally used as ornamental plants because they have unique plant parts, such as *F. elastica*, which has several variations in leaf color and stipules. In addition, the ability to absorb carbon and having a beautiful crown-like *F. lyrata* makes this species commonly planted in city parks or urban forests in Jakarta, Bekasi, and Bogor (Santoso et al. 2021). The high public interest in various species of introduced plants needs to be balanced with efforts to awareness about native *Ficus*, which also have beautiful crowns such as *F. annulata*, *F. drupaceae*, *F. virens*, or *F. superba*, so that planting in urban forests can be directed at native species.

Distribution *Ficus* spp. in Bogor City

Ficus spreads throughout Bogor City. *Ficus* spp. found in Bogor City are generally species with a wide distribution in Indonesia, such as *F. benjamina*, *F. caulocarpa*, *F. microcarpa*, *F. subulata*, *F. variegata*, and *F. virens* (Sukmawati 2019). The abundance of *Ficus* spp. categorized as very high (45-140), was found around the Bogor Botanic Gardens, Sempur Field, Bogor City Square, Sudirman Street, and Ahmad Yani City Forest. The abundance of species in the high category (21-44) was also found in other green belt corridors around the Bogor Botanic Gardens, Dr. Semeru Street, and the largest residential area in Bogor City (Figure 3A). Areas with a relatively very high and high category of the abundance of *Ficus* are included in the Landscape Heritage Bogor City. Therefore, the vegetation in green belt corridors, river boundaries to settlements that are structuring the urban landscape gets attention and periodic maintenance by the local government. The maintenance activity carried out is routine pruning of trees alongside roads and rivers. In addition, planting tree species in Bogor City Green Open Space is still being carried out. *Ficus*, which has a habit of trees and hemiepiphyte, is maintained to create shady vegetation that provides coolness around this Landscape Heritage.

Ficus found around the Bogor Botanic Gardens are generally species planted and then spread and grow naturally as hemiepiphytes on green belt corridor and surrounding buildings. In addition, some species are also planted as ornamental plants in office areas and public facilities such as schools, hospitals, and city parks. *Ficus* found around the Bogor Botanic Gardens include *F. benjamina* and *F. virens* with habitus in the trees and hemiepiphytes.

Several *Ficus* spp. have limited distribution around the Bogor Botanic Gardens, including *F. annulata*, *F. callophylla*, *F. drupacea*, *F. superba*, and *F. tinctoria* subsp. *gibbosa*. These five species were probably dispersed with the help of animals and visitors to the Botanic Gardens. Generally, these *Ficus* species have a habitus as hemiepiphyte that grows on trees in the green belt around the Botanic Gardens, such as *Samanea saman* and *Canarium asperum*. Bogor Botanic Gardens in the middle of Bogor City provides many ecological bene-

fits to the surrounding area, such as for animals (birds, bats, insects, and small mammals). Botanic Gardens can be a habitat, a source of food, and a bridge connecting animals' movement space (Arifin & Nakagoshi 2011).

Alongside the Ciliwung River and Cisadane River, consistently *Ficus* abundance was moderate (7-20). Generally, the species found around rivers are *F. racemosa* and *F. variegata*. Both species of *Ficus* can be environmental bioindicators because their presence can indicate ecosystem function changes and provide animal feed (birds and small mammals) throughout the year. However, these two species may be slightly spread in residential areas due to fruit dispersal by animals (birds or bats). Another *Ficus* found in the riverbank, or edge water stream is *F. fulva*. It was commonly found in smaller streams/rivers around agricultural and open areas. Kuaraksa et al. (2012) explained that *F. variegata* and *F. fulva* are suitable species for habitat restoration due to their high adaptability and fast growth. The presence of tree species around the river is expected to preserve the habitat around the river and reduce erosion, landslides, and drought.

Open spaces in Bogor City such as agricultural land, plantations, and areas under development had a low species abundance (0-6) (Figure 3A). Agricultural and plantation activities require a wide area, with management activities including weeds control such as *Ficus* seedling weeds with trees and shrubs. Therefore *Ficus* spp. were found in small numbers in those areas and generally only grow alongside rivers and roads. The southern part of Bogor City currently has an extensive open area due to massive development in toll road construction to housing development, so land clearing is carried out. It has been predicted based on a study by Nurwanda & Honjo (2018), which analyses the land-use change in Bogor City that occurred very quickly, which increased the average air temperature. In 1990, air temperature in Bogor City was recorded at around 23,8°C, then increased to around 26,4°C in 2007, and around 25,7°C in 2017. The temperature increase would occur more often if this developed area does not provide sufficient vegetated area. *Ficus* species commonly found in open areas are *F. hispida* and *F. septica*, both of which can grow in open and dry areas (Parrish et al. 2003; Kuaraksa et al. 2012) because they have mechanisms to defend themselves from drought and maintain balance turgor (Hao et al. 2010). *Ficus* and other plant species in this open area benefit the soil from potential surface run-off and erosion.

