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The diversity of aroids (Araceae) in Bogor Botanic Gardens, Indonesia: Collection, conservation and utilization

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Abstract. *Yuzammi. 2018. The diversity of aroids (Araceae) in Bogor Botanic Gardens, Indonesia: Collection, conservation and utilization. Biodiversitas 19: 140-152.* Bogor Botanic Gardens is an *ex-situ* conservation centre, covering an area of 87 ha, with 12,376 plant specimens, collected from Indonesia and other tropical countries throughout the world. One of the richest collections in the Gardens comprises members of the aroid family (Araceae). The aroids are planted in several garden beds as well as in the nursery. They have been collected from the time of the Dutch era until now. These collections were obtained from botanical explorations throughout the forests of Indonesia and through seed exchange with botanic gardens around the world. Several of the Bogor aroid collections represent 'living types', such as *Scindapsus splendidus* Alderw., *Scindapsus mamilliferus* Alderw. and *Epipremnum falcifolium* Engl. These have survived in the garden from the time of their collection up until the present day. There are many aroid collections in the Gardens that have potentialities not widely recognised. The aim of this study is to reveal the diversity of aroids species in the Bogor Botanic Gardens, their scientific value, their conservation status, and their potential as ornamental plants, medicinal plants and food. The methods of the research include direct observation in the garden and nursery collections, analysis of the Gardens' long-term registration database, as well as herbarium studies in both the Herbarium Bogoriense and the Gardens'own herbarium. A total of 130 species of aroids belonging to 36 genera have been cultivated in the Bogor Botanic Gardens. It is estimated that the gardens has 29% of the total number of genera in the world (21 genera are native to Indonesia). The aroid collection consists of terrestrial plants, aquatic plants and climbing plants (61 species, 12 species and 57 species, respectively). *Amorphophallus paeoniifolius* has developed further as a food plant. Genera such as *Aglaonema*, *Alocasia*, *Apoballis*, *Rhaphidophora* and *Scindapsus* have long been used as ornamental plants. Futhermore, some *Homalomena* species can be extracted for essential oils, while *Epipremnum pinnatum* has application in the treatment of cancer. Descriptions of some endemic, rare and high value species are discussed in this paper.

Keywords: Araceae, Bogor Botanic Gardens, *ex-situ* conservation, living type, utilization

INTRODUCTION

Bogor Botanic Gardens is an *ex-situ* conservation facility, covering an area of 87 ha located in the heart of Bogor City, West Java, Indonesia. The Gardens was initially named *'s Lands Plantentuin te Buitenzorg* and was planned as a centre for acclimatization of economic plants. Today, in the year of her 200th anniversary, the role of the Bogor Botanic Gardens has evolved to fulfill its mission through five principal functions: conservation, research, education, tourism, and environmental services. The decline in the quality of our natural environment, the phenomenon of climate change, and the degradation of our rainforests have focussed attention on the Gardens' ultimate goal, that is the goal of conserving the flora of Indonesian for the long-term.

As a centre for *ex-situ* conservation, the Gardens has collected many plant species from rainforests representative of all parts of the Indonesian archipelago. The Gardens has also cultivated various species from overseas through a seed exchange programme with other botanic gardens wordwide. Apart from these external collections, there exist native plants in the Gardens, that date from vegetation preceding the official foundation of the Gardens, that are accepted as part of the Gardens' collection, and that are regarded as a spontaneous collection. The Gardens' collections consist of 214 families; 3,201 species; and over 12,376 specimens (registration database of Bogor Botanic Gardens). One of these collections is the family Araceae—the aroids. Members of this family have been cultivated in the Gardens since the beginnings of the Dutch era, but the aroid collection has been judiciously added to, and continues to be so, right up to the present day.

The Araceae is one of the largest monocot families. The members of the family are dispersed world-wide, notably in the tropics, with particular concentrations in tropical America, mainland Southeast Asia, and the Malesian region (Malaysia, Indonesia, Singapore, Brunei, the Philippines, Timor Leste and Papua New Guinea) (Mayo et al. 1997, Boyce 2015). According to Boyce (2015) and Boyce and Wong (2015), the Malesian Region contains the largest proportion of the world's Araceae, with an estimated 42 established genera and about 12,000 validly named species. It is believed that the number of valid species may expand as research reveals new species. Indonesia has the largest number of Araceae genera among the Malesian countries.

The occurence of some endemic and rare Araceae species, such as *Amorphophallus titanum* (Becc.) Becc. ex

Archang, emphasises the value of the Gardens in terms of its conservation function. The collections have high scientific value because many new species have been erected on the basis of the Gardens' collections. Those particular collections are called 'living types', and some are still alive in the Gardens, such as *Scindapsus splendidus* Alderw. The potential of the Araceae collection for conservation and economic purposes has not yet been fully explored. Therefore, this study aims to make known the diversity of the aroids species in the Bogor Botanical Gardens collected from the colonial era up to the present day; aims to reveal its scientific value; aims to conserve its rare endemic members; and aims to list the species with particular potential for ornamental horticulture, for medicinal uses, and for food production.

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 method of the study was based on direct observation of all the Gardens' aroid collections, both in the field and in the nursery (cultivated in the glass house and in the screen house). Plant materials obtained from forests first have to be acclimatized in the nursery, by growing them out until they produce inflorescences adequate for identification purposes.

The inflorescence is an important character in the identification of aroid species.There are two important parts of the infloresecence; they are the spadix and the spathe. The real, numerous, tiny flowers are attached to the spadix. Details of this can be seen in Figure 1.

To ensure the validity of species names, herbarium studies were needed. The herbarium studies were conducted at the Herbairum Bogoriense and at the Gardens'own herbarium. Others supporting data were obtained from the registration database of the Bogor Botanic Gardens that records the Gardens' plant listings over the years.

RESULTS AND DISCUSSION

The aroids collections at the Bogor Botanic Gardens

As a centre of plant conservation, the Bogor Botanic Gardensis the ultimate stronghold for preserving the richness of Indonesian biodiversity. The Gardens' collection consists of about 12,376 specimens and 3,201 species in total (based on the registration database in August 2017), excluding specimens in the nursery. The estimated number of species actually exceeds this, because many specimens are still held in the nursery. In general, the Gardens' collections are from throughout the Indonesian lowland forests, as well as from overseas via seed exchange among botanic gardens word-wide.

