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Diversity, potential and conservation of Annonaceae in Bogor Botanic Gardens, Indonesia

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Abstract. *Handayani T. 2018. Diversity, potential and conservation of Annonaceae in Bogor Botanic Gardens, Indonesia. Biodiversitas 19: 591-603.* The Annonaceae is a large family of trees, shrubs and climbers consisting of about 109 genera and 2440 species. This family has important economic value for fresh fruit, cosmetics and perfumes, timber, traditional medicines, processed foods and beverages, insecticides, and ornamental plants. It also has an important role in forest ecosystems and in environmental management, as a key habitat organism. Despite its many uses, the family has not received special attention, and many of its species have been forgotten. Therefore, efforts are required to conserve the Annonaceae. Conservation of the Annonaceae depends upon *ex-situ* as well as *in-situ* methods. Conservation by ex situ approaches is considered effective because it can save from extinction species that are rare, endemic or of as yet recognized, unknown usefulness.The research reported in this paper aimed to determine Annonaceae diversity in Bogor Botanic Gardens (BBG), West Java, Indonesia as well as its current and potential utilization, with a view to developing ways of ensuring preservation of the collection within the Gardens. The study used direct observation of the Garden's collection, compilation and scrutiny of relevant data from the long-term BBG registration database, analysis of past research data, and a literature study. Currently, BBG holds in its collection about 28 genera and 83 species of the Annonaceae family. The collection is estimated to cover 80% of the total species scattered across the Malesian region. Within the collection there are 49 tree species (59.04%), 14 shrub species (16.87%) and 20 liana species (24.09%). Most of the collections are from Java and Sumatra, while the fewest are from Maluku Islands and Papua. Among 40 species observed, 7 species are used for their fruit, 7 species have cosmetic or perfume uses, 22 species are a source of timber, 34 species have uses in traditional medicine, 6 species are used in the food or beverage industry, 19 species can be used as ornamental plants, 8 species for insecticides, and 4 species for other uses.The Annonaceae collections consist of young and old plants.Plants within the Gardens that are more than 100 years old include trees (7 species), shrubs (3 species) and a liana (1 species).The most widely used parts for traditional medicine are roots and leaves. This paper discusses the efforts taken by BBG to conserve the Annonaceae, include maintaining the diversity of the collection, researching the potential usefulness of the collection and exploring different approaches to its conservation.

Keywords: Annonaceae, collection, conservation, research, potential

INTRODUCTION

The human population of Indonesia continues to increase from year to year. Increasing populations cause environmental problems due to over-exploitation of land, expansion of plantations, and deforestation (Nagel 2011). These activities have caused destruction of forests as habitats for flora and fauna. Forest destruction also causes the loss of species that are known to the public, or unknown and hence not available for potential utilization. In order to prevent the possible flora extinction in the wild, such as particular species of the family Annonaceae, conservation efforts are being undertaken at sites outside the flora's natural habitats (ex situ conservation), such as in the facilities of Bogor Botanical Gardens (BBG) in West Java, Indonesia.

The Annonaceae is a large family of trees, shrubs, and climbers, which occurs in tropical and subtropical regions. It consists of about 109 genera and 2440 species (Couvreur et al. 2012). Economically, the family is important as a source of edible fruits (Aziz et al. 2016);cosmetics and perfumes (Leboeuf et al. 1982; Bele et al. 2011, Akpabio and Akpapan 2012; Uyoh et al. 2013; Handayani 2016); timber (Nurfadilah et al. 2017); traditional medicines (Wang et al. 2002; Blessing et al. 2010; Purwantiningsih et al. 2011; Wang et al. 2012; Rosandy et al. 2013; Biba et al. 2014; Enabulele et al. 2014); processed foods and beverages (Bele et al. 2011; Akpabio and Akpapan 2012; Eze-Steven et al. 2013; Tatdao et al. 2014); ornamental plants (Handayani 2016; Handayani 2017); pesticides (Bele et al. 2011; Cheng et al. 2012); and other comodities (Wakhidah et al. 2017). Members of the Annonaceae play an important ecological role in terms of species diversity, especially in tropical rainforest ecosystems (Couvreur et al. 2012). However, the Annonaceae populations in natural habitats continue to be threatened. Pressures on forest in the form of exploitation for forest products, and of conversion to agricultural land, plantations, housing and mining land occur continuously (Yusuf et al. 2005; Komara et al. 2016). Harvesting Annonaceous plants from the forest, as a source of timber or raw material for traditional medicine is a direct cause of population decline of particular species. This affects the balance of the forest ecosystem. □

Bogor Botanical Gardens is located in Bogor city, West Java Province, Indonesia. As an *ex-situ* plant conservation institution, BBG plays important roles in preventing plant species extinction. Apart from this, the existence of BBG in the middle of downtown Bogor makes a very important contribution to the tackling of environmental problems in Bogor city and its surroundings.The Annonaceae is one of the families in the plant collection of BBG with a particularly large number of species represented. The Annonaceae play an important role in the artificial forest ecosystem of the Gardens. The plants have ecological, hydrological, and climatological functions. Many members of the collection are large enough to represent significant carbon sinks within the ecosystem (Didi Usmadi, pers. com.). They also contribute to the oxygen balance and provide habitats for other organisms. The loss of Annonaceae in the wild and BBG would have impacts on the balance of these ecosystems and human life dependent on them. It is therefore essential that concerted efforts be taken both in the wild and within the BBG *ex-situ* conservation facility, to provide for the preservation of the family Annonaceae and the sustainability of their utilization by human society (Sari et al. 2005;Yusuf et al. 2005; Nagel 2011; Couvreur et al. 2012;

The conservation of the Annonaceae involves both in situ and ex-situ approaches. In situ conservation is indirect, since the goal to protect the Annonaceae is not specific. In situ conservation focuses on species that grow in protected forest, national parks, indigenous forest, nature parks and nature reserves (Hartini and Puspitaningtyas 2009). Ex situ conservation aims to preserve the Annonaceae directly within botanical gardens, city forests, city parks, arboreta and community plantations. Due to its ability to preserve species that are rare, endemic or of unknown benefits, this method is considered more effective in preventing extinction of targeted species.

This study aimed to: (i) determine the diversity of the Annonaceae as represented in Bogor Botanic Gardens, (ii) record the results of previous research carried out into Annonaceae at BBG, (iii) explore the potential of the Annonaceae for utilization by society, and (iv) study the ways to conserve the family's diversity.

MATERIALS AND METHODS

Time and place

This research was carried out at Bogor Botanic Gardens (BBG), Bogor, West Java, Indonesia between 2014 and 2016. The altitude of BBG is about 260 m asl, relative humidity is 34-80 %, and temperature varies between 25-39°C.

Plant materials

This research used the collection of Annonaceae in BBG as the study material. Data on the Annonaceae members of the Gardens were compiled from the Registration and Nursery Sub-divisions of BBG as well as from a review of the published literature.

