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To cite this article: I F Wanda *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **308** 012080

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Ex situ Conservation of *Diospyros* spp. (Ebenaceae) in the Bogor Botanic Gardens, Indonesia

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Abstract. *Diospyros* spp. is one of the genera of the Ebenaceae that has the highest distribution in tropical Asia and Africa. The high rate of deforestation in the tropics, so we need for preservation of species in conservation ex-situ at the Botanical Gardens. Research on the basic information and potential of *Diospyros* spp., the collection of the Bogor Botanical Gardens has been carried out through direct observation of all the Gardens' *Diospyros* collections, both in the field and in the nursery. The results obtained as many as 32 species of *Diospyros* spp. which have been collected with the most specimens of the species *Diospyros celebica*, *D. buxifolia*, and *D. maritima*. Meanwhile, the source collection *Diospyros* spp. mostly from Sulawesi. The general potential of *Diospyros* spp. used as a valuable timber (ebony) and edible fruit.

1. Introduction

Ebenaceae is a family that currently has only three genera namely *Diospyros*, *Lissocarpa* and *Euclea*. While the other four genera such as *Cargillia*, *Maba*, *Royena*, and *Tetraclis* were declared extinct. Centre of Ebenaceae diversity is Southeast Asia, Madagascar, Central Africa, and South America. To date, the number of species from Ebenaceae is estimated to reach 1,698 species and only 751 species have been received [1]. The genera *Diospyros* and *Euclea* that have spread of species in the tropics is estimated consist of 500-600 species. Conservation needs to reduce the extinction of plants in nature when at the same time high rates of tropical deforestation occur. Thus, botanical gardens become one of the alternative solutions for plant conservation.

By the end of 2017, the Bogor Botanic Gardens has maintained 15,215 specimens, belonging to 160 families, 1,032 genera and 3,788 species [2]. Some of them collections from genus *Diospyros* which collected during plant exploration activities in Indonesia and seed exchanged from overseas. This occurs because the genus of *Diospyros* was an important component of forest composition in the continent of Africa and Asia [3],[4]. *Diospyros* originating from Africa, especially West Africa, include *D. ebenum* and *D. melanoxylon*. *Diospyros* that grow in Asia mostly come from India and Ceylon (*D. philippinensis*, *D. ebenum* and *D. graciliflora*); from the Philippines (*D. pilosanthera*, *D. plicata*, *D. valascoi*); and from Malaysia (*D. buxifolia*, *D. scortechinii*, *D. clavigera*, *D. graciliflora* and *D. lucida*) [5], [6], [7].

Plant collections from genus *Diospyros* in the Bogor Botanic Gardens need further study related to the sources, taxonomy up to the potential plant to improve usability in public life. Some species of



genus *Diospyros* is an important product economically. Some of these valuable parts include wood production (ebony) and fruit (persimmon). Ebony is widely used for the manufacture of luxurious furniture, sculpture or carvings, fans, spiked items, decorative tools, brushes, wind instruments and also for building construction such as house poles and bridges [8]. There are about 90-100 species of ebony trees, but which produce only a few heartwoods, among others: *D. celebica* Bakh., *D. ebenum* Koen., *D. ferrea* Bakh., *D. lolin* Bakh., and *D. rumpii* Bakh. The most famous Ebony is *D. celebica* because its heartwood was brown and *D. rumpii* with black and unlined stripes [9].

The purpose of this research is to collect information of species and potential of plant collections from genus *Diospyros* which have been conserved by Bogor Botanic Gardens. The natural resource conservation strategy has three main stages; how to save resources, how to learn them and how to use these resources. This research is part of the learning stages of plant species richness for the development and conservation of *Diospyros* spp. in Indonesia

2. Materials and Methods

All of the materials used in this study were based on the cultivated plants growing in the Center for Plant Conservation Botanic Gardens, Indonesian Institute of Sciences (LIPI), Bogor City, West Java, Indonesia or popularly known as Bogor Botanic Gardens.

The study was conducted at Bogor Botanical Gardens-LIPI in January - May 2017. The method of the study was based on direct observation of all the Gardens' *Diospyros* collections, both in the field and in the nursery. To ensure the validity of species names, herbarium studies were needed. The herbarium studies were conducted at the Herbarium Bogoriense and at the Gardens' own herbarium. Others supporting data were obtained from the database unit Subsect. Registration and Nursery Bogor Botanic Gardens that records the Gardens' plant listings over the years.