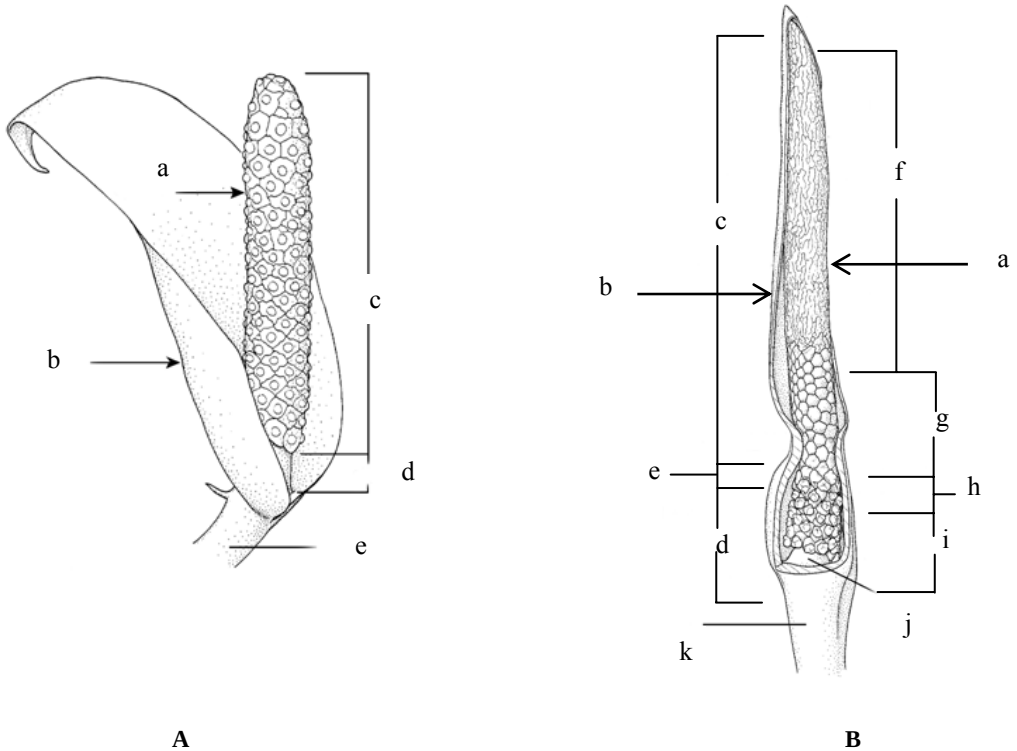

Figure 1. Inflorescence. A. Bisexual flowers : a. spadix, b. spathe, c. hermaphrodite flowers, d. stipe, e. peduncle; B. Unisexual flowers: a. spadix, b. spathe, c. limb, d. lower spathe, e. constriction, f. appendix, g. male zone, h. sterile zone, i. female zone, j. stipe, k. peduncle (illustration by Lesley Elkan)

The Araceae is one of the richest families in the Gardens. The members of this family are spread in several beds of the Gardens and also in the nursery. Based on observation, there are 36 genera (29% of the total genera word-wide), of which 21 genera are native to Indonesia (58.3% of the total number of genera in Indonesia). Currently, the Araceae in the Gardens is estimated to comprise about 130 validly named species (3.7% of the world's aroid species and about 13.9% of the total number of Indonesian species) (see Table 1 and Figure 3). As mentioned above, the number of genera of Araceae in the Gardens is slightly over half the number of genera in Indonesia. The Gardens still needs to collect about 15 genera in order to complete a collection of all native genera known to exist in the archipelago. To fulfill this purpose, therefore, continuing flora exploration of the Indonesian forests is necessary.

In general, the habitats of the Araceae can be divided into three categories: terrestrial, climbing, and aquatic (here used in broad sense). The Bogor Botanic Gardens houses genera from all three habitats of the family; seven genera for the aquatic habitat, of which four genera are native to Indonesia, with 12 species in total; 17 genera for the terrestrial, of which 11 genera are native to Indonesia, with 61 species in total; and 12 genera of climbers, of which six genera are native to Indonesia, with 57 species in total (Figure 2 and Table 2). These numbers, both for genera and species native to Indonesia, are inadequate for such a large and old botanic garden. An increase in the number of genera and species could be achieved by collection efforts in the Indonesian forests with more focus on endemic and rare species of Araceae especially for conservation puposes. As can be seen in Figure 2, the Gardens needs to acquire nine more of the aquatic genera, namely *Aridarum, Bakoa, Becephalandra, Cryptocoryne, Furtadoa, Hottarum, Ooia, Piptospatha* dan *Podolasia*. On the other hand, for the terrestrial habitat, only three more genera (*Arisaema, Remusatia* dan *Typhonium*) are required to complete a representative collection, and for the climbers only three more genera (*Pedicellarum*, *Phymatarum* and *Pothoidium*) are required (Yuzammi et al. 2017).

Conservation and scientific value of the collection

The Bogor Botanic Gardens was established by C.G.C Reinwardt on 18 May 1817, with the purpose of accomodating all the living collections of the time that had been collected from the forests, notably from Java. Several collections were introduced from overseas such as from Africa and Latin America. One of these collections was the oil palm (*Elaeis guineensis*). During the Dutch Era, research had focussed on development of the Gardens collections to meet economic needs (Sukarya and Witono 2017).

Since the time of its foundation, many botanists from around the world have visited the Gardens to conduct research or to carry out flora explorations in the Indonesia forests; for example Carl Ludwig Blume, Johannes Elias Teijsmann, Justus Karl Hasskarl, Cornelis Rugier Willem Karel van Alderwerelt van Rosenburgh (known as Alderwerlt), Heinrich Gustav Adolf Engler and Cornelis Andries Backer (van Steenis-Kruseman 1950). Many new species have been published based on the Gardens' collections such as *Amorphophallus decus-silvae* Backer & Alderw. and *Lasia concinna* Alderw. These collections were called 'living types'; later on, these were not used directly for determining the species but usually the 'type specimens' were made from the same plant material. The type specimens are used as the reference for determining species names.

Table 1. The number of genera and species of Araceae in the world, Indonesia, and the Bogor Botanic Gardens, Indonesia

Region	Genera	Species
World	125	3525
Indonesia	36	669*
Bogor Botanic Gardens	36	129

Note: *Estimated number (the calculation is still in progress)

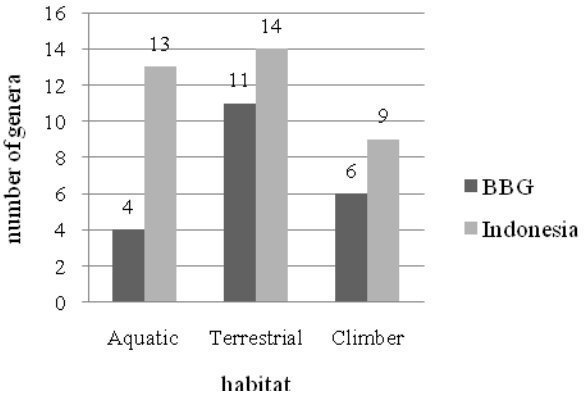

Figure 2. Number of Araceae genera in three habitat categories, for Indonesia as a whole and for the collection held in the Bogor Botanic Gardens (BBG)

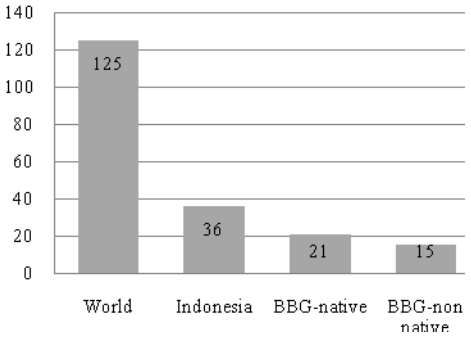

Figure 3. Number of Araceae genera in the world; in Indonesia; and in the Bogor Botanic Gardens (BBG) indigenous (native) and non-Indonesian collections