Observations on the diversity of Annonaceae

Only plants that have been identified to species level were observed as part of the assessment of diversity. Forty species of trees, shrubs and lianas were used as observation samples. Observations focused on variation in species, plant habit, flower color, coloration of new foliage, specimen origin, habitat, and reproductive traits. Observations were made by naked eye, camera, and microscope. The size of trees was classified as small if the had a high < 5 m and large trees were those with a high > 5 m. The floral diameter was measured with a ruler: flowers were classified as small if they had a diameter < 2 cm; medium flowers were 2-5 cm in diameter, and large flowers were those with a diameter > 5 cm.

Observation of recent research activity conducted on Annonaceae

The research reported here summarises all research recently carried out on the Annonaceae collection of BBG; this includes research done in greenhouses, in the open garden, and reported in published literature. All research relating to seeds is generally carried out in a greenhouse. Observations on reproductive aspects of the growing plants are conducted in the open gardens. Observations on insect visitors were carried out on 15 flowering plants.This study also reviewed other research that was conducted at BBG.

Observation of the potential uses of Annonaceae

Observations were made on 40 species in the BBG plant collection. Observations of the potential uses of the plant were carried out directly, and included recording interesting aspects of the plants, such as the color of flowers, the color of young leaves, and the stature of trees. Furthermore, interviews and information from the literature were also used as source data.

Observation of the conservation of Annonaceae

Observations were conducted on conservation activities related to the technical preservation of plant members of the Annonaceae. *In situ* conservation, location data were obtained from the literature. Data relating to technical aspects of plant conservation were collected from technicians working in BBG. Data relating to the collection were also observed directly and obtained from the Registration and Nursery Sub-Divisions.

Data analysis

The data on plant origins, number of species based on ages cultivated in BBG and useful parts of the plant were collated and analyzed using an MS Excel spreadsheet.

RESULTS AND DISCUSSION

Diversity of Annonaceae in Bogor Botanical Gardens

Table 1 summarizes the types of data collected on the diversity of Annonaceae in BBG, including information about plant species, plant origins, habit, plants age, growth site, reproduction traits, young leaf color, and flower color. Based on the catalog of "*An Alphabetical List of Plant*

Species Cultivated in The Bogor Botanic Gardens" (Sari et al. 2010), 83 species belonging to 28 genera have been identified in the Annonaceae collection.The collection is estimated to hold plants belonging to 80% of the total species scattered in the Malesian region. The number of species per genus varies from one to 11 species. *Anomianthus, Dasymaschalon, Desmos, Enicosanthum*, *Meiogyne, Platymitra, Saccopetalum*, and *Xylopia,* are genera consisting of just one species. *Polyalthia*is the genus with the most number of species, i.e., 11 species.

Table 1. Characteristics of Annonaceae plants in Bogor Botanic Gardens, West Java, Indonesia

Characteristic documented	Recorded states of characteristic
Origins of the plants	Indonesia; foreign
Habitus	Tree; shrub; and liana
Age of plants	Young; old
The growth site	Shaded; slight shade; and open area
Flowering and fruiting season	Seasonal; simultaneous
Flowering type	Flushing; not flushing
Flowering pattern	Once a year; continuously
The size of flower	Small; medium; and large
The color of young leaf	Greenish-brown, pink, and yellowish-green
The color of flower	White, red, purplish-red, green, purplish-green, yellow, reddish-yellow, brown, and reddish-brown

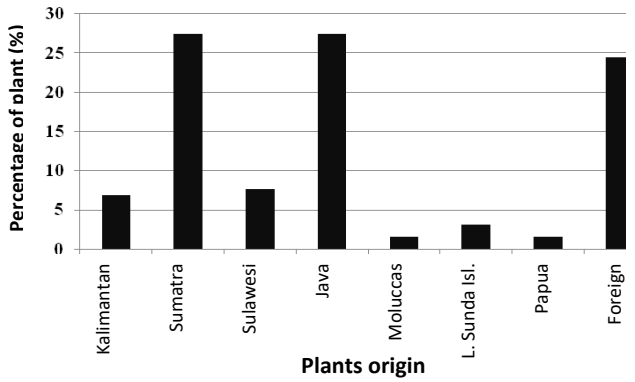

Figure 1. The origins of Annonaceae plants in the collection of Bogor Botanical Gardens, West Java, Indonesia

Figure 2. The total number of species in the Annonaceae family of Bogor Botanical Gardens, West Java, Indonesia, classified according to the age of the plant specimen in the collection

Plants habitus

The growth habit of Annonaceae members varies; i.e.trees, shrubs or lianas. At BBG, the Annonaceae collection is composed of 49 species of tree (59.04%), 14 species of shrub (16.87%) and 20 species of liana (24.0%). The greatest numbers of tree species are in the *Polyalthia* genus. Most of the shrubs are from the genera *Annona* and *Goniothalamus*.The members of the genus *Uvaria* are mostly liana. The size of the trees in Annonaceae family rang from small to large. Small tree There are ten species of large trees, i.e*., Cananga odorata, Cyathocalyx sumatranus, C. martabanicus, Meiogyne virgata, Mezzettia parviflora, Monodora myristica, Polyalthia glauca, P.lateriflora, Platymitra macrocarpa, Stelechocarpus burahol,* and *Xylopia aethiopica.*

Origin of the plants

The collection of Annonaceae in BBG comes from various regions of Indonesia and foreign introductions. The largest number of plants in the collection is from Java and Sumatra, while the fewest are from Maluku and Papua (Figure 1). Because the amount of exploration conducted on the islands of Java and Sumatra has been greater than in Maluku and Papua, so the possibility of obtaining collections has also been greater. In addition, the diversity of all flora collections in BBG from Java and Sumatra is higher than from Maluku and Papua.

Age of plants

The Annonaceae collection of BBG consists of both young and old plants. Based on my observation of 40 sample species one specimen per species) and results of data analysis from the BBG Registration section, the plants specimen of 13 species are still young (< 25 years), 21 species are more than 50 years old, 11 species are more than 100 years and a plant of one species is more than 150 years old (Figure 2). The plants which more than 100 years old are from seven species of trees, three species of shrub and one species of liana.The oldest tree in the Annonaceae collection, a specimen of *Platymitra macrocarpa,* is 173 years of age; it was planted in BBG in 1844. The oldest shrub, a specimen of *Goniothalamus macrophyllus,* 120 years old, was planted in 1897. One plant belonging to the species *Uvaria rufa* at 118 years of age is the oldest liana in the Annonaceae collection. It was planted in BBG in 1899.

