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Ornamental Plant's Potentials of Indonesian Native Rubiaceae Collected in Cibodas Botanical Garden

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ABSTRACT

Cibodas Botanical Garden (CBG) is an ex-situ plant conservation institution, maintaining living collection from various taxa including Rubiaceae. Most of Rubiaceae ornamental plants are introduced species with regard to their attractive characters. However, introduced species of ornamental plants is one of significant global plant invasion pathways. The aims of this research was to conduct inventory study of CBG's Rubiaceae collection, to determine native and introduced species, and to bring out CBG's native Rubiaceae potential as ornamental plants. The research was divided into two methods, field study and literature study. Field study was conducted by making inventory of Rubiaceae living collections and plant morphology observations. Literature study was conducted by obtaining data of plant distributions, utilization as ornamental plants, and also comparing domesticated species with CBG's living collections. Results showed that CBG has collected 20 genera, 50 species and 116 specimens of Rubiaceae as living collections. There are 22 native species, 15 introduced species and 13 species that can not be determined. There are 5 species commonly utilized and cultivated as ornamental plants, 8 species are not known for their aesthetic characters but has potential as ornamental plants. These species are Gardenia pterocalyx Valeton, Hypobathrum frutescens Blume, H. racemosum (Roxb.) Kurz, Mycetia cauliflora Reinw., Pavetta montana Reinw. Ex Blume, Psychotria angulata Korth, P. montana Blume, and Wendlandia densiflora (Blume) DC. This study demonstrated that there is a promising potential from these lesser-known native Rubiaceae species for ornamental use. CBG should conduct more research about native species's potential as ornamental plants.

Keywords:
Native ornamental plants; Tropical ornamental; Native Rubiaceae

1. Introduction

Botanical garden is an institution that collected plant species for scientific research, conservation, display and education (Hulme 2011). Scientists in botanical gardens recast their experience in horticulture, curation, species-based research, and education

(Mounce et al. 2017). Plants in botanical gardens are utilized for education, scientific purposes and displays. Botanical gardens have taken greater responsibility to educate people about global environmental change and conservation issues (Ballantyne et al. 2008; Mounce et al. 2017). The main principle for plant conservation implementation in botanical gardens is save it, study it, and use it sustainably. One example of sustainable use of botanical garden plant collection is the development of garden collections for ornamental plant use (Chen & Sun 2018).

Ornamental plants are those plants that attract attention and carried interest by their aesthetic characteristics such as whole plant colors and forms, flowers shape and colors, phenological aspect, projected shadow, swing by the wind and the visual structure form (Silva 2009). In general, plants considered as ornamental plants are based on their aesthetic value without considering their origin. This is due to plant invasion risks that could be carried by exotic ornamental plants and may expose potential threat to local biodiversity (Baiyewu et al. 2005; Conser et al. 2015; Hulme et al. 2008). Ornamental plants play major role as plant invasion pathways (Chowdhuri & Deka 2019; Wilgen et al. 1996). Therefore, native species should be chosen as ornamental plants. There are four benefits of native plants: environmental and productivity benefits, aesthetic values, educational and recreational benefits, and economic advantages (Alam et al. 2017; Salisbury et al. 2017). Therefore, native ornamental plants are the most appropriate to be cultivated and planted in both rural and urban ecosystems (Idilfitri et al. 2014).

Rubiaceae is one of the largest plant families with over 620 genera and 13,000 species. Rubiaceae's natural distribution are globally wide with tropical and sub-tropical region as the center of the distribution (Bremer & Eriksson 2009). Rubiaceae has been cultivated throughout the world and mostly for non-food utilization (Hammer & Khoshbakht 2015). Several commonly cultivated genera such as Gardenia, Ixora, Mussaenda, and Serissa were used as ornamental plants for their beautiful flowers, fruits, leaves, also branch architectures (Hall & Dickson 2011). Botanical gardens could develop ornamental plants from potential native plant bioresources such as Rubiaceae to minimize the extensive use of exotic plant species and to avoid plant invasion risks from imported exotic ornamental plants.

Ornamental plants have a long history as invasive pathways. There is an idea that most authentic nature is the furthest from human interference (Wilson et al. 2016). As a conservation institution, CBG has the urge to promote native species with economic values. These species should not only easy to domesticate, but should also have conservation values and resistance to local pests (Hoyle et al. 2020). As one can expect in the future, native species are common ornamental plants both in numbers of species and abundance of individuals. Therefore, the aims of this research were to conduct inventory study of Rubiaceae of CBG's collection, to distinguish native from introduced Rubiaceae species of CBG's collection, and to examine which species of CBG native Rubiaceae are potential as ornamental plants based on morphological generative and vegetative parameters.

2. Materials and Methods

Research site

The research was carried out in Cibodas Botanical Garden, Cipanas, West Java, Indonesia. CBG was established by Johannes Elias Teijsmann on 11 April 1852, with its

first name Bergtuin te Tjibodas. CBG is located on the mountain slope of Mount Gede and Mount Pangrango, approximately at 1100-1425 m above sea level. It has an area of 84.89 ha with average air humidity around 74%, average air temperature 22.61% (Junaedi, et al. 2019). Built for acclimatization facility for new introduced species from overseas, CBG expanded its task to ex-situ conservation, research, environmental education, ecotourism, and environmental services.

CBG first Rubiaceae collection was *Cinchona calisaya* L., which was was collected for the purpose of medicinal plants. CBG then collected more Rubiaceae from different genus. We examined CBG's catalogues since 1930 until 2019. Based on the 1930 catalogue, we found that CBG has collected several native Rubiaceae. They are *Argostemma montanum*, *Ophiorrhiza longiflora*, and *Ophiorrhiza neglecta*.

Data collections

Data were collected from April to June 2019, through field study and literature study approaches. Data of CBG's Rubiaceae collections were obtained from SINDATA (KRC 2019) and from CBG's catalogues. A list of ornamental CBG's Rubiaceae collections were compiled from various literature studies. Field study was carried out for two purposes. First, to validate Rubiaceae collections existences in the garden based on SINDATA and CBG catalogue. Second, to conduct plant morphology observations to characterize the ornamental potential of the observed Rubiaceae species based on its morphological characters (Silva 2009), such as flowers shape, scent, and colors, leaves shape, leaves color, and visual structures. CBG's Rubiaceae species that were absent in the ornamental CBG's Rubiaceae species list are then assessed for their ornamental plant potential.

3. Results and Discussion

We validated the existence of 