Table 2. The number of genera and species of the Araceae family cultivated in the Bogor Botanic Gardens (BBG), together with the source locations for the collections

Genera	Habitat	Number of species (world)	Number of species (BBG)	Source locations of the collections
Aglaonema	Terrestrial	22	6	Sumatra, Java, Kalimantan, Sulawesi, Maluku, S.E. Asia
Alocasia	Terrestrial	100	8	Sumatra, Java, Kalimantan, Sulawesi, Tropical Asia
Aglaodorum	Aquatic	1	1	Tropical Asia
Amorphophallus	Terrestrial	220	11	Sumatra, Java, Kalimantan, Sulawesi, Maluku, LSI, Papua, Germany
Amydrium	Climber	5	3	Kalimantan, Sulawesi, Papua
Anadendrum	Climber	40	1	Sumatra, Kalimantan, Papua
Anchomanes	Aquatic	6	1	Tropical Africa
Anthurium	Climber	950	10	Costa Rica, Australia, Peru, Tropical America, Brazil, Germany
Anubias	Aquatic	8	1	Tropical Africa
Apoballis	Terrestrial	12	4	Sumatra
Cercestis	Climber	10	1	Congo (Tropical Africa)
Colocasia	Terrestrial	19	1	Sumatra, Java
Culcasia	Terrestrial	28	1	The Netherlands
Cyrtosperma	Aquatic	13	5	Sumatra, Papua, Solomon Island
Dieffenbachia	Terrestrial	68	6	Costa Rica, Colombia, Belgia, USA, Singapore, The Netherlands, Brazil
Dracontium	Terrestrial	24	2	Nicaragua, South America, England
Epipremnum	Climber	15	5	Sumatra, Java, Kalimantan, Sulawesi, Maluku, Malaysia
Gonatopus	Terrestrial	5	1	Tropical Africa
Holochlamys	Terrestrial	1	1	Papua
Homalomena	Terrestrial	98	8	Sumatra, Java, Kalimantan, Sulawesi, Maluku, Papua, Peninsula Malaysia
Lasia	Aquatic	2	1	Java, Kalimantan, Papua
Leucocasia	Terrestrial	1	1	Sumatra, Java
Monstera	Climber	48	3	Mexico, Polandia, Tropical America
Montrichardia	Aquatic	2	1	Brazil
Philodendron	Climber	482	13	Colombia, England, Brazil, Italy, The Philippines, India, Costa Rica, Mexico, Polandia, Venezuela
Pistia	Aquatic	1	1	Circum tropical
Pothos	Climber	70	3	Sumatra, Java, Kalimantan
Rhaphidophora	Climber	104	8	Sumatra, Java, Kalimantan, Sulawesi, Maluku, Papua, India, England
Rhodospatha	Climber	28	1	Peru
Sauromatum	Terrestrial	9	1	Sumatra
Schismatoglottis	Terrestrial	119	4	Sumatra, Java, Kalimantan, Sulawesi, Maluku, Papua
Scindapsus	Climber	35	7	Sumatra, Java, Kalimantan, Sulawesi
Spathiphyllum	Terrestrial	49	2	Sumatra, Java, Sulawesi, Maluku
Syngonium	Climber	34	3	Mexico
Xanthosoma	Terrestrial	140	3	Brazil, Panama, Colombia, Tropical America, Guatemala, Puerto Rica, Cuba, Suriname, West Africa
Zamioculcas	Terrestrial	2	1	Tropical Africa
			130	

Sources: (Mayo et al. 1997; Sari et al. 2010; The Plant List 2013; Boyce and Wong 2015; Boyce and Croat 2016; Yuzammi et al. 2017; and direct observation in the field)

Cornelis Rugier Willem Karel van Alderwerelt van Rosenburgh (Alderwerelt.) and Heinrich Gustav Adolf Engler were two important botanists who published many new Araceae species based on the Gardens' collections. Alderwerlt primary interest was in fern but he also described many new species in the Araceae. He almost never collected material from the field, describing most of his species from material at the Bogor Botanic Gardens (van Steenis-Kruseman 1950). *Lasia concinna* Alderw., *Schismatoglottis wahaiana* Alderw., *Scindapsus mamilliferus* Alderw. and *Scindapsus splendidus* Alderw. are among the species erected from the Gardens's collections. On the other hand, Engler mostly working based on living collections at the Botanischer Garden Berlin Dahlem as well as on herbarium specimens which were sent to him by many botanists from around the world. He travelled to Bogor, arriving in December 1905 and staying until February 1906. He undertook field trips in Java, visiting Mount Gede, Mount Papandayan, Kawah Manuk (West Java) and Mount Tengger, Tosari (East Java)

(van Steenis-Kruseman, 1950). Many new species have been published by Engler based on the Gardens'collections for example, *Epipremnum falcifolium* Engl., *Homalomena gigantea* Engl. (Synonym for *Homalomena pendula* (Blume) Bakh.f.), *Schismatoglottis treubii* Engl. (Synonym of *Apoballis rupestris* (Zoll. & Moritzi ex Zoll.) S.Y.Wong & P.C.Boyce) and *Scindapsus treubii* Engl. (Hay et al. 1995). Unfortunately, recent observation in the Gardens'collections found that one of remaining 'living types', *Scindapsus treubii* Engl., (and other Aroids) was no longer survived. It is presumed that prolonged drought during 2016 – 2017 the death of caused this valuable species. So, only three of these species — *Epipremnum falcifolium* Engl., *Scindapsus mamilliferus* Alderw. and *Scindapsus splendidus* Alderw. (Figure 4) — have survived until the present day (Yuzammi and Rivai 2015).

Those survivors are all climber, while none of the terrestrial aroids survived (Table 3). In addition to the environmental changes around the Gardens, termites also caused lossing the Gardens'collections. In general, most of member of the aroids can not endure much longer in drought or exposure sunlight directly, notably terrestrial aroids, such as *Aglaonema*, *Alocasia*, *Homalomena* and *Schismatoglottis*.

Several species of the Araceae are threathened in their habitat, therefore conservation efforts are urgently needed, particularly for endangered and endemic species — some species of *Amorphophallus* for example. Yuzammi et al. (2014) reported that *A. discophorus* Backer & Alderw., a locally endemic and rare species in East Java, is presumed extinct in the wild. Unfortunately, the Gardens expeditions have failed to refind and collect it. Two endemic and rare species of *Amorphophallus*, *A. gigas* Teijsm.& Binn.and *A. titanum* (Becc.) Becc. ex Arcang, are now cultivated in the Gardens. Another rare, endemic rare species is *A. asper* (Engl.) Engl. & Gehrm., which has recently been collected from the wild. These last three species are only found in Sumatra.