Leaf and flower colors

The color of young leaves of Annonaceae varies, i.e. greenish-brown, pink, and yellowish-green (Figure 3.A, 3.B, 3.C). Species whose young leaves are pink include *Stelechocarpus burahol, Melodorum fruticosum*, and *Polyalthia lateriflora,* whereas, *Saccopetalum horsfieldii, Monodora myristica* and *Polyalthia rumphii* have young leaves that are yellowish-green. Plants with greenish-brown young leaves can be found in the species *Goniothalamus macrophyllus* and *Meiogyne virgata.* The size of flowers of Annonaceae species in BBG varies from small to large. From the 40 species sampled, 15 plants had small flowers, 15 had medium-sized flowers and 10 had large flowers. *Platymitra macrocarpa* flowers are the smallest in size,

while the flowers of *Monodora myristica* have the largest size. The color of the Annonaceae flowers also varies. The color variations found are white, red, purplish-red, green, purplish-green, yellow, reddish-yellow, brown, and reddish-brown.The most common color found is yellow. Flower color can be single (one color) or mixed (more than one color). Single colored flowers can be found in the species *Cananga odorata* (Figure 3.E), *Cyathocalyx martabanicus* and *Polyalthia rumphii*. Mixed colors can be found in flowers of *Monodora myristica* (Figure 3.D), *Polyalthia lateriflora* (Figure 3.H), or *Mitrephora polypyrena* (Figure 3G). Sometimes, the color of the flowers will change with the age of the flowers. For example, when the flower of *Mitrephora polypyrena* blooms its outer petal is white (Figure 3.G) but then turns to yellow. Flower color is an important visual cue for most pollinators (Johnson and Dafni 1998).

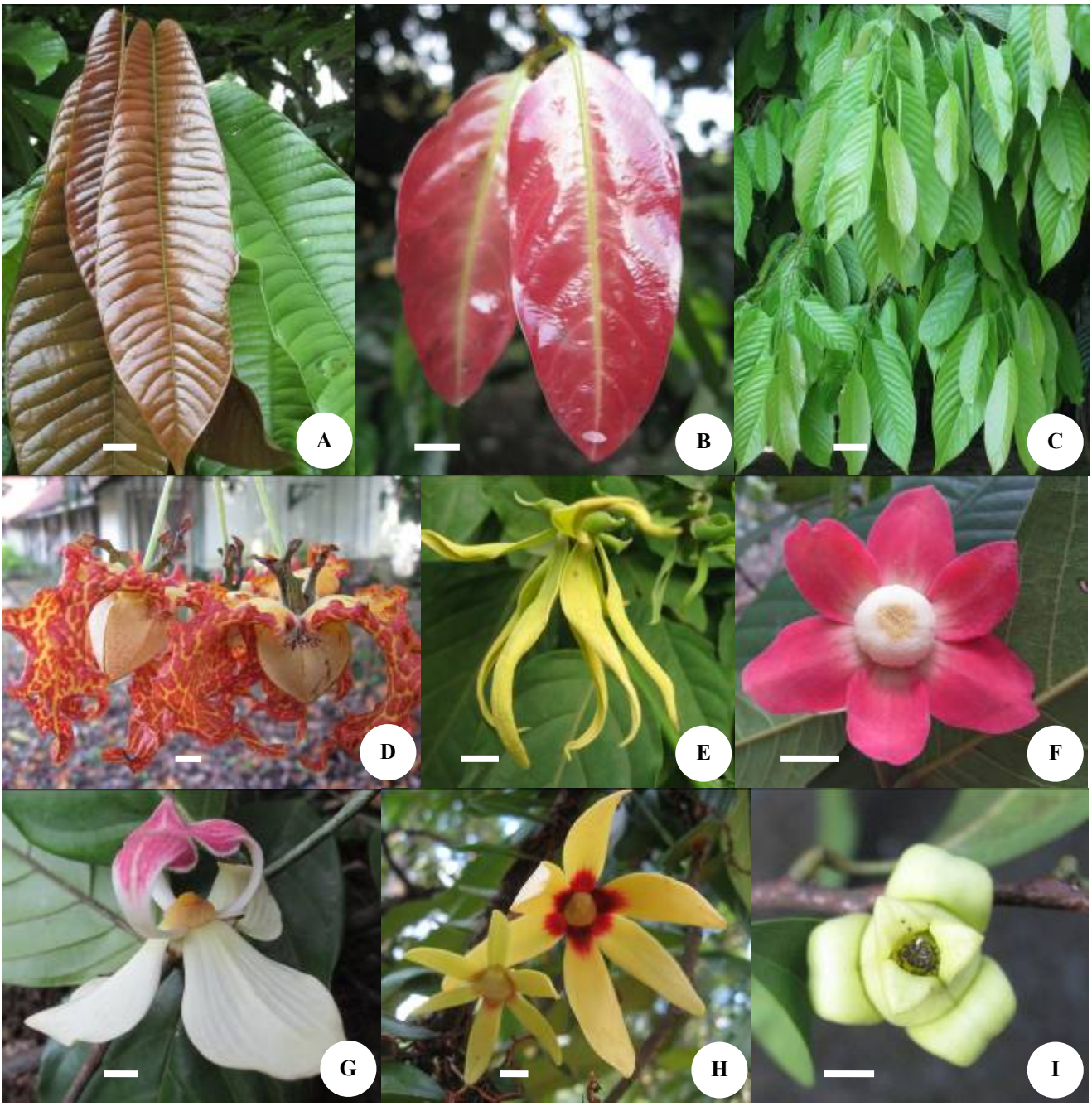

Figure 3. The color of young leaves, and flowers of Annonaceae plant species. A. *Goniothalamus macrophyllus* young leaves, B. *Stelechocarpus burahol* young leaves, C. *Polyalthia rumphii* young leaves D. *Monodora myristica* flower, E. *Cananga odorata* flower, F. *Uvaria hirsuta* flower, G. *Mitrephora polypyrena* flower, H. *Polyalthia lateriflora* flower, I. *Alphonsea teysmannii* flower. 3.A-C scales = 2 cm; 3.D-I scales = 1 cm

Growth site of the plants

The environment of the growth sites of the Annonaceae in the BBG collection varies, from shady locations, to slightly shaded, to open locations. These differences in location cause differences in growth and development of the plants. Plants in shaded places grow poorly, with incomplete branching, susceptibility to disease, and difficulty in flowering and fruiting. Plants in open areas have healthier, stronger growth, perfect branching and often produce flowers and fruit. Initially, specimens of Annonaceae collected from exploration trips are planted insufficient light in BBG. Some vigorous species grow fast and large so that they are not overshadowed by other species. On the other hand, some plant growing in shady locations will grow slower and with difficulties. An example of this in BBG, is one specimen of the species *Orophea hexandra* that is growing in the shade of a *Polyalthia rumphii*.

The traits of reproduction

The reproductive traits of Annonaceae vary according to the species. According to Handayani (2016) members of Annonaceae in BBG (40 species) generally, have a flowering and fruiting time from January to December. The numbers of flowering and fruiting species fluctuated each month ranging from 29-35 species and 21-28 species respectively. The flowering season peaks in October-November (35 species), while the peak of the fruiting season occurs in December (28 species). The flowering in some species is preceded by a flushing phase while some do not have a flushing phase. Flushing is a phenomenon in plants generally initiated by partial or complete fall of adult leaves; followed by growth of new leaves or leaf buds at the end of the stem, the tip of twigs or axillary leaves; and then followed by the appearance of flowers. From the 40 species sampled, indications of flushing were observed in 16 species, while 24 species exhibited a"non-flushing" type of flowering. Flowering patterns of the species also vary; from flowering once a year through to continuous flowering each year. As many as six species flower only once a year, while 24 species flower throughout the year.