Ficus spp. can grow in various habitats and sometimes have specific distribution. Subgenus *Synoecia* (*F. pumila* and *F. punctata*) has habitus as root climbers and is generally grown as ornamental plants that decorate buildings or fences. *Ficus variegata*, *F. racemosa*, and *F. fulva*, easy to grow around streams, have also been described. Subgenus *Sycidium* and *Sycomorus* also grow naturally and distribute in open areas or around settlements. There are shrubs and treelet. In contrast, *Ficus* as a tree is generally planted as ornamental plants or grows naturally around the parent tree.

The presence of several *Ficus* that dominates Bogor City certainly has a big part in the ecological function of the city. *Ficus benjamina* and *F. septica*

dominate in Bogor City and have relatively different habitat preferences, although they often grow together in open areas. *Ficus benjamina* generally grows on the street, while mostly *F. septica* grows around settlements. The presence of *F. benjamina* in urban areas can be used as biomonitoring because it has a very important role in the environment, as a recent study in Mexico showed that *F. benjamina* was able to absorb various metal pollutants (Pb, Zn, Cu) from the air (Castañeda-Miranda et al. 2020; Morton-Bermea et al. 2021). In addition, *F. benjamina* can create new niches for various birds in urban areas, such as Depok City, Sentul City, and Dramaga Campus (Pradana et al. 2018; Mardiastuti et al. 2021). The presence of *F. septica* around settlements also has a high ecological role because it can reduce the heavy metals content (phytoremediation) such as mercury (Hg) from the soil (Mariwy et al. 2020). *Ficus septica* also has much bioactive content that is antibacterial (Sudirga & Suprapta 2021). Ethnobiologically, the leaves, and roots of the *F. septica* are widely used as food, medicine, and natural fiber. The indigenous people of Kampung Pinolobu, Sabah, Malaysia, use the roots of *F. septica* as postpartum, stomach aches, and headaches (Awang-Kanak et al. 2021). Also, indigenous peoples in Lampung use these leaves as an eco-friendly leaf plate known as Tebakak (Martinus et al. 2021). Thus, the community can utilize the presence of *F. septica* around the settlements of Bogor City.

Another species that dominates Bogor City is *F. callosa*, which has a tree habitus. This species is common in open areas and settlements. Wijaya & Defiani (2021) in Gianyar, Bali, stated that *F. callosa* have distributed around the riverbank. *Ficus callosa* distribution is limited in the northern Bogor, towards the centre, and is no longer found in southern Bogor (Figure 3B). The main reason for the absence of *F. callosa* in the southern area of Bogor City is the high development and the wider agricultural area.