The occurrence of aroids is often interconnected with particular animals, for example bats, birds and mammals. These are known as frugivores and as seed dispersers. According to Vieira and Izar (1999) aroids are important food sources for arboreal and semi-arboreal mammals in the Brazilian Atlantic rainforest and may play important roles in seed dispersal. Hetterscheid and Ittenbach (1996), Yuzammi et al (2017) mentioned that Bulbuls and hornbills are known as the distributors of *Amorphophallus* seeds. Other aroid species, such as *Alocasia* spp., play important ecological roles in filling forest gaps.

Utilization and future potential

Many species of the Araceae have the potential to be developed as ornamental plants, due to their remarkable diversity leaf shapes, as well as the attractive color of the leaves and/or inflorescences in some species. Additionally, some species have application as medicinal plants, food sources, forages, or for extraction of essential oils. A list of the potential uses of members of the Araceae collection in the Gardens is provided below, in Table 4.

As ornamental plants

Members of the genus *Aglaonema* are well-known as ornamental plants due to their attractive and colorful leaf blades. Many of the members can cross-breed producing new hybrids, some of which have high economic value. Several genera such as *Alocasia*, *Aglaodorum*, *Cyrtosperma* and *Spathiphyllum* are well known commercially. Many aroids in the collection of Bogor Botanic Gardens have not had much public exposure, yet they actually have high potential to be developed as ornamentals; these include *Amydrium humile*, *Apoballis acuminatissima*, *Cyrtosperma beccarianum, Rhaphidophora angustata* and *Pothos roxburghii* (see Table 4).

As sources of food

Almost all members of the Araceae family contain oxalate crystals which can cause irritation and itching. However, these irritating substances can be removed from aroid tubers after extensive treatment; by slicing them under running water, soaking in saline water, or burying them in charcoal husks (Yuzammi et al. 2017). Taro (*Colocasia esculenta*) is one species in the Araceae that has long been used as a food source. In addition, Sugiyama and Santosa (2008) reported that the tubers of several species of *Amorphophallus* have been used for various purposes in several countries world-wide. One of these species is *A. paeoniifolius*, well-known locally in Indonesia as 'suweg', the tuber of which is used by some people as a functional food (Isnaini and Yuzammi 2013, Yuzammi et al. 2014). Utami (2008) found that the Glycemic Index (GI) value for the tuber of this species is 36, which means that it is suitable for diabetics in preventing high blood sugar levels.

As medicinal plants

The utilization of Araceae for medicinal purposes has long been known, notably in China. In Chinese traditional medicine, the rhizome of *Homalomena aromatica* is often used to relieve lower back pain and numbness of the knee (IMC 2003). On the other hand, Xin et al. (2014) reported that the rhizome of *H. occulta* can be applied to cure stomach aches and arthritis, and also as an anti-inflammatory agent and as a tonic. Koller (2008) stated that both the rhizome and the leaf of *Alocasia macrorrhizos* can be used to treat cancer, tumors and snake bites. Futhermore, Saswati et al. (2013) revealed that material from several species of the Araceae family can inhibit the activity of certain pathogenic bacteria. The species are:*Anchomanes difformis*, which inhibits the activity of *Klebsiella pneumoniae* and *Staphylococcus aureus* bacteria; *Epipremnum aureum*, which inhibits the activity of the bacteria *Escherichia coli*, *Bacillus subtilis*, *B. cereus* and *Micrococcus luteus*; *Dieffenbachia picta*, which inhibits the activity of *Salmonella typhi* and *Pseudomonas aeruginosa*; and *Colocasia esculenta*, which inhibits the activity of *Vibrio cholerae* and *V. harveyi*.

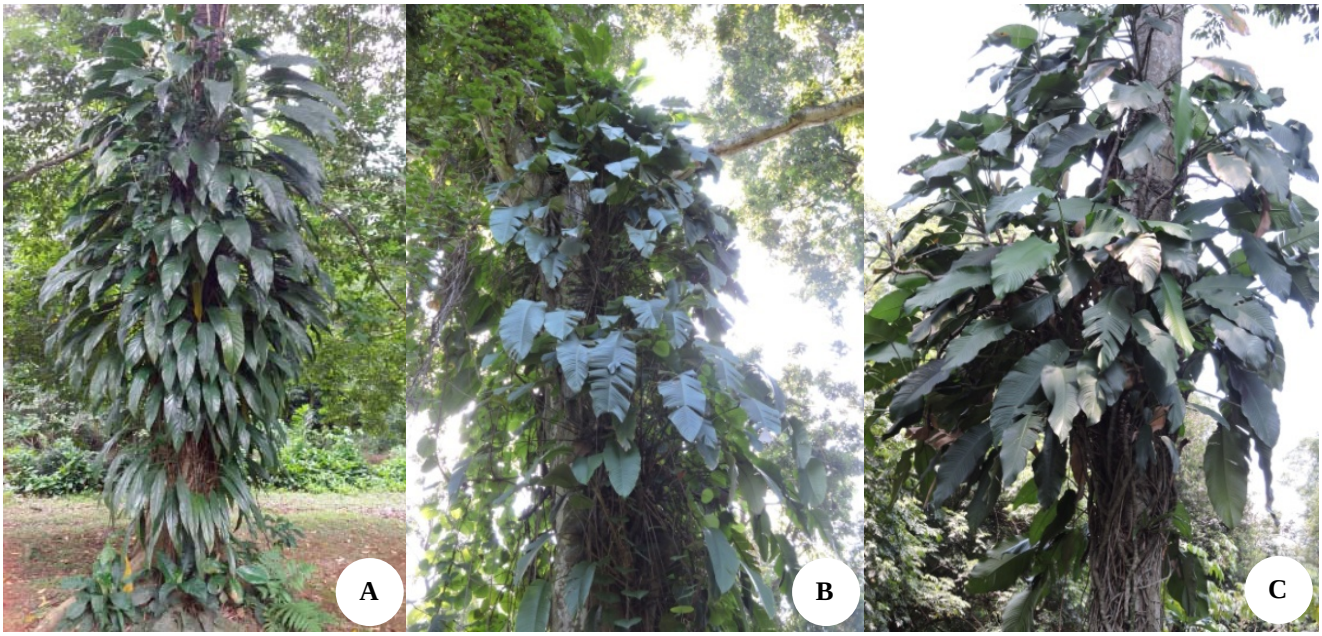

Figure 4. Three of 'living types' plant collections have survived in the Bogor Botanic Gardens. A. *Epipremnum falcifolium* Engl.; B. *Scindapsus mamiliferus* Alderw.; C. *Scindapsus splendidus* Alderw.