Faunal visitors

Based on my observation in BBG faunal visitors to Annonaceae plants include insects, squirrels, bats and birds. Squirrels, bats and birds visit to Annonaceae plants for eat the fruit of Annonaceae and disperse seed. There are many visitor insects to Annonaceae flowers, i.e.: black beetle, bees, fruit fly, green flies, mites, small black ants, small red ants, gray ants, and weaver ants. Direct observation in BBG, large black beetle visit the flower of *Annona montana.* Medium bees, small bees, mites visit the flower of *Cananga odorata, Dasymaschalon blumei, Mitrephora polypyrena* and *Stelechocarpus burahol.* Fruit fly and green fly visit the fruit of *Stelechocarpus burahol , Alphonsea teysmannii* and *Dasymaschalon blumei*. Small black ants, small red ants, gray ants, and weaver ants visit many kinds of species i.e *Artabotrys hexapetalus, Goniothalamus ridleyi, Monodora angolensis*, *Polyalthia lateriflora, P. rumphii, P. suberosa,* and *Stelechocarpus burahol*. The successful fruiting of a species is influenced by visiting insects, especially pollinators. Some of the visiting insects are suspected of being pollinators, because their feet were observed to be carrying pollen from one flower to others. According to Goodrich (2012) and Saunders (2012) there are five groups of Annonaceae flower pollinators namely beetles, bees, flies, mites and cockroaches. On the other hand, in BBG, cockroaches have never been recorded visiting flowers of Annonaceae. Sometimes there is a symbiosis between plants and visiting insects such as weaver ants with *Polyalthia rumphii*. Symbiosis between ants and Annonaceae plants in BBG also occur in *Polyalthia lateriflora*, *Monodora angolensis* and *Goniothalamus ridleyi*. From that symbiosis, the ants get food, while the plants get protection from pests and diseases. Weaver ants feeding on leaf-eating caterpillars record in *Polyalthia lateriflora* and *P.rumphii*. They help plants from pest attacks. Small red ants make a nest in the inflorescence flowers of *G. ridleyi.* In this interactions are suspected ants get nectar and nest, while plant flowers are protected by ants from other insect disturbances. However, symbiosis between these plants species with insect visitors still requires further research. According to Frederickson et al (2012), ant-plant interactions are classic examples of mutualism. Numerous plant species make food or housing to attract ants, which defend the plants against herbivores or other enemies. These ants collect extrafloral nectar or food bodies from plants.

Research into Annonaceae in Bogor Botanical Gardens

Research is important for revealing potential uses in plants. Research can not be separated from conservation in an institution such as BBG. One of the missions of the BBG is to enhance research to support conservation and promote sustainable use of tropical plants resources. The BBG promotes greater of use of Indonesian flora by: conducting inventories and evaluation of useful and potentially useful plant species; by promotion of useful plant species; by conducting ex situ conservation of useful and potentially useful plant species; by conducting research into the conservation, anatomy, ecology, botany, physiology and horticuture of useful and potentially useful plant species; and by developing plant collections that have potential for public cultivation. These useful plants include species with potential to be developed into medicinal plants, food plants, timber plants, ornamental plants and others. Researchers at BBG are given the option of researching and studying selected taxa, e.g. Annonaceae, Araceae, Arecaceae, Asclepiadaceae, Begoniaceae, Nepenthaceae, Orchidaceae, Piperaceae, etc. Various fields of science relating to these taxa are studied, in order to support the development and utilization of plants with recognised potential. Some studies relating to Annonaceae that have been carried out in BBG are presented in Table 2.

Seed germination research

The greatest amount of research on Annonaceae in BBG has concentrated on the processes of seed germination, followed by reproductive biology. This research emphasis is closely related to problem-solving

Table 2. Research activities on Annonaceae plants that have been carried out in Bogor Botanic Gardens, West Java, indonesia

Field of research	Kinds of research
Anatomy	Seeds anatomy of: *Artabotrys hexapetalus, Mezzettia parviflora, Platymitra macrocarpa, Meiogyne virgata* and *Polyalthia suberosa.*
Phenology	Germination phenology of: *Alphonsea javanica, Annona glabra, A, montana, A. muricata*, *A. squamosa, Artabotrys hexapetalus, Cananga odorata, Cyathocalyx sumatranus, Dasymaschalon blumei, Meiogyne virgata, Mezzettia parviflora, Mitrephora polypyrena, Orophea hexandra, Platymitra macrocarpa, P.lateriflora, P.littoralis, P. rumphii,* and *P. suberosa*.
Reproductive biology	Flowering and fruiting time of Annonaceae species in Bogor Botanic Gardens,
Morphology	Seedling morphology of the Annonaceae, flowering morphology of the Annonaceae.
Taxonomy	Taxonomy of *Desmos*.
Propagation	Seed propagation, air layering and grafting.
Ethnobotany	The ornamental plants of Annonaceae, potential of Annonaceae. The medicinal plants of the Annonaceae in BBG.

priorities, to the availability of research materials, and to the amount of research time required to achieve effective outcomes. Most of the seeds of Annonaceae in BBG have problems in germination, due to the hardness of the seed coats, and the immaturity of the embryos when the seeds first ripen (Handayani 2016). Besides that, seed materials for many species of Annonaceae become available almost every month, so research into germination phenology can be carried out without delay. Germination phenology research focuses on the topics of seed viability, early seed germination, and seed germination patterns. The result of this research is very useful for the practical propagation and storage of Annonaceae seeds. The seeds of the Annonaceae are categorized as orthodox seeds (Ellis 1991, Corsato et al. 2012) if the moisture content of the seeds is low, the seeds can be stored for a long time). Some species do not have problems in germination, thus sprouting quickly with high germination percentages and vigour, such as *Alphonsea javanica, Annona glabra*, and *Polyalthia lateriflora.* Their propagation is usually by using seeds. Conversely, species with seeds that germinate slowly with low viability frequently have problems with propagation from seed; examples are *Meiogyne virgata* and *Orophea hexandra*. Based on germination experiment in BBG, *Meiogyne virgata* germinate on 50 days after showing, with a viability of 66.67%. Otherwise, *Orophea hexandra* germinate on 72 days after sowing, with a viability of 66%.

Research on seed anatomy

Research on seed anatomy is carried out on species that have germination problems, such as slow or delayed germination. This problem generally arises from particular aspects of the texture or structure of the seed. So, seed anatomy studies have tended to focus on these aspects. Anatomical observation of *Artabotrys hexapetalus* seeds showed that Annonaceae seeds have hard texture of the ruminate endosperm. This is the factor that causing the seeds to take such a long time to germinate (Handayani 2016). According to Svoma (1998), seeds of some members of the Annonaceae have two or three integuments, ruminate endosperm, fibrous mesotesta, and imperfect embryo growth at the time the seeds first ripen. These factors are suspected as causes of slow or delayed seed germination. The results of seed anatomy research can be used to overcome the problems that exist in seed germination of the Annonaceae.