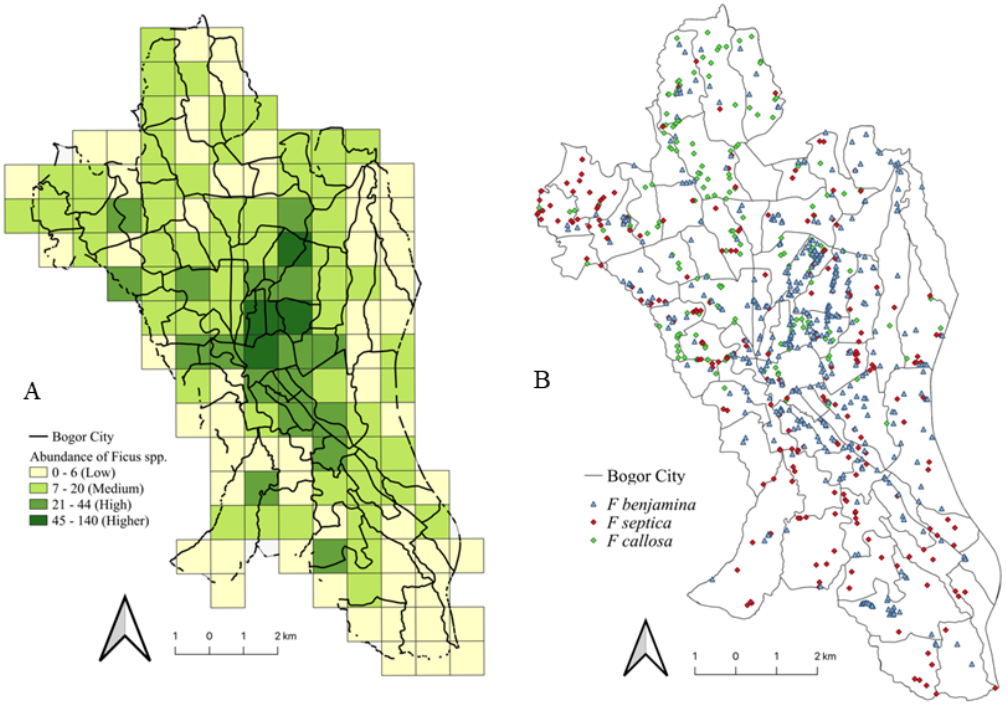

Figure 3. *Ficus* spp. distribution in Bogor City. (A) Abundance of *Ficus* spp.; (B) Distribution dominant *Ficus* spp.

Naturalized *Ficus* spp. in urban areas is common, especially as ornamental plants such as *F. lyrata*, *F. altissima* 'Variegata', *F. religiosa* to *F. pumila*. Thus, the abundance of naturalized *Ficus* spp. is getting higher and will gradually suppress the existence of the native *Ficus* spp., leading to a decrease in the number of these native *Ficus* spp. These introduced species are generally planted in the green belt corridors, green open space, and public facilities around settlements in relatively large numbers of individuals, even recently introduced species in Java, such as *F. auriculata*, *F. maclellandii*, and F. *natalensis* subsp. *lepreurii* has been widely planted in home gardens (Peniwidiyanti et al. 2021). Introduced species have a relatively high distribution and abundance of species potential (Table 1) and increased public demand. Planting introduced species in large numbers and areas, such as along roads in residential areas, certainly has a high potential for ecological disturbance in pest attacks, diseases, or decreased soil quality and fruit-eating animals in the vicinity (Krishnan & Borges 2018). The native *Ficus* species generally grows in open areas along roadsides and does not receive special attention from the local community, such as *F. retusa*, *F. subulata*, *F. heteropleura*, *F. caulocarpa*, and *F. subcordata*. Other species of *Ficus* spread with the help of animals such as *F. annulata*, *F. superba*, and *F. callophylla*, which do not receive regular maintenance. Several native *Ficus* recommended for planting activities in Green Open Spaces include species with beautiful crowns such as *F. annulata*, *F. retusa*, *F. subcordata*, and *F. virens*. Other native figs that can be recommended for planting rehabilitation include riverbanks such as *F. variegata*, *F. racemosa*, and *F. fulva*, while planting rehabilitation in open areas such as *F. hispida*, *F. fistulosa*, and *F. ampelos*.

CONCLUSION

Ficus spp. in Bogor City identified 37 species. It is classified into six subgenera: *Ficus*, *Pharmacosycea*, *Sycidium*, *Sycomorus*, *Synoecia*, and *Urostigma*. Subgenus *Urostigma* has the highest species with 22 species, and all species were monoecious. The relative abundance of *Ficus* spp. most recorded around the Bogor Botanic Gardens and the Ahmad Yani City Forest. *Ficus benjamina* and *F. septica* had relatively high abundance and distribution in Bogor City. Another species with a relatively high abundance was *F. callosa*, which was distributed from the north to the centre of Bogor City. *Ficus racemosa*, *F. variegata*, and *F. fulva*, which generally grow around rivers, can be environmental indicators to show land-use change. Several *Ficus* spp. also only grows around the botanic gardens and can indicate that an ex-situ conservation area also significantly increases *Ficus* diversity in Bogor City.

AUTHORS CONTRIBUTION

All authors (PNW, IQ, TC) had an equal contribution to the conceptualization of research, designing experiments. PNW collected, analyzed data, and wrote the manuscript. IQ and TC supervised all processes and wrote the manuscript.