Table 3. List of new species have been published based on the Gardens' collections (called as 'living types')

Name of 'Living Type' Plants	Protologue	Bed no in BBG	Notes
Aglaonema robustum Alderw. [Synonym of *Aglaonema commutatum* Schott]	Bull. Jard. Bot. Buitenzorg III, 4: 328 (1922)	XI.B.IX. 147	Death in 2015
Aglaonema elongatum Alderw. [Synonym of *Aglaonema simplex* Blume]	Bull. Jard. Bot. Buitenzorg III, 4: 324 (1922)	XI.B.IX. 61	Death in 1928
Aglaonema grande Alderw. [Synonym of *Aglaonema simplex* Blume]	Bull. Jard. Bot. Buitenzorg III, 4: 325 (1922)	XI.B.IX. 62	Death in 1955
Alocasia crassifolia Engl. [Synonym of *Alocasia alba* Schott]	Pflanzenr. 71 (IV.23E): 82 (1920)	XI.B.VII. 123	Death record not available
Alocasia crassinervia Engl. [Synonym of *Alocasia puber* (Hassk.) Schott]	Pflanzenr. 71 (IV.23E): 82 (1920)	XI.B.VII.55	Death in 1949
Alocasia inornata Hallier f.	Meded. Rijks-Herb. Leiden 26: 7 (1915)	XI.B.VII. 120	Death record not available
Alocasia nobilis Hallier f. [Synonym of *Alocasia inornata* Hallier f.]	Meded. Rijks-Herb. Leiden 26: 6 (1915)	XI.B.VII. 9	Death record not available
Amorphophallus brooksii Alderw. [Synonym of *Amorphophallus gigas* Teijsm. & Binn.]	Bull. Jard. Bot. Buitenzorg III, 1: 368 (1920)	XI.B.VII. 74	Death in 1920
Amorphophallus decus-silvae Backer & Alderw.	Bull. Jard. Bot. Buitenzorg III, 1: 369 (1920)	XIX.K. 45	Death in 1954
Anadendrum malaianum Backer & Alderw. [Synonim of *Anadendrum microstachyum* (de Vriese & Miq.) Backer & Alderw.]	Bull. Jard. Bot. Buitenzorg III, 1: 369 (1920)	XII.B.IV. 6	Death record not available
Epipremnum ceramense var. *flavispathum* Alderw. [Synonym of *Epipremnum ceramense* (Engl. & K.Krause) Alderw.	Bull. Jard. Bot. Buitenzorg III, 1: 376 (1920)	Z. 34	Death in 1940
Epipremnum falcifolium Engl.	Bot. Jahrb. Syst. 25: 11 (1898)	Y.2 & 2a	Survived, up to now
Epipremnum mirabile f. *multisectum* Engl. [Synonym of *Epipremnum pinnatum* (L.) Schott.]	Bot. Jahrb. Syst. 25: 12 (1898)	Z. 141	Death record not available
Homalomena gigantea Engl. [Synonym of *Homalomena pendula* (Blume) Bakh f.]	Pflanzenr.55 (IV.23Da): 62 (1912)	XI.B.X. 103	Death in 2015

Homalomena polyandra Alderw. [Synonym of *Homalomena punctulata* Engl.]	Bull. Jard. Bot. Buitenzorg III, 4: 178 (1922)	XI.B.IX. 134	Death in 2001
Homalomena rubrovaginata var. *subpurpurea* Alderw. [Synonym of *Homelomena humilis* var. *major* (Hassk.) Furtado	Bull. Jard. Bot. Buitenzorg III, 4: 332 (1922)	XI.B.X. 3	Death in 1950
Lasia concinna Alderw.	Bull. Jard. Bot. Buitenzorg III, 1:379 (1920)	II.Q.D. 5	Death in 2016
Rhaphidophora foraminifera (Engl.) Engl. [Synonym of *Epipremnum foraminiferum Engl*.]	Pflanzenr. 37 (IV.23B): 45 (1908)	XI.B.X. 100	Death in 1920
Rhaphidophora octovulata Alderw. [Unresolved name]	Bull. Jard. Bot. Buitenzorg III, 4: 195 (1922)	IX.B.IX. 51	Death in 1969
Rhaphidophora peeploides Engl.	Bot. Jahrb. Syst. 25: 7 (1898)	Z. 61	Death in 1984
Rhaphidophora pilosula Alderw. [Synonym of *Rhaphidophora puberula* Engl.]	Bull. Jard. Bot. Buitenzorg III, 1: 386 (1920)	Z. 112	Death in 1948
Schismatoglottis acutangula Engl. [Synonym of *Schismatoglottis calyptrata* (Roxb.) Zoll. & Moritzi	Pflanzenr. 55 (IV.23Da): 110 (1912)	XI.B.X. 147	Death in 1950
Schismatoglottis bifasciata Engl.	Pflanzenr. 55 (IV.23Da): 107 (1912)	XI.B.X. 61	Death in 1930
Schismatoglottis calyptratoides Alderw. [Synonym of *Schismatoglottis calyptrata* (Roxb.) Zoll. & Moritzi	Bull. Jard. Bot. Buitenzorg III, 4: 213 (1922)	XI.B.X. 165	Death in 1925
Schismatoglottis concinna var. *nitida* Hallier f. ex Engl.	Pflanzenr. 55 (IV.23Da): 97 (1912)	XI.B.X. 48	Death in 1920
Schismatoglottis eximia Engl.	Pflanzenr. 55 (IV.23Da): 101 (1912)	XI.B.X. 65	Death in 1949
Schismatoglottis glauca Engl.	Pflanzenr. 55 (IV.23Da): 106 (1912)	XI.B.X.	Death record not available
Schismatoglottis hastifolia Hallier f. ex. Engl. [Synonym of *Apoballis hastifolia* (Hallier f. ex Engl.) S.Y. Wong & P.C. Boyce]	Pflanzenr. 55 (IV.23Da): 116 (1912)	XI.B.X. 56	Death in 1920
Schismatoglottis irrorata Engl. [Synonym of *Schismatoglottis motleyana* (Schott) Engl.]	Pflanzenr. 55 (IV.23Da): 109 (1912)	XI.B.X.	Death record not available
Schismatoglottis latevaginata Engl.	Pflanzenr. 55 (IV.23Da): 106 (1912)	XI.B.X. 25	Death in 1960
Schismatoglottis latifolia var. *rubescens* Engl. [Synonym of *Apoballis rupestris* (Zoll. & Moritzi ex Zoll.) S.Y. Wong & P.C. Boyce	Pflanzenr. 55 (IV.23Da): 118 (1912)	XI.B.X. 51	Death in 1920
Schismatoglottis longicuspis Engl. [Synonym of *Schismatoglottis wallichii* Hook. f.]	Pflanzenr. 55 (IV.23Da): 100 (1912)	XI.B.X.	Death record not available
Schismatoglottis opaca Engl. [Synonym of *Schismatoglottis tecturata* (Engl.) Schott]	Pflanzenr. 55 (IV.23Da): 86 (1912)	XI.B.X. 120	Death in 1927
Schismatoglottis puberulipes Alderw.	Bull. Jard. Bot. Buitenzorg III, 4:200 (1922)	XI.B.X. 118	Death in 1996
Schismatoglottis rotundifolia Engl. [Synonym of *Apoballis mutata* (Scort ex. Hook f.) S.Y. Wong & P.C. Boyce	Pflanzenr. 55 (IV.23Da): 122 (1912)	XI.B.X.	Death record not available
Schismatoglottis rubrocincta Engl. [Synonym of *Apoballis acuminatissima* (Schott) S.Y. Wong & P.C. Boyce	Pflanzenr. 55 (IV.23Da): 106 (1912)	XI.B.X.	Death record not available
Schismatoglottis ruttenii Alderw. [Synonym of *Schismatoglottis calyptrata* (Roxb.) Zoll. & Moritzi	Bull. Jard. Bot. Buitenzorg III, 4:211 (1922)	XI.B.X. 69	Death in 1990
Schismatoglottis treubii Engl. [Synonym of *Apoballis rupestris* (Zoll. & Moritzi ex Zoll.) S.Y. Wong & P.C. Boyce]	Pflanzenr. 55 (IV.23Da): 119 (1912)	XI.B.X.	Death record not available
Schismatoglottis wahaiana Alderw.	Bull. Jard. Bot. Buitenzorg III, 4:209 (1922)	XI.B.X. 10	Death record not available
Scindapsus mamiliferus Alderw.	Bull. Jard. Bot. Buitenzorg III, 1: 387 (1920)	Z. 58	Survived, up to now
Scindapsus splendidus Alderw.	Bull. Jard. Bot. Buitenzorg III, 4: 226 (1922)	Z. 54	Survived, up to now
Scindapsus treubii Engl.	Bot. Jahrb. Syst. 25: 13 (1898)	Y. 10	Death in 2017