3. Results and Discussion

3.1. Results

Distribution of plant collections *Diospyros* spp. in Bogor Botanical Garden is divided into 31 Bed number in BBG. The plant was collected during exploration and seed exchanged with other countries in the continent of Asia, Africa, and Australia. Based on the inventory and identification results there are 32 species of plant collections including genus *Diospyros* consisting of 198 specimens. A total of 31 species have been identified with 140 specimens of plant collections. Meanwhile, the plant collections that still identified at the genus level (*Diospyros* sp.) were 41 plant collections consisting of 58 specimens.

Diospyros spp. most collected by Bogor Botanic Gardens are 13 specimens (9:29%), of *Diospyros celebica*, 12 specimens (8:57%) of *D. buxifolia* and 12 specimens (8:57%). of *D. maritima*. Meanwhile, the plant collection has 1 specimen, namely *D. borneensis*, *D. diepenhorstii*, *D. glabrata*, *D. ehretioides*, *D. lanceifolia*, *D. malaccensis*, *D. natalensis*, *D. nigra*, *D. oblonga*, *D. racemose*, *D. subrhomboidea*, *D. subtruncata*, *D. venosa* dan *D. virginiana*. These species must be reproduced to ensure the existence of the collection is maintained.

Table 1. List of collection *Diospyros* spp. Bogor Botanical Garden

Species	Origin	Bed no in BBG	Number of specimens
<i>Diospyros andamanica</i> (Kurz) Bakh.	East Kalimantan, Central Sulawesi, Jambi	IV.C. 101a, 113 IV.D. 201. XIII.F. 16, 17-17a	6
<i>Diospyros aurea</i> Teijsm. & Binn.	Lampung	IV.D. 199-199a-	3

Species	Origin	Bed no in BBG	Number of specimens
		199b	
<i>Diospyros borneensis</i> Hiern	eastern	XXIV.A.198 Kalimantan.	1
<i>Diospyros buxifolia</i> (Blume) Hiern	West Java, South Kalimantan, Central Sulawesi, Southeast S., Bangka Belitung	IV.C. 79. IV.D. 196. XG130-130a-130B XII.C. 190. XIII.F. 14 XIX.M. 40 XV.JAXXXV.14. XXIV.A.236, 167- 167a	12
<i>Diospyros cauliflora</i> Blume	Banten, West Sumatra, West Java	IV.C. 86-86a. IV.D. 127 XIII.E. 11, 15 XVII.E. 130 XXV.A. 200-200a- 200B.	10
<i>Diospyros celebica</i> Bakh.	South Sulawesi, S, North Maluku, East Kalimantan	IV.D. 190-190a. VIII.G.20. XG 110-110a. XIX.E.70-70a, 72, 86. XXIV.A.297,303-303 303b	13
<i>Diospyros coriacea</i> Hiern	Papua, West Java, Jambi	IV.D. 211-211a. XXIV.A. 12a-12b, 187, 199-199a- 199b-199c.	9
<i>Diospyros diepenhorstii</i> Miq.	West Sumatra	IV.C. 73.	1
<i>Diospyros discolor</i> Willd.	Philippines, Papua, West Java	IV.C. 90-90a-90b. IV.D. 119, 180- 180a. XXV.A. 38.	10
<i>Diospyros ehretioides</i> Wall. ex G.Don	Thailand	XVI.IB 14	1
<i>Diospyros frutescens</i> Blume	West Java, Bengkulu, North Sulawesi	IV.C. 87-87a IV.D. 140B, 194. XI.B.XVI. 182 XIX.J. 1a, 22. XVII.I. 78, 80.	9
<i>Diospyros glabrata</i> (Warb.) Kosterm	West Sumatra	XXIV.A. 237	1
<i>Diospyros korthalsiana</i> Hiern	South Kalimantan	XG 104.	3