Reproductive biology research

Research into the reproductive biology of plants growing in BBG is important to an understanding of how best to conserve them. This research attempts to answer such questions as why certain species in the Gardens fail to flower, or flower but are unfruitful or produce only few fruit. This research includes observation of the type and number of pollinators, the pattern of blooming, the type and structure of the flowers, the development and maturation of fruit, and aspects of seed germination (Okada 1990, Handayani 2016, Handayani 2017). The research draws upon various scientific disciplines including taxonomy, physiology, phenology, morphology, ecology and plant propagation technology (Kessler 1988; Nurmawati 2003). BBG conducts research on flowering and fruiting time of Annonaceae species as a part of this reproductive biology research program. Particular species of Annonaceae growing in the Gardens are carefully studied as to their time of flowering and fruiting, their flowering types, flowering patterns, fruiting patterns, peak flowering times and fruiting seasons, and insect visitors to their reproductive parts. The results are utilized for various practical purposes, such as breeding of Annonaceae, planning exploration trips, collecting Annonaceae seed in the wild, ensuring presence of pollinators and adequate pollination, conserving and utilizing the potential of Annonaceae species.

Ethnobotany research

The development and utilization of a plant species is part of conservation action (Hidayat et al. 2011; Zegeye 2017). Botanical gardens explore the potential and utilization of collected species through various sources of information about them, such as local people in their native localities, user communities, exhibitions, and reviews of published literature. Apart from the botanical gardens themselves, the results of such research are also utilized by other institutions involved in the plant sciences. For example, information obtained about plants identified as potential sources of food can be communicated to other institutions with a particular expertise in the plant food industry. Plants with potential medicinal uses are of interest to those institutions with a focus on pharmacology and developing plant based medicines.The success of these

endeavours depends upon knowledge drawn from various disciplines such as taxonomy, propagation, biochemistry, and ethnobotany. Taxonomy is useful for accurate identification of particular plants in the Annonaceae worthy to be developed and utilized further. Annonaceae plants are also studied for their use through ethnobotany (Hidayat and Astuti 2009; Handayani 2013; Handayani 2014). Ethnobotanical data is obtained from various sources, such as from local people and from surveys of past written records.

Potential use of Annonaceae collections

Species of the Annonaceae represent a biological resource available to fulfill human needs. Many species in the Annonaceae have been long known for their usefulness in meeting such needs and many potential new uses are being uncovered by ongoing research (Qayed et al. 2015, Liaw et al. 2016). Table 3 presents a detailed list of these identified uses for species of the Annonaceae.

Table 3. List of identified uses for species of the Annonaceae

Genera	Species	1	2	3	4	5	6	7	8	9
Alphonsea	*Alphonsea teysmannii* Boerl.	+	-	+	-	-	-	-	-	-
	Alphonsea javanica Scheff.	+	-	+	-	-	-	-	-	-
Anaxagorea	*Anaxagorea javanica* Blume	-	-	-	+	-	-	-	-	-
	Annona glabra L.	-	-	-	+	-	-	+	-	-
Annona	*Annona muricata* L.	+	-	-	+	+	-	+	+	+
	Annona montana Macfad.	+	-	-	+	-	-	+	-	-
	Annona squamosa L.	+	-	-	+	+	-	+	-	-
Anomianthus	*Anomianthus auritus* (Blume) Backer	+	-	-	-	-	+	-	-	-
Artabotrys	*Artabotrys hexapetalus* (L.f) Bhandari	-	+	-	+	-	+	-	+	-
	Artabotrys suaveolens (Blume) Blume	-	+	-	+	-	+	-	-	-
Cananga	*Cananga odorata* (Lam.) Hook.f. & Thomson	-	+	+	+	+	+	+	+	+
	Cyathocalyx martabanicus Hook.f. & Thomson	-	-	+	-	-	+	-	-	-
Cyathocalyx	*Cyathocalyx sumatranus* Scheff	-	-	+	+	-	-	-	-	+
Dasymaschalon	*Dasymaschalon blumei* Finet & Gagnep	-	-	-	+	-	+	-	-	-
Desmos	*Desmos chinensis* Lour	-	-	-	+	-	+	-	-	-
Enicosanthum	*Enicosanthum paradoxum* Becc	-	-	+	+	-	-	-	-	-
	Goniothalamus macrophyllus (Blume) Hook.f. & Thomson	-	-	-	+	-	+	-	-	-
Goniothalamus	*Goniothalamus malayanus* Hook.f. & Thomson	-	-	-	+	-	+	-	-	-
Meiogyne	*Meiogyne virgata* (Blume) Miq	-	-	+	+	-	-	-	-	-
Melodorum	*Melodorum aberans* Maingay ex Hook.f. & Thomson	-	-	-	+	-	-	-	-	+
	Melodorum fruticosum Lour	-	-	-	+	+	+	-	-	-
Mezzettia	*Mezzettia parviflora* Becc	-	-	+	+	-	-	-	-	-
	Mitrephora celebica Scheff	-	-	+	+	-	+	-	-	-
Mitrephora	*Mitrephora teysmannii* Scheff	-	-	+	+	-	-	-	-	-
	Monodora angolensis Welw	-	+	-	+	+	+	-	-	-
Monodora	*Monodora myristica* (Gaertn.) Dunal	-	+	+	+	+	+	+	-	-
	Monodora tenuifolia Benth	-	+	-	+	+	+	+	-	-
Neo-uvaria	*Neo-uvaria acuminatissima* (Miq.) Airy Shaw	-	-	+	+	-	-	-	-	-
Orophea	*Orophea hexandra* Blume	-	-	-	+	-	-	-	-	-
	Polyalthia celebica Miq	-	-	+	+	-	-	-	-	-
	Polyalthia glauca (Hassk.) Boerl	-	-	+	-	-	-	-	-	-
Polyalthia	*Polyalthia lateriflora* (Blume) Kurz	-	-	+	+		+	-		-
	Polyalthia rumphii (Blume ex Hensch) Merr	-	-	+	+	-	+	-	-	-
Platymitra	*Platymitra macrocarpa* Boerl	-	-	+	-	-	-	-	-	+
Popowia	*Popowia bancana* Scheff.	-	-	+	+	-	+	-	-	-
	Popowia pisocarpa (Blume) Endl. ex Walp.	-	-	+	+	-	-	-	-	-
Saccopetalum	*Saccopetalum horsfieldii* Bennett	-	-	+	+	-	+	-	-	-
Stelechocarpus	*Stelechocarpus burahol* (Blume) Hook.f. & Thomson	+	+	+	+	-	+	-	-	-
Uvaria	*Uvaria rufa* Blume	-	-	-	+	-	-	-	-	-
Xylopia	*Xylopia aethiopica* (Dunal) A.Rich.	-	-	+	+	-	-	-	-	-

Note: 1. Fruit, 2. Cosmetic and perfume, 3. Timber, 4. Traditional medicine, 5. Food/beverage industry, 6. Ornamental plants, 7. Insecticide, 8. Ceremonies, 9. Environment control. Source: Sosef et al. (1998), Leboeuf et al. (1982), Wang et al. (2002), Blessing et al. (2010), Bele et al. (2011), Purwantiningsih et al. (2011), Akpabio and Akpapan (2012), Cheng et al. (2012), Wang et al. (2012), Eze-Steven et al. (2013), Rosandy et al. (2013), Uyoh et al. (2013), Biba et al. (2014), Enabulele et al. (2014), Tatdao et al. (2014), Handayani (2016), Handayani (2017), Wakhidah et al. (2017)

Food

There are eight Annonaceae species in BBG that have potential to be used for their edible fruits, either fresh or processed. *Annona muricata* (soursop) and *A. squamosa* (sweetsop) have potential as fresh fruit producers. They are two of the best known Annonaceous fruits in Indonesia. Both species have been planted on a large scale in fruit plantations. Soursop is also used in the food and beverage industry. Its fruit are juiced for fresh drinks and packaged beverages. Soursop and sweetsop are also included in various snacks, such as dodol, jam, jelly, and candy.The fruits of *A. muricata* are extensively used to prepare syrups, candies, beverages, ice creams and shakes (Moghadamtousi et al. 2015). Other species that produce fruits but are rarely eaten because their taste is less palatable are *Annona glabra* and *A. montana*. The pulp of the fruit of *Alphonsea teysmannii*, *A. javanica,* and *Melodorum fruticosum* is sweet and edible but not commonly consumed. These edible fruits have high potential to be developed as popular local fruits, thus requiring research for their development and domestication.