Sources: Hay et al. 1995, The Plant List 2013, Registration database of the Bogor Botanic Gardens (BBG) and and direct observation in the field

As aromatic plants

Many members of the genus *Homalomena* release a refreshing pleasant smell when the rhizomes or petioles are crushed. Dfferent species of the genus produce different aromas; for example, *H. cordata* has a smell similar to carrot, whereas *H. pendula* smells likes mango. Moreover, essential oils can be extracted from the rhizomes of *Homalomena aromatica* and can be used as a component in oriental perfumes (Chomchalow 2002, IMC 2003, Goswami et al. 2016). Additionally, Policegoudra et al. (2012) reported that the *H. aromatica* rhizomes yielded 2% of essential oil in which 62.5% of major constituent was linalool.

Further research is needed into such essential oils, particularly for Indonesian species.

Description of selected species

Short descriptions of selected species are presented below (Figure 5). The selection criteria are based on those species that are native to Indonesia and that are representative of the potential mentioned above.

Aglaonema pictum (Roxb.) Kunth.

Description. Terrestrial herb, c. 50 cm high; petiole shorter than lamina, 4-8 cm long; leaf blade lanceolate, tip acuminate, entire or crenate, slightly dull, dark green with irregular, blackish-green blotches with silver pattern adaxially, 20 cm long; midrib very conspicuous abaxially, sunken adaxially.

Habitat. Found in secondary forest, air humidity 25-45%, on sandy clay, at elevation up to 1000 m

Distribution. Endemic to Sumatra and Nias island (Nicolson 1969)

Notes. Having colorful blade, like an army uniform, therefore members of this species have potential to be developed as ornamental plants. This species can also be used as a parent for hybridization purposes.

Alocasia suhirmaniana Yuzammi & A.Hay

Description. Terrestrial herb, 50-65 cm high; leaves 1-3 together; petiole yellowish-green, densely longitudinally and obliquely mottled purple-brown, minutely and densely puberulous; leaf blade broadly ovate-sagittate, c. 55 cm long, peltate, pendent, thinly leathery, margin slightly undulate, glossy dark green above with pale green major venation, dark purple beneath

Habitat. Found in lowland secondary forest, in shady places, often on limestone.

Distribution. Endemic to Southeast Sulawesi

Notes. *Alocasia suhirmaniana* has high potential as an ornamental leaf plant, owing to the beautiful color and form of its leaves. Yuzammi and Hay (1998) and Hay (1998) stated that the species is distinguished from the Longiloba group by having puberulent petioles and a blackish-purple spathe.

Amorphophallus paeoniifolius (Dennst.) Nicolson (Yuzammi et al. 2017)

Description. Terrestrial herb; tuber depressed globose, dark brown with rootscars prominent, c. 30 cm in diam.; petiole c. 2 m long, surface somewhat corrugate to strongly echinate-verrucate, pale to dark green or blackish green with large and small pale bloches and numerous tiny dark dots; leaf blade c. 3 m in diam., highly dissected; inflorescence with short peduncle; spathe campanulate; limb spreading strongly undulate.

Habitat. Found in secondary forest, teak forest, grave yards, at disturbed places, on shady to fully exposed area, at elevations up to 800 m.

Distribution. Madagascar, eastward through India to Malesia, Thailand, Indochina, southern China, Polynesia and northern Australia.

Notes. There are two kinds of landrace, knowing as 'walur' and 'suweg' by the Javanese people. The first one has a rough to very rough petiole and the latter has a somewhat smooth to slightly rough petiole. Only 'suweg' is edible as a food source, after significant processing treatment.

Amydrium humile Schott

Description. Occasionally a climbing plant, often forming sprawling ground colonies; stem brownish, c. 2 cm in diam., forming internodes from which the leaves emerge; leaves scattered; petiole rounded, green, somewhat swollen at based and c. ⅓-½ of the upper part, the color of the swollen part somewhat different to the whole petiole, yellowish green; leaf blade cordate, sometimes with posterior lobes overlapping, leathery; the inflorescence emerges from internodes of branches.

Habitat. Found in secondary forest, at slightly shady and moist sites, sometimes found on thick litter over rocks, on sandy-clay soil type, c. 90% air humidity, at an elevation of 1,260 m; Dzu and Boyce (1999) mentioned that this species occurs at an elevation up to 1,800 m..

Distribution. Sumatra and Peninsular Malaysia.

Notes. *Amydrium humile* is the only member of the genus that forms sprawling colonies and does not flower on climbing shoots (Dzu and Boyce 1999).

Apoballis acuminatissima (Schott) S.Y.Wong & P.C.Boyce

Description. Terestrial herb, c. 30 cm high; petiole red to reddish-purple, glabrous; leaf blade oblong-lanceolate with slight basal lobes, c. 15 cm long, pale green, plain or with sliver bloches adaxially, bright red abaxially.

Habitat. Found on well drained soils, on hills, often growing on sandy clay, at elevations of 400-1.500 m.

Distribution. Endemic to Sumatra

Notes. The genus *Apoballis* is differentiated from *Schismatoglottis* in having a deciduous wing sheath to the petiole. Also, the sterile zone separating the staminate and pistillate flower zones is inflated and with only a few scattered staminodes. Moreover, the spathe limb hardly opens and remains attached until late in infructescence development (Wong and Boyce 2010). This species has high potential as an ornamental, owing to the beautiful coloration of its leaf blade in many clones; it is suitable both as an indoor and outdoor plant.