Species	Origin	Bed no in BBG	Number of specimens
		XXIV.A. 90a-90b.	
<i>Diospyros lanceifolia</i> Roxb.	Sumatra: Jambi	IV.C. 107.	1
<i>Diospyros lolin</i> Bakh.	Papua, North Maluku	XXIV.A.263-263a, 296-296a	4
<i>Diospyros macrophylla</i> Blume	Sri Lanka, West Java, Banten, Lampung, South Kalimantan, South Sulawesi	IV.C. 75. IV.D.128., 135-135a, 157-157a. XG 125 XXIV.A.212-212a, 267	10
<i>Diospyros malabarica</i> (DESR.) Kostel.	Southeast Sulawesi, South S, India	IV.C. 114 IV.D.215-215a-215b XXIV.A. 300-300a-300b- 302BXXIV.A.302- 302a IV.C. 76.	11
<i>Diospyros malaccensis</i> Bakh.	Southeast Sulawesi	XXIV.A. 270	1
<i>Diospyros maritima</i> Blume	Seram, Banten, Central Kalimantan, North Sulawesi, Papua Australia	IV.A. 184. IV.C. 103. IV.D. 191-191a, 202. XV.A. 233. XX.D.161a. XXIV.A.202-202a XXV.B. 44. (0+) IV.C. 112, 96	12
<i>Diospyros mespiliformis</i> Hoshst. ex A. DC.	Sudan	IV.D. 200-200a. IV.C. 102.	3
<i>Diospyros natalensis</i> (Harv.) Brenan	South Africa	XV.JAXXXV.6	1
<i>Diospyros nigra</i> (JFGmel.) Perrier	West Java	XXIV.A. 215.	1
<i>Diospyros oblonga</i> Wall. G.Don ex	Ceram	XIX.H. 68.	1
<i>Diospyros pilosanthera</i> Blanco	Maluku, Pacific Islands.	XXIV.A. 200. XIII.N. 11 XXV.B. 135.	3
<i>Diospyros racemosa</i> Roxb	West Java	IV.C. 74.	1
<i>Diospyros ridleyi</i> Bakh	North Sulawesi	IV.D. 198.	2
<i>Diospyros</i> sp.	*	*	58
<i>Diospyros subrhomboidea</i> King & Gamble	Central Java	XXIV.A. 234	1
<i>Diospyros subtruncata</i> Hochr.	Sumatra	IV.G. 46. (0+)	1

Species	Origin	Bed no in BBG	Number of specimens
<i>Diospyros sumatrana</i> Miq.	Sulawesi: Gorontalo	XXIV.A. 250 XIX.B.37-37a-37b- 37c.	5
<i>Diospyros venous</i> Wall. Ex A.DC.	Java	IV.C. 77. (0+)	1
<i>Diospyros virginiana</i> L.	Australia	IV.D. 179.	1

3.2. Discussion

3.2.1. Ex situ Conservation of *Diospyros* spp. in Bogor Botanic Gardens. *Diospyros* generally have a tree or bush habitus and do not climb (nonclimbing species). Terminal shoots are missing, alternate, sometimes having dots that look transparent or with glandular holes. Flower dioecious or polygamous. Flowers axillary, rarely solitary, usually will soon wither after anthesis; Stamens amount 4 to more, often in pairs and forming two whorls (the arrangement of sepals, petals, leaves, branches stipules or radial); Ovary rudimentary, ovary usually solitary, stigma often have 2- gap. Calyx usually has 3-5 (-7) lobes, sometimes *truncatus*; Berry berries are fleshy and slightly rough, usually with a stiff and enlarged calyx. Seeds are 1-10 (or more) [10].

The conservation status of species from the genus *Diospyros* has not been determined because of the small number of research and study related to the existence of a *Diospyros* spp. population in the wild. Population status of *Diospyros* spp. is necessary to assign its conservation policy, including the utilization and development of the species. Based on the latest IUCN Redlist (International Union for Conservation of Nature) data, only *D. celebica* has a conservation status that belongs to the vulnerable category (VU Al cd) which means it is at high risk for extinction in the wild. The IUCN is an institution engaged in the conservation of global natural resources and for the species, it issued a list of the kinds of plants and animals in danger of extinction. These status criteria are estimated to be reduced by more than 20% over the past ten years or after three generations and should be the primary target for conservation, both habitat and species [11].