ACKNOWLEDGMENTS

The authors would like to thank Saintek Scholarship 2019 by The Ministry of Research and Technology of the Republic of Indonesia (which recently became The National Research and Innovation Agency) for granting the scholarship and supporting this research. Gratitude also goes to the Head of Plant Conservation and Botanic Gardens for permission during specimen preparation in laboratory and herbarium observation.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

REFERENCES

Akbar, M.A.H. & Nurhayati, H.S.A., 2018. Preservation of heritage trees on the de Groote Postweg Lane in Bogor City. *IOP Conference Series: Earth and Environmental Science*, 203 (2018) 012007. doi: 10.1088/1755-1315/203/1/012007.

Ariati, S.R. & Widyatmoko, D., 2019. Botanic Garden Profile: Bogor Botanic Gardens. *Sibbaldia*, 17, pp.11–28.

Arifin, H.S. & Nakagoshi, N., 2011. Landscape ecology and urban biodiversity in tropical Indonesian cities. *Landscape and Ecological Engineering*, 7(1), pp.33–43. doi: 10.1007/s11355-010-0145-9.

Awang-Kanak et al., 2021. A Preliminary Survey on Edibles and Medicinal Plants Used By Dusun of Kampung Pinolobu, Kadamaian, Kota Belud, Sabah, Malaysia. *Journal of Tropical Biology and Conservation* 18, pp.21–30.

Backer, C.A. & Bakhuizen van den Brink, R.C., 1963. *Flora of Java* volume I. Groningen: Wolters-Noordhoff N.V.

Backer, C.A. & Bakhuizen van den Brink, R.C., 1965. *Flora of Java* volume II. Groningen: Wolters-Noordhoff N.V.

Backer, C.A. & Bakhuizen van den Brink, R.C., 1968. *Flora of Java* volume III. Groningen: Wolters-Noordhoff N.V.

Basso-Alves et al., 2014. Different ontogenetic processes promote dicliny in *Ficus* L. (Moraceae). *Acta Oecol.*, 57, pp.5-16. doi: 10.1016/j.actao.2013.02.012.

Bawa, K.S., 1980. Evolution of dioecy in flowering plant. *Ann Rev Ecol.,* 11, pp.15-39.

Berg, C.C. & Corner, E.J.H., 2005. Moraceae: Ficeae. Flora Malesiana-Series 1, Spermatophyta,17(2), pp.1-702.

Castañeda-Miranda et al., 2020. Magnetic biomonitoring of atmospheric dust using tree leaves of *Ficus benjamina* in Querétaro (México). *Environ Monit Assess,* 192, 382. doi: 10.1007/s10661-020-8238-x.

Corlett, R.T., 2005. Figs (*Ficus*, moraceae) in urban Hong Kong, south China. *Biotropica*, 38(1), pp.116–121. doi: 10.1111/j.1744-7429.2006.00109.x.

Cottee-Jones et al., 2016. The Importance of *Ficus* (Moraceae) Trees for Tropical Forest Restoration. *Biotropica*, 48(3), pp.413–419. doi: 10.1111/btp.12304.

Ebika et al., 2015. Hemi-epiphytic *Ficus* (Moraceae) in a congolese forest. *Plant Ecology and Evolution*, 148(3), pp.377–386. doi: 10.5091/plecevo.2015.1024.

Fu et al., 2017. Development of 15 Polymorphic Microsatellite Markers for *Ficus virens* (Moraceae). *Applications in Plant Sciences*, 5(1), pp.1600101. doi: 10.3732/apps.1600101.

Hao et al., 2010. Differentiation of leaf water flux and drought tolerance traits in hemiepiphytic and non-hemiepiphytic *Ficus* tree species. *Functional Ecology*, 24(4), pp.731–740. doi: 10.1111/j.1365-2435.2010.01724.x.

Harrison, R.D., 2008. Adaptive significance of phenological variation among monoecious hemi-epiphytic figs in Borneo. *Symbiosis*, 45(1–3), pp.83–90.

Harrison, R.D. & Yamamura, N., 2003. A few more hypotheses for the evolution of dioecy in figs (*Ficus*, Moraceae). *Oikos*, 100(3), pp.628–635.

Hendrayana et al.., 2019. Diversity and distribution of figs (*Ficus* spp.) across altitutes in Gunung Tilu, Kuningan, West Java, Indonesia. *Biodiversitas* 20(6). pp.1568-1574. doi: 10.13057/biodiv/d200612.

Huang et al., 2019. Fruiting phenology and nutrient content variation among sympatric figs and the ecological correlates. *Botanical Studies*, 60(1). doi: 10.1186/s40529-019-0275-9.