Table 4. The potential of species of Araceae cultivated in the Bogor Botanic Gardens for use as ornamentals and in aquascapes, as food sources, as vegetables, as animal feedstock, as medicines, and as aromatic plants

Genera	Species	Food	Ornamental	Medicine	Forage	Vegetable	Aquascape	Aromatic
Aglaonema	*commutatum* Schott		•					
	costatum N.E.Br.		•					
	marantifolium Blume		•					
	nitidum (Jack) Kunth		•					
	pictum (Roxb.) Kunth		•	•				
	simplex (Blume) Blume		•					
Alocasia	*alba* Schott		•					
	longiloba Miq.		•					
	macrorrhizos (L.) G.Don		•	•	•	•		
	portei Schott		•					
	reginae N.E.Br.		•					
	ridleyi A.Hay		•					
	sarawakensis M.Hotta		•					
	suhirmaniana Yuzammi & A.Hay		•					
Aglaodorum	*griffithii* (Schott) Schott						•	
Amorphophallus	*asper* (Engl.) Engl. & Gehrm.		•					
	beccarii Engl.		•					
	borneensis (Engl.) Engl. & Gehrm.		•					
	decus-silvae Backer & Alderw.		•					
	gigas Teisjm.& Binn.		•					
	hirsitus Teisjm.& Binn.		•					
	muelleri Blume	•	•					
	paeoniifolius (Dennst.) Nicolson	•			•	•		
	pendulus Bogner & Mayo		•					
	titanum (Becc.) Becc. ex Archang		•					
	variabilis Blume		•					
Amydrium	*humile* Schott		•					
	medium (Zoll. & Moritzi) Nicolson		•					
	zippelianum (Schott) Nicolson		•					
Anadendrum	*microstachyum* (de Vriese & Miq.) Backer & Alderw.		•					
Anchomanes	*difformis* (Blume) Engl.		•					
Anthurium	*cordatum* (L.) Schott		•					
	crassinervium (Jacq.) Schott		•					
	digitatum (Jacq.) Schott		•					
	geitnerium A.Regel		•					
	obtusilobum Schott		•					
	palmatum (L.) Schott		•	•				
	*pedato-radiatum*Schott		•					
	pedatum (Kunth) Endl. ex Kunth		•					
	pentaphyllum (Aubl.) G.Don		•					
Anubias	*barteri* var.*glabra* N.E.Br.						•	
Apoballis	*acuminatissima* (Schott) S.Y. Wong & P.C. Boyce		•					
	hastifolia (Hallier f. ex Engl.) S.Y. Wong & P.C. Boyce		•					
	mutata (Scort. ex Hook.f.) S.Y. Wong & P.C. Boyce		•					
	rupestris (Zoll. & Moritzi ex Zoll.) S.Y. Wong & P.C. Boyce		•					
Cercestis	*mirabilis* (N.E.Br.) Bogner		•					
Colocasia	*esculenta* (L.) Schott	•		•		•		
Culcasia	*mannii* (Hook.f.) Engl.		•					
Cyrtosperma	*beccarianum* A.Hay						•	
	cuspidispathum Alderw.						•	
	johnstonii (N.E.Br.) N.E.Br.						•	
	macrotum Becc. ex Engl.						•	
	merkusii (Hassk.) Schott						•	
Dieffenbachia	*amoena* Bull.		•					
	bowmannii Carrière		•					
	fournieri N.E.Br.		•					
	seguine (Jacq.) Schott		•					
	*splendens*W.Bull		•					
	memoria-corsii Fenzi.		•					
Dracontium	*gigas* (Seem.) Engl.		•					

	polyphyllum L.		•	•		
Epipremnum	*aureum* (Linden & André) G.S. Bunting		•			
	falcifolium Engl.		•			
	giganteum (Roxb.) Schott		•			
	nobile (Schott) Engl.		•			
	pinnatum (L.) Engl.		•	•		
Gonatopus	*boivinii* (Decne.) Engl.					
Holochlamys	*beccarii* (Engl.) Engl.		•		•	
Homalomena	*caerulescens* Jungh. ex Schott			•		•
	cordata Schott					•
	gigantea Engl.		•			•
	humilis (Jack) Hook.f.		•			
	lindenii (Rodigas) Ridl.		•			
	megaphylla M.Hotta					•
	pendula (Blume) Bakh.f.		•	•		•
	punctulata Engl.		•			
Lasia	*spinosa* (L.) Thwaites			•	•	
Leucocasia	*gigantea* (Blume) Schott	•	•			
Monstera	*adansonii* var. *laniata* (Schott) Madison		•			
	deliciosa Liebm.	•	•	•		
	obliqua Miq.		•			
Montrichardia	*arborescens* (L.) Schott			•	•	
Philodendron	*bipinnatifidum* Schott ex Endl.		•	•		
	crassinervium Lindl.		•			
	erubescens K.Koch.& Agustin		•			
	gloriosum André		•			
	hederaceum (Jacq.) Schott		•			
	imbe Schott exKunth		•	•		
	*melanochrysum*Linden & André		•			
	ornatum Schott		•			
	panduriforme (Kunth) Kunth		•			
	pedatum (Hook.) Kunth		•			
	sagittifolium Liebm.		•			
	squamiferum Poepp.		•			
	tripartitum (Jacq.) Schott		•	•		
Pistia	*stratiotes* L.			•	•	
Pothos	*junghuhnii* Schott		•			
	roxburghii de Vriese		•			
	scandens L.		•			
Rhaphidophora	*angustata* Schott		•			
	conica Engl.		•			
	conocephala Alderw.		•			
	foraminifera (Engl.) Engl.		•			
	korthalsii Schott		•			
	montana (Blume) Schott		•			
	schlecteri K.Krause		•			
	sylvestris Blume) Engl.		•			
Rhodospatha	*latifolia* Poepp.		•			
Sauromatum	*horsfieldii* Miq.		•			
Schismatoglottis	*calyptrata* (Roxb.) Zoll. & Moritzi		•			
	lancifolia Hallier f. & Engl.		•			
	pumila Hallier f. ex Engl.		•			
	trivittata Hallier		•			
Scindapsus	*cuscuaria* (Aubl.) C.Presl.		•			
	hederaceus Miq.		•	•		
	mamilliferus Alderw.		•			
	pictus Hassk.		•			
	roseus Alderw.		•			
	splendidus Alderw.		•			
	treubii Engl.		•			
Spathiphyllum	*commutatum* Schott		•			
	cannifolium (Dryand. ex Sims) Schott		•			
Syngonium	*auritum* (L.) Schott		•			
	podophyllum Schott		•			
	schottianum H. Wendl. ex Schott		•			
Xanthosoma	*helleborifolium* (Jacq.) Schott	•				
	robustum Schott	•				
	sagittifolium (L.) Schott	•		•		
Zamioculcas	*zamiifolia* (Lodd.) Engl.		•			

Sources: Johnson 1999, Koller 2008, Saswati et al. 2013, and direct observation in the field

Figure 5. A. *Aglaonema pictum* (Roxb.) Kunth; B. *Alocasia suhirmaniana* Yuzammi & A.Hay; C. *Amorphophallus paeoniifolius* (Dennst.) Nicolson; D. *Amydrium humile* Schott; E. Inflorescence of *Amydrium humile* Schott; F. *Apoballis acuminatissima* (Schott) S.Y.Wong & P.C.Boyce; G. *Cyrtosperma beccarianum* A.Hay; H. *Epipremnum pinnatum* (L.) Engl.; I. *Rhaphidophora angustata* Schott; J. *Rhaphidophora foraminifera* (Engl.) Engl.: K. *Schismatoglottis calyptrata* (Roxb.) Zoll. & Moritzi

Cyrtosperma beccarianum A.Hay (Hay 1998)

Description. Helophytes of semi-shady sites, up to 150 cm high; leaves 3-7; petiole sparsely armed to un-armed, rarely rather densely spiny, green, variously blotched and marble green, brown and pink; leaf blade with the anterior pointed down and posterior lobes up, posterior lobes 3-4 times longer than anterior, yellowish green adaxially, pale green abaxially.