In Indonesia, *Diospyros* genus consists of 78 species, which spread across the archipelago of Indonesia, namely Borneo, Sumatra, Maluku, Irian Jaya, Sulawesi, Java, Madura, Lombok, and Flores [12]. The spread of *Diospyros* in Indonesia can be described as follows; *D. celebica* is naturally found in Sulawesi, especially in Parigi, Poso, Donggala, Maros, Maluku, and Mamuju; *D. ebenum* is naturally found in Sulawesi (Minahasa, Poso, Buton), Maluku (Halmahera, Tanimbar, Aru) and Nusa Tenggara (Sumbawa, Flores); *D. lolin* is naturally found in Maluku especially in Morotai, Bacan, Halmahera, Aru and Tanimbar; *D. macrophylla* is naturally found in Java, Madura, Sumatra (Langkat, Simalungun, Kroe, Kotabumi), Kalimantan (Sambas, Purukcau, Muara Tewe, Martapura, Pleihari, P. Laut, Balikpapan, Kutai) and Sulawesi (Poso, Donggala, Palopo, Malili, Mamuju); *D. pilosanthera* is naturally present in Borneo (Kutai, Bulungan, Berau, Tarakan, Tidung), Sulawesi (Poso, Bolaang Mongondow, Gorontalo, Minahasa, Banggai, Muna), Maluku (Morotai, Buru, Tanibar, Halmahera) and Irian Jaya [13].

The family collection of Ebenaceae at the Bogor Botanic Gardens is from Indonesia and introduced abroad. Plant collections of *Diospyros* in Indonesia (Figure 1), mostly came from Sulawesi (22%), Sumatra (20%) and Java (19%). Based on its biogeographic history, the Sulawesi island is formed from a very unique occurrence with a combination of continental islands which is a combination of the continents of Laurasia and Gondwana as well as some parts of the sea island. This occurrence put the Sulawesi island on a unique path, both its geomorphological form and its high biodiversity [14]. Subsequently, followed by Papua (12%), Kalimantan (9%) and Maluku (9%). Meanwhile, overseas introductions come from Australia, Philippines, Thailand, Sri Lanka and South Africa with 19% of the total.

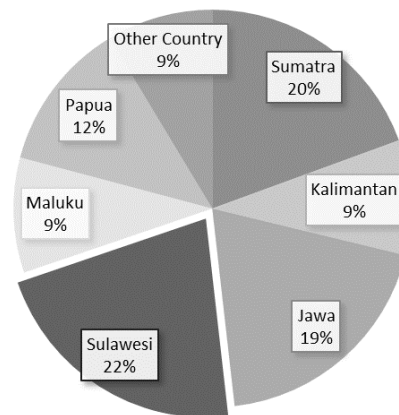


Figure 1. Source collection of *Diospyros* spp. Bogor Botanic Gardens

The Bogor Botanical Garden as an ex-situ plant conservation institution has a function to preserve plants from extinction, find potential plants and how to use them. It has an important role for the preservation of the *Diospyros* in Indonesia. Various steps for conservation have been taken such as exploration activity in Indonesia up to propagation of *Diospyros* spp. in a nursery. Table 2 shows the results of *Diospyros* spp. from exploration activities in Indonesia until February 2017.

Table 2. List of collection *Diospyros* spp. results of exploration.

No. Access and No. Collectors	Plant Name	Source	Total
B2014070023 / SF.372	<i>Diospyros buxifolia</i> (Blume) Hiern	West Sulawesi	5
B2014080042 / KSN.040	<i>Diospyros buxifolia</i> (Blume) Hiern	Bangka Belitung	5
B2011090039 / YY.96	<i>Diospyros celebica</i> Bakh.	North Maluku	1
B2013040085 / MN.442	<i>Diospyros macrophylla</i> Blume	West Kalimantan	3
B2015040023 / DO.1143	<i>Diospyros macrophylla</i> Blume	South Kalimantan	4
B2012040006 / DM.2427	<i>Diospyros malabarica</i> (DESR.) Kostel.	South Sulawesi	1
B201007412 / TT.1542	<i>Diospyros malabarica</i> (DESR.) Kostel.	Southeast Sulawesi	2
B2014070012 / SF.361	<i>Diospyros pilosanthera</i> Blanco	West Sulawesi	1
B20010347 / LG.356	<i>Diospyros</i> sp.	Papua	1
B2015040072 / DO.1253	<i>Diospyros</i> sp.	South Kalimantan	1
B2015050302 / DM.2923	<i>Diospyros</i> sp.	Bintan Island	1
B2015050049 / HR.1164	<i>Diospyros</i> sp.	Enggano Island	2
B2013070111 / YL.19204	<i>Diospyros</i> sp.	East Kalimantan	5
B2014040096 / IP.782	<i>Diospyros</i> sp.	Central Kalimantan	3
B2013070076 / YL.19077	<i>Diospyros</i> sp.	East Kalimantan	8
B2013040141 / HR.755	<i>Diospyros</i> sp.	North Sumatra	9