Cosmetics and perfumes

A total of seven species are important as raw materials used for cosmetics and perfumes.*Cananga odorata* flowers (also leaves and fruits) yield an important essential oil ylang-ylang (contain 1-2% volatile oil) widely used in the manufacture of numerous beauty products such as perfumes, soap, shampoos and hair oils (Brokl et al. 2013). Macassar oil is the main product using coconut oil scented with ylang-ylang oil. This product has been marketed in limited quantity. In Borneo and Java, *Cananga odorata* flowers are worn in women's hair to impart an agreeable scent. An essential oil is extracted from the flowers of *Artabotrys hexapetalus* used in perfumes (Shiva et al. 2015). Kept for their fragrant flowers, the fragrance lasts for several days after cutting the flowers. When soaked in water, the flowers are able to scent entire rooms. Another popular species used for an oral deodorant and body-odor remover is kepel fuit or *Stelechocarpus burahol* (Darusman et al. 2012). According to Tisnadjaja (2006), kepel or burahol fruit has traditionally been used as a perfume material, especially in palaces; consuming the fruit can convey its scent to sweat, breath and even urine.The genus *Monodora* produces fragrant flowers. In addition, the flesh of its fruit yields essential oils used for perfumes, soaps, and detergents (Eze-Steven et al. 2013),

Timber

Wood is another product that can be obtained from species of Annonaceae. There are 22 species belonging to 15 genera that have potential use for timber. The wood has potential uses in construction, house-building, ship and boat building, furniture, household utensils, agricultural implements, tool-handles, packing cases, sporting goods, plywood, match boxes, firewood, splints and boxes. Table 4 shows the genera with members that are commonly used as a source of wood (Sosef et al. 1998; Nurfadilah et al. 2017).

Table 4. List of genera of Annonaceae with uses for their timber or wood-products (Sosef et al. 1998; Nurfadilah et al. 2017)

Genus	Wood uses
Alphonsea	Construction, ship and boat building, furniture, household utensils, agricultural implements, tool-handles, packing cases, matches, matchboxes, and firewood.
Cananga	Construction, furniture, tool-handles, wooden shoes, boxes, net floats, making drum, making canoes.
Cyathocalyx	Construction, house building, agricultural implements, tool-handles, toys, matchboxes, splints, and firewood.
Meiogyne	Construction, household utensils, furniture, boxes, plywood, and firewood
Mezzettia	Construction, interior finish, packing cases, planking, matchboxes, splints, plywood, and firewood.
Mitrephora	Interior joinery, poles, tool-handles, matches boxes, splints, packing cases, and firewood.
Polyalthia	Construction, house building, furniture, light faming, decorative wall paneling, oars, wooden shoes, tool-handles, sporting goods, splints, packing cases, boxes, plywood, and firewood.
Platymitra	Construction, ship and boat building, furniture, sporting goods, agricultural implements, tool-handles, packing cases, matchboxes, splint, and firewood.
Xylopia	Construction, interior joinery, packing boxes, tool-handles, splints, firewood, matchboxes, and furniture

Ornamental plants

The utilization of Annonaceae as ornamental plants is well recognized. Ornamental Annonaceae are grouped into potted plants, landscape plants, hedge plants, and roadside trees. *Cananga odorata* and *Artabotrys hexapetalus* are commonly used as potted plants due to their beautiful, fragrant flowers. Some members of Annonaceae have potential for landscaping, such as *Cananga odorata, Monodora tenuifolia, Artabotrys hexapetalus, Goniothalamus macrophyllus* and *Dasymaschalon blumei*. *Melodorum fruticosum* has potential as a hedge plant. Furthermore, *Alphonsea teysmannii, Cananga odorata, Monodora myristica, Polyalthia lateriflora, Mitrephora polypyrena,* and *Cyathocalyx martabanicus* can be planted as roadside trees. The diverse shapes and colors of flowers of Annonaceae plant species contribute to their appeal. The flowers of many species have bright and showy petals.

Traditional medicines

Annonaceous plants have been known as sources of traditional medicines since ancient times. However, phytochemical and pharmacological research has evolved since the discovery of the first acetogenin, uvaricin, in 1982 (Liaw et al. 2016). Many studies have reported the presence of chemical compounds in Annonaceae plants that are useful for medicine (Alali et al. 1999, Wang et al. 2002; Moghadamtousi et al. 2015). Plants of this family have

recognized sources of alkaloids, diterpenes, flavonoids, and polyketide compounds. Among them, acetogenins are regarded as characteristic secondary metabolites of this family (Liaw et al. 2016). The Annonaceae acetogenins are now one of the most rapidly growing classes of new natural products and offer exciting prospects as anti-cancer, anti-convulsant, anti-arthritic, anti-parasitic, anti-malarial, hepatoprotective, and anti-diabetic agents (Cochrane et al. 2008; Moghadamtousi et al. 2015). Alali et al. (1999) list various identified compounds in the Annonaceae as being potentially anthelmintic, *in vivo* cytotoxic anti-tumorous, anti-microbial, and anti-protozoal. They recommend research for new chemotypes as anti-tumor and pesticidal agents (Alali et al. 1999).

Based on the listing in Table 3, a total of 40 species belongs to 21 genera have been studied and found to contain chemical compounds useful for medicine.Various plants in the family have been used to treat diseases such as cancer, dysentery, fever, diarrhea, mothers' post-natal conditions, itching, ulcer, stomach-ache, worms, convulsions and constipation (Wang et al. 2002; Blessing et al. 2010; Purwantiningsih et al. 2011; Wang et al. 2012; Rosandy et al. 2013; Biba et al. 2014; Enabulele et al. 2014). The plant part most used for traditional medicine is the root, followed by the leaves (Figure 4). Leaf utilization for traditional medicine is common in rural communities. According to Nahdi et al. (2016), leaves of *Annona muricata* (soursop) and *Stelechocarpus burahol* are used by the Turgo, Yogyakarta community for high blood pressure and in treating gout. The roots, bark, fruit, and leaves of *Annona muricata* are commonly used to treat malaria, fevers, liver ailments and headaches among peoples of India, Madagascar, Indonesia, Costa Rica, Barbados and a few countries in Africa and South America (Frausin et al. 2014). Moghadamtousi et al. (2015) reported that *Annona muricata, A. squamosa* and *A. reticulata* are extensively used as traditional medicines against an array of human ailments and diseases, especially cancer and parasitic infections.