Habitat. This species is found close to streams, in wet places or in swamp forest (Hay 1988).

Distribution. Endemic to Papua

Notes. Having a unique leaf-form, therefore the species has high potential as an ornamental plant.

Epipremnum pinnatum (L.) Engl. (Boyce 1998)

Description. Climber plant, climbing tree up to 15 m; pre-adult plants form ground colonies, adult plant climbing; stem smooth with internodes separated by variously prominent leaf scars, green, older stem sub-woody, pale brown papery epidermis; petiole glabrous, dark green,

canaliculate, 20-60 cm long with basal and apical geniculum; leaf blade 60-93 cm long, regularly pinnatifid, ovate to oblong-elliptic in outline, dark green adaxially, paler abaxially; pinna up to 6.5 cm wide with truncate to acute apex, pellucid dots occur especially adjacent to the midrib in leaves just beginning to exhibit pinnae, each pinna with 1 primary lateral vein with many interprimary veins.

Habitat. Found in primary and secondary forest, on open areas in lowland monsoon forest and rainforest, as weeds on rubber plantation, sometimes growing on rocks and on the seashore, on various media including granite, andesite and limestone, at elevations 1-1,600 m.

Distribution. Bangladesh, Andaman Islands, Myanmar, Thailand, Vietnam, Laos, China, Hongkong, Taiwan, Japan, Malaysia, Singapore, Indonesia, Philippines, Solomon Islands, Vanuatu, New Caledonia, New Guinea, Australia, Marshall Islands, Belau Islands, Fiji, Tonga, Cook Islands, Western Samoa

Notes. Widespread species. It is well known as 'daun ekor naga' or dragon tail leaf and it can inhibit the growth of cancer cells (Yuzammi 2008).

Rhaphidophora angustata Schott (Boyce 2000)

Description. Climber plant, up to 20 m; stem smooth, bright green; leaves weakly spiralled on an adherent and flagelliform shoot, few to many-leaved fans; petiole deeply canaliculate with prominent petiolar sheath, apical most geniculate; leaf blade entire, falcate-lanceolate to falcate-oblong,oblique,15-61 cm long; midrib prominent abaxially, slightly sunken adaxially; primary venation pinnate, slightly raised abaxially, somewhat impressed adaxially.

Habitat. Found in primary and secondary lowland forest, in humid locations, along rivers, climbing on trees, sometimes on rock, at elevations of 125-1,500 m.

Distribution. Sumatra and Peninsular Malaysia

Notes. *Rhaphidophora angustata* is highly characteristic by its high-climbing stems with scattered large fan-like clusters of brilliant pale green leaf blades, and has for potential as an ornamental leaf plant.

Rhaphidophora foraminifera (Engl.) Engl. (Boyce 2001)

Description. Climber plant, climbing up to 15 m; pre-adult plants form extensive terrestrial colonies; stem smooth, mid green; petiole canaliculate, 22-52 cm long, apical geniculum pubescent, prominent; petiolar sheath prominent; leaf blade ovate to oblong-lanceolate, slightly oblique, entire to slightly or extensively round to rhombic perforated on each side of the midrib, yellowish pubescent abaxially when young, 7-53 cm long.

Habitat. Found climbing on trees in secondary forest, sometimes climbing on trees in thickets near the main road to South Sumatra, up to 800 m elvation (according to Boyce 2001, from 10-700 m).

Distribution. Sumatra, Peninsular Malaysia, Kalimantan, Sabah, Sarawak, Brunei Darussalam

Notes. Having unique perforations along the leaf blade, this species is a beautiful ornamental leaf plant.

Schismatoglottis calyptrata (Roxb.) Zoll. & Moritzi (Hay & Yuzammi 2000)

Description. Terrestrial herb, often forming colonies or clumps, c. 60 cm high; petiole smooth, greenish, c. 50 cm long, petiole sheath fully attached, persistent; leaf blade oblong-lanceolate with the base cordate, with posterior lobes rounded, blade usually dull midgreen, dull green, sometimes variegated with 1-2 bands or irregularly spotted grey-green to yellowish green adaxially, c. 35 cm long; Inflorescence 1-8 together, lower spathe narrowly ovoid, green; limb differentiated from lower spathe by an abrupt constriction, creamy to pale greenish-yellow, caducous immediately after female anthesis.

Habitat. Found in lowland forest and lower montane forest, often along forest margins, on both wet and well-drained soils, from sea level up to 1,700 m elevation.

Distribution. China to Indo-China, toward east Vanuatu and all Malesian regions except they most seasonally monsoonal.

Notes. Widespread species. This species has variation in leaf blade color so that at least some clones has potential to be developed as an ornamental plant. This species is suitable for growing as an ornamental leaf plant as well as a border plant in the garden.

In conclusion, Bogor Botanic Gardens, Indonesia's premier *ex-situ* plant conservation facility, has a high diversity of aroids (Araceae) in its collection. This collection has been cultivated from Dutch times up to the present day. Some species that still survive, are living types; among them *Scindapsus splendidus* and *Epipremnum falcifolium*. The aroid collection consists of 130 species in 36 genera, of which 21 genera are native to Indonesia. The conservation efforts have been carried out particularly for endangered and endemic species, such as *Amorphophallus titanum, A. gigas, A. asper* and *Apoballis acumatissima*. Some species such as *Alocasia* spp. have important ecological value due to their ability to fill forest gaps. The occurence of aroids is often interconnected with certain animals, for example bats and birds. Those are recognised to be frugivorous and are dispersers of seeds. In addition, almost all members of the aroid family have high potential as ornamental plants. Some species are edible such as *Amorphophallus paeoniifolius* and *Colocasia esculenta*. Others have potential as medicine plants, notably *Epipremnum pinnatum*, while some species of *Homalomena* are known for their aromatic essential oils. On the other hand, there are many potentially useful aroids in Bogor Botanic Gardens that have not received much public attention; in particular, species with a climbing habit. Further research is recommended. Flora exploration throughout the forests of Indonesia must continue, in order to assemble for conservation purposes a complete representation of the archipelago's genera of Araceae within the Bogor Botanic Gardens.

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