Ina-Geoportal [Indonesia Geoportal Web]. 2021. Peta Wilayah Kota Bogor. *Ina-Geoportal*, viewed 20 February 2021, from https://tanahair.indonesia.go.id/portal-web/download/perwilayah.

Jeevanandam, N. & Corlett, R.T., 2013. Fig wasp dispersal in urban Singapore. *Raffles Bulletin of Zoology*, 61(1), pp.343–347.

Jim, C.Y., 2014. Ecology and conservation of strangler figs in urban wall habitats. *Urban Ecosystems*, 17(2), pp.405–426. doi: 10.1007/s11252-013-0322-3.

Kalam, M.R., 2018. *Penilaian Fungsi Ekologis Hutan Kota Ahmad Yani di Kecamatan Tanah Sareal Kota Bogor*. Institut Pertanian Bogor.

Kent, M., Stevens, R., & Zhang, L., 1999. Urban plant ecology patterns and processes: a case study of the flora of the city of Plymouth, Devon, UK. *Journal of Biogeography,* 26(6), 128101298.

Khoiriyah, E., 2014. Pendidikan Pertanian (Landbouwonderwijs) Di Bogor Pada Tahun 1903-1920. *Avatara*, 2(3), pp.126–133.

Krishnan, A. & Borges, R.M., 2018. A fig tree in a concrete jungle: fine-scale population genetic structure of the cluster fig *Ficus racemosa* in an urban environment. *Urban Ecosystems*, 21(1), pp.171–181. doi: 10.1007/s11252-017-0707-9.

Kuaraksa, C., Elliott, S. & Hossaert-Mckey, M., 2012. The phenology of dioecious Ficus spp. tree species and its importance for forest restoration projects. *Forest Ecology and Management*, 265, pp.82–93. doi: 10.1016/j.foreco.2011.10.022.

Lok et al., 2013. *Native Fig Species As a Keystone Resource for the Singapore Urban Environment*, Raffles Museum of Biodiversity Research, Department of Biological Sciences, Faculty of Science: Singapore.

Mardiastuti, A., Mulyani, Y.A. & Kusrini, M.D., 2021. Bird visit to Ficus benjamina in two urbanization gradients in the tropics. *IOP Conf. Series: Earth and Environmental Science* 948 (2021), 012061. doi: 10.1088/1755-1315/948/1/012061.

Mariwy, A., Dulanlebit, Y.H. & Yulianti, F., 2020. Heavy metal mercury accumulation study using awar-awar (*Ficus septica* Burm. f.) plants. *Indonesian Journal of Chemical Research* 7(2), pp.159-169.

Martinus et al., 2021. Tebakak Leaves Plates as an Eco-friendly Disposable Plates: Cultural Roots, Technology and People Transformations. *2nd International Indonesia Conference on Interdisciplinary Studies,* 606, pp.302-307. doi: 10.2991/assehr.k.211206.042.

Meteorological, Climatological and Geophysical Agency (BMKG)., 2021, Daily Data in *UPT Bogor Region II Climatology Station, Bogor City, West Java. No. Stasiun 96753*, viewed 23 June 2021, from https:// dataonline.bmkg.go.id/data_iklim.

Metusala et al., 2020. The identification of plant reliefs in the lalitavistara story of Borobudur temple, Central Java, Indonesia. *Biodiversitas,* 21(5), pp.2206-2215. doi: 10.13057/biodiv/d210549.

Morton-Bermea et al., 2021. Mercury, Platinum, Antimony and Other Trace Elements in the Atmospheric Environment of the Urban Area of Mexico City: Use of *Ficus benjamina* as Biomonitor. *Bulletin of Environmental Contamination and Toxicology*, 106, pp.665-669. doi: 10.1007/s00128-020-03080-9.

Mulyani, Y.A, Kusrini, M.D. & Mardiastuti, A., 2021. Diversity of fig trees in a tropical urban residential area of Sentul City, Bogor, West Java. *IOP Conf. Series: Earth and Environmental Science,* 918, 012013. doi: 10.1088/1755-1315/918/1/012013.

Nazareno, A.G., Alzate-Marin, A.L. & Pereira, R.A.S., 2013. Dioecy, more than monoecy, affects plant spatial genetic structure: The case study of *Ficus*. *Ecology and Evolution*, 3(10), pp.3495–3508. doi: 10.1002/ece3.739.