Pesticides

There are eight species identified as sources of insecticidal compounds. Isman and Seffrin (2014) reported that seed extracts of *Annona squamosa* and *A. muricata* can be used against the diamond-back moth (*Plutella xylostella*) and the cabbage looper (*Trichoplusia ni*). Seed extracts of *A. squamosa* also inhibit larval growth of *Spodoptera litura.* Furthermore, leaves of *Annona glabra* placed in hen nests kill lice on the fowl (Isman and Seffrin 2014). Blessing et al. (2010) stated that infusion of the leaves is used for treatment of lice, and also for corn pests (*Spodoptera frugiperda*) in Argentina. Another material for killing larval and pupal of *Spodoptera frugiperda* is a seed extract of *A. montana* (Isman and Seffrin 2014). Cheng et al. (2012) reported that the essential oil of *Cananga odorata* leaves is used against maize weevils (*Sitophilus zeamais*). Abdullahi et al. (2010) reported that African nutmeg (*Monodora myristica*) is effective in controlling *Dermestid maculates* infesting dried fish. Seed powders of *M. myristica* have insecticidal activity against the cowpea

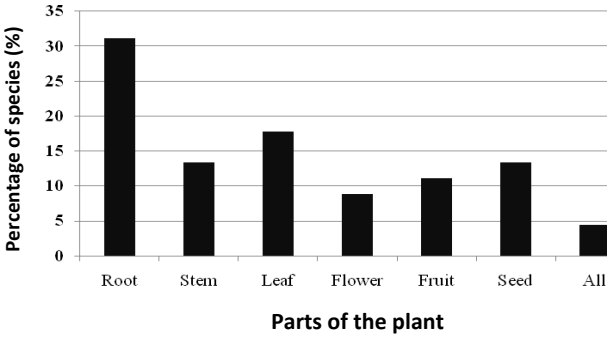

Figure 4. Parts of the plants of Annonaceae used in traditional medicines

brucid (*Callosobruchus maculates*). Moreover, *Monodora tenuifolia* was reported as toxic to the insects, *Ootheca mutabilis* or cowpea flea beetle (Abdullahi et al. 2010). Based on the research by Suleiman et al. (2014), the essential oil from the leaves of *Artabotrys hexapetalus* has strong activity against female *Anopheles gambiae* mosquitoes. The repellency activity of essential oil from leaves was higher than from stem bark.

Ceremonies

Utilization of plants in traditional ceremonies still continues today. There are two species of Annonaceae commonly used for traditional ceremonies as well as religious ceremonies, C*ananga odorata*, and *Annona muricata.* According to Wakhidah et al. (2017), these plants are generally used in ceremonies to welcome the birth of a baby in Nganjuk Regency, in East Java, Indonesia.They are also used in the "Kesada" ceremony held by Tengger villages in East Java (Pramita et al. 2013; Wakhidah et al. 2017) and the "Oke Sou" ceremony in West Halmahera, Indonesia (Wakhidah et al. 2017). The "Oke Sou" ceremony is held to give recognition to girls of the community when they reach the age of puberty. *Cananga odorata* is also commonly used in the "Sura" month welcoming ceremony by communities in the Nganjuk Regency of East Java (Ayuningtyas and Hakim 2014; Wakhidah et al. 2017). It is also used in the "Sekaten" ceremony in Central Java (Ayuningtyas and Hakim 2014) and the "Balimau" traditional ceremony in Pariaman, West Sumatra (Hulyati et al. 2014).

Habitat for other organisms

Some species of Annonaceae are used as habitats by other organisms (direct observation): examples include *Cananga odorata*, *Goniothalamus ridleyi*, *Melodorum fruticosum*, *Polyalthia lateriflora*, *P. rumphii* and *Monodora angolensis.* Colonies of weaver ants (*Oecophylla smaragdina*) are commonly found in *Cananga odorata, Melodorum fruticosum, Polyalthia lateriflora*, *P. rumphii and Monodora angolensis*. They complete their life-cycles on these Annonaceae species. They make a nest by weaving the leaves of the plant. They eat insects that visit the plant. They breed by laying their eggs in the nest.

Another plant used for habitat is *Gonioithalamus ridleyi*. It is a habitat of red ants. The plant and ants are in symbiosis. The plant provides an environment and food for ants. Ants keep the plants free from pest attacks. Another example, *Cananga odorata,* forms a habitat for various flora and fauna. This tree provides a growing platform and medium for flora such as pigeon orchids, nest-bird ferns, ant plants, dragon-scale ferns, parasitic plants, and *Hoya* spp.

Contributions to environmental health

Plants of the Annonaceae, as components of the BBG environment, fulfill ecological functions, climatological functions, and hydrological functions. These functions contribute to the health of the environment both within and beyond the BBG precinct. Examples of the ecological functions to which they contribute are in regulating temperature, humidity, and water reserves in Bogor. BBG is often called the "lungs of Bogor City". All plants in BBG absorb carbon dioxide and release oxygen into the air. The ability of plants to generate oxygen and to transpire water from their leaves is an example of their climatological role. The density of the human population and vehicle traffic in Bogor affects the quality of the urban environment of Bogor city.Various human activities release carbon dioxide into the atmosphere in ever-increasing amounts. Plant life, on the other hand, including BBG's significant Annonaceae collection, absorbs carbon dioxide. Although almost all plant species function as “carbon sinks”, large growing trees like C*ananga odorata, Annona squamosa* and *A. muricata* are considered particularly effective carbon sinks (Usmadi, pers. comm.). BBG also serves a hydrological function, to which the Annonaceae contribute, by intercepting rainfall and facilitating its infiltration into the soil.□

Why is conservation of Annonaceae important?

The occurrence of large-scale natural habitat destruction is a key reason why active steps are required to preserve plant diversity. The conversion of natural habitat into land for housing, industry, agriculture, and plantations endangers the continuing existence of some plant species, including particular members of the Annonaceae (Yusuf et al. 2005; Komara et al. 2016).The rate of forest destruction as natural habitat, world-wide, has been so rapid in recent decades that preservation efforts have scarcely been adequate to reduce the rate of species loss (Yusuf et al. 2005, Komara et al. 2016, Zegeye 2017). Although *in situ* conservation is already an important part of conservation strategies in Indonesia, this is not specifically aimed at preserving the Annonaceae. According to Komara et al. (2016), the production forest of East Kutai, East Kalimantan province is used as a mining area. In this area, the species *Neo-uvaria acuminatissima, Polyalthia obliqua, Polyalthia sumatrana* and *Sageraea glabra* have been eliminated. Another example of threatened Annonaceae sustainability in nature is apparent in West Sumatra. The natural forest of Rimbo Panti in West Sumatra has long been a habitat for *Cyathocalyx sumatranus, Meiogyne virgata, Mitrephora sp, Polyalthia obliqua, P. reticulata* and *P.spathulata* (Yusuf et al. 2005). They are important sources of timber. The presence of illegal logging and land clearing for crop cultivation has threatened the sustainability of the species (Yusuf et al 2005). Therefore, ex situ conservation must be carried out to avoid extinction of endangered species of Annonaceae.