No. Access and No. Collectors	Plant Name	Source	Total
B2013120007 / AP.187	<i>Diospyros</i> sp.	South Kalimantan	10
B2013070118 / YL.19245	<i>Diospyros</i> sp.	East Kalimantan	12
B2015050309 / DM.2943	<i>Diospyros</i> sp.	Bintan Island	1

In addition to collecting biodiversity of *Diospyros* spp. from all over Indonesia, the Bogor Botanical Gardens also multiply the collection of *Diospyros* from living collections in the garden. Here is a list of plant species that have been propagated until June 2017.

Table 3. List of *Diospyros* spp. which has been propagated in the nursery.

Plant Name	Total
<i>Diospyros discolor</i> Willd.	58
<i>Diospyros macrophylla</i> Blume	605
<i>Diospyros buxifolia</i> (Blume) Hiern	24
<i>Diospyros malabarica</i> (DESR.) Kostel.	150
<i>Diospyros</i> sp.	11
Total	848

3.2.2. Potential and utilization. *Diospyros* spp. includes high-value and potentially valuable plants. *D. celebica* or commonly known as the black wood is the kind of luxury wood is much preferred by consumers. Ebony has a beautiful color, durable and shiny, so it is suitable to be used as furniture or crafts such as wall hangings, sculptures or carvings. *D. ebenum*, *D. ferrea*, *D. lolin* and *D. humpi* produce good heartwood. *D. rumpii* has heartwood with black and unlined striped heartwood. *D. discolor* produces edible fruit as known as bisbul fruit in West Java. *D. discolor* is known by various names, such as buah mentega, buah lemak (Melayu) and sembolo (Java). This fruit has the potential as a local fruit because it is popular in the community. *D. discolor* wood is very nice to be used as a material for wooden craft because the wood is reddish brown to black and has a smooth texture, strong and hard. Besides its use in the form of wood and fruit, one of the common species of *Diospyros* also be used as medicinal plants, namely *D. pilosanthera* which is widely used by Seram Island community to treat a headache, toothache, stomach pain to post-partum pain reliever [15].

Ecologically, *Diospyros* spp. have many roles in the forming of ecosystems on every island in Indonesia. Generally, *Diospyros* can be found in the mangrove forest and lowland forest. *D. ferrea* found in Papua Island is associated with mangrove forests and *D. maritima* is able to survive in secondary forests and shrubs [16]. Meanwhile, *D. maritima* were found on the island of Java, particularly on the Pulau Dua become the main component of mangrove forest and on the southern part of East Java become the main component of limestone hills/karst [17]. This show the adaptability of *Diospyros* spp. is excellent in various types of ecosystems. *Diospyros* spp. can be studied further as reclamation plant of forest area.

4. Conclusion

Bogor Botanic Gardens has collected 32 species of genus *Diospyros* which consists of 198 specimens. All species of *Diospyros* in Bogor Botanic Gardens are planted collections that were preserved as ex situ conservation which the largest source collected from Sulawesi. This collection of plants is important to be the object of research because it has the potential for building materials, handicrafts,

household items, and groceries. The preservation of this plant is very important to ensure its continuous availability and utilization.

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Acknowledgements

We would like to thank to Director of Center for Plant Conservation Bogor Botanic Gardens, LIPI for supporting this research. Many thanks to Dr. Siti Roosita Ariati for giving permission at the database unit Subsect. Registration and Nursery Bogor Botanic Gardens. We also grateful for generous assistance from Mrs. Ratna Suti Astuti, Sri Hartini and Kartika Ning Tyas.