Nurwanda, A. & Honjo, T., 2018. Analysis of land use change and expansion of surface urban heat island in Bogor city by remote sensing. *ISPRS International Journal of Geo-Information*, 7(5), 165. doi: 10.3390/ijgi7050165.

Parrish et al., 2003. Genetic evidence for natural hybridization between species of dioecious *Ficus* on island populations. *Biotropica*, 35(3), pp.333. doi: 10.1111/j.1744-7429.2003.tb00587.x.

Peniwidiyanti et al., 2021. Newly Recorded Alien Species of *Ficus* L. (Moraceae) in Java, Indonesia. *Journal of Tropical Biodiversity and Biotechnology*, 6(2), 65313. doi: 10.22146/jtbb.65313

Plant of the World Online (POWO), 2021, *Plant of the World Online* viewed 1 February 2021, from https://powo.science.kew.org.

Pradana, D.H., Mardiastuti, A. & Yasman, Y., 2018. Utilization of *Ficus benjamina* by Birds at Urban Habitat in Depok. *Bioma : Berkala Ilmiah Biologi*, 20(1), pp.75.

Reyes et al., 2012. *Ficus benjamina* leaves as indicator of atmospheric pollution: A reconaissance study. *Studia Geophysica et Geodaetica*, 56(3), pp.879–887. doi: 10.1007/s11200-011-0265-1 879.

Ridwan, M. & Pamungkas, D.W., 2015. Diversity of trees around the springs in Panekan Sub-District, Magetan, East Java. *Prosiding Seminar Masyarakat Biodiversitas Indonesia* 1(6), pp.1375-1379. doi: 10.13057/psnmbi/m010619.

Santoso et al. 2021. Pendugaan biomassa dan serapan karbon di beberapa areal taman hutan kota Jakarta, Bekasi dan Bogor. *Jurnal Penelitian Hutan Tanaman,* 18(1), pp.35-49.

Serrato, A., Ibarra-Manriquez, G. & Oyama, K., 2004. Biogeography and conservation of the genus *Ficus* (Moraceae) in Mexico. *Journal of Biogeography,* 31, pp.475-485. doi: 10.1046/j.0305-0270.2003.01039.x

Shi et al., 2014. An ethnobotanical study of the less known wild edible figs (genus *Ficus*) native to Xishuangbanna, Southwest China. *Journal of Ethnobiology and Ethnomedicine*, 10, 68. doi: 10.1186/1746-4269-10-68.

Siswo, Yun, C.W. & Abdiyani, S., 2019. Distribution of tree species around springs and trees-springs interplay possibility in the springs area of Soloraya, Central Java, Indonesia. *Forest Science and Technology*, 15(3), pp.128–139. doi: 10.1080/21580103.2019.1626772.

Soviyanti, A.N., 2017. *Penilaian Jasa Lingkungan Pohon pada Jalur Hijau Jalan sebagai Upaya Mereduksi Polusi Udara di Kota Bogor*. Institut Pertanian Bogor.

Sudirga, S.K. & Suprapta, D.N., 2021. Biological control of anthracnose disease (*Colletotrichum acutatum*) in chili peppers by crude leaf extract of fig (*Ficus septica* Brum.f.). *Sabrao Journal* 53(1), pp.79-87.

Sukmawati, J., 2019. Keanekaragaman dan Distribusi Ekologis *Ficus* spp. di Kalimantan. *Buletin Kebun Raya*, 22(2), pp.85–94.

Tarachai et al., 2011. Diversity of Figs and Their Pollinators in Chiang Mai Province, Thailand. *Chiang Mai Journal of Science*, 38, 384, pp.638–647.

Teixeira et al., 2018. Morphological diversity and function of the stigma in *Ficus* species (Moraceae). *Acta Oecologica*, 90, pp.117–131. doi: 10.1016/j.actao.2018.02.008.

The Central Bureau of Statistics of Bogor., 2021. *Kota Bogor Dalam Angka*. Kota Bogor: The Central Bureau of Statistics of Bogor.

Wijaya, I.M.S. & Defiani, M.R., 2021. Diversity and distribution of figs (*Ficus*: Moraceae) in Gianyar District, Bali, Indonesia. *Biodiversitas,* 22(1), pp.233-246. doi: 10.13057/biodiv/d220129.

Zhang et al., 2020. Genomes of the Banyan Tree and Pollinator Wasp Provide Insights into Fig-Wasp Coevolution. *Cell*, 183(4), pp.875-889.e17. doi: 10.1016/j.cell.2020.09.043.