Conserving representative species of Annonaceae in BBG means that they will be preserved as potential sources of fruit, medicine, ornamentals, insecticides and timber that might benefit humans. It preserves genetic variation in populations and food webs, and for ecosystem services. Plants with recognized high economic value for production of fruit, medicines, ornamentals, insecticides or timber tend to be widely developed, but those with low economic value or unrecognized value will not be cultivated and will be more likely to be cut down. *Annona muricata* and *A. squamosa* are fruit-producing plants well known to the public. These species are widely grown both individually and in plantation. However, other species, such as *Annona glabra, A. montana, Alphonsea teysmanii, A. javanica*, and *Stelechocarpus burahol*, have fruits with low economic value and are rarely planted or are even cut down by the community (Tisnadjaja et al. 2006). The use of Annonaceae plants for traditional medicine is widespread. As a result, some people still take plants or their parts directly from the forest. If this exploitation continues, it can decrease the plant population leading to their extinction. The harvest of root and bark for medicine can lead to eventual death of the plants. Another threat is the logging of Annonaceae plants as a source of wood.

Annonaceae plants are also a source of germplasm for ornamental plants. Pressure on forests, exploitation of potential ornamental plants, and trade in ornamental plants of high value or even of low economic value have threatened their populations in forests (Nagel 2011). Therefore, specimens of potential ornamental plants need to be preserved in safe locations outside their natural habitat. If such a species is planted in BBG, and later on the species is lost from its natural habitat, then it is often possible to return preserved specimens to the place where the plant originated. Some Annonaceae plants are important sources of insecticidal compounds. Research on the chemical the composition of such potential insecticidal plant species should be developed in order to reduce dependence on chemical insecticides. Annonaceae species with potential as sources of biological insecticides should be preserved *ex-situ* in locations like BBG.

Annonaceae plants need to be preserved as important components of the BBG ecosystem, in its role as the "lungs of Bogor city" benefiting human health and stabilizing the microclimate of the local environment. Annonaceae plants provide feed and shelter for local fauna such as birds, squirrels, bats, pollinators, and beneficial insects. Annonaceae trees also provide habitat for other flora, such as ferns, orchids, lichens and other epiphytes. The loss of Annonaceae would harm the survival of some of these dependent species. Observation in BBG, when the Annonaceae plants die, plants that stick will also die. Conservation of Annonaceae in BBG is also for historical reasons. Some Annonaceae specimens are old plants well

over 100 years of age. Based on the author's observations, many of these old species in the collection have long played an important role in the forest ecosystem of BBG; examples include *Alphonsea teysmannii, Cyathocalyx martabanicus, Mezzettia parviflora, Platymitra macrocarpa* and *Stelechocarpus burahol.* They are big trees with significant ground coverage, providing habitat both underground and in their crowns for other living things. *Platymitra macrocarpa* planted in 1844 is the oldest living Annonaceae tree in the Gardens. This plant is a living type specimen, so it has great taxonomic significance. According to Kessler (1988), this species is distributed very locally and seems to be rare.Old trees have high conservation value, especially if the species to which they belong no longer survive in nature or are difficult to find.

Some members of Annonaceae also have historical value as flora of provincial identity in Indonesia.*Cananga odorata* is the floral emblem of North Sumatra Province, while *Stelechocarpus burahol* is the floral emblem of Yogyakarta Province. *Melodorum fruticosum* is the national flower of Cambodia. It is also the provincial flower of Sisaket Province, in Thailand.

How does Bogor Botanic Gardens conserve plants of the Annonaceae family?

Exploration, cultivation, research, utilization, and dissemination of information are all part of BBG's program of plant conservation. The plant collection in the Gardens comes from forest directly, from donations, and from seed exchange with other institutions. BBG carries out exploration throughout the archipelago to collect plants from the forest, especially of rare, endangered and potentially useful plant species. They collect seedlings, cuttings, fruit or seed. Selected materials are then recorded: collector codes, date of collection, species name, genus name, family name, geographic coordinates and altitude of location, habitat environment details, type and quantity of materials taken, are all recorded. Data obtained from the exploration site are submitted to the Nursery and Registration section of BBG. Plants collected from natural field sites are first acclimatized and adapted in a nursery. After a plant reaches a height of 50-100 cm it is planted out in the Gardens. The plant is given a name plate made of zinc. Each plant is given a name plate which bears the name of the species, family, plant origin and planting location. If the name of the species is unknown, it is just labelled with name of the family and genus.

For healthy growth of a collection, it is necessary to carry out intensive maintenance by applying appropriate cultivation technology.This involves preparing a suitable area of ground and planting hole, selecting a healthy seedling, watering, weeding, fertilizing, pruning, and controlling pests and diseases. A planting hole is dug 2-3 weeks before planting. In the hole is placed a mixed planting medium of soil, husk, compost, and manure. Selected plantlets must be lush, healthy, and strong at the time of planting and have no signs of pests or diseases.Watering plants are carried out twice a day in the dry season, while in the rainy season it is done only as needed. Weeding is carried out to remove competitive weeds around the plant, as well as to loosen the soil around the plants. This can stimulate better root growth. Fertilization is done at the beginning of planting and/or during the plant's growth period. Fertilizer used is compost, manure or inorganic fertilizer. Pruning is usually carried out on branches that are too dense. Plants with canopies that are too thick can disrupt the surrounding plants. Pruning aims to facilitate sunlight reaching the soil surface, to avoid fungal attack, and to prevent trees falling over trees during strong winds. The eradication of pests and diseases is carried out on affected plants, by spraying both biological and chemical pesticides.

Because of its function as a center of acclimatization, plant display, conservation, and research (physiology, morphology, taxonomy, germination, etc.), BBG also carries out propagation of plants held in its collection. Propagation by vegetative or generative means is carried out either conventionally or by tissue culture, especially for rare plants, endemic plants, critical plants (i.e., plants for which there is only one collection) and some ornamental plants. The results of these propagation efforts are used to replace dead plants, to plant displays, for landscaping, to provide research materials, for use in community service, and for environmental education. □

In summary, the present study has summarised the diversity of the family Annonaceae growing in the BBG in terms of plant species; plants origins; habit; age of plants growing in the Gardens; growth sites; their reproductive traits; their young leaf color; and flower color. Species of Annonaceae have been listed that have potential uses for providing fresh fruit; cosmetics and perfumes; timber; traditional medicines; processed foods and beverages; ornamental plants; insecticides; habitat for other dependent organisms; and for benefits to the local environment. Destruction to Annonaceae native habitats means that ex situ conservation of Annonaceae is an important part of the BBG mandate. Many species of Annonaceae in BBG are of high historical value. To support ex situ conservation, BBG researches the anatomy, phenology, reproductive biology, morphology, taxonomy, propagation technology and ethnobotany of Annonaceae. In support of its conservation program, BBG carries out exploration, cultivation, research, utilization, and dissemination of information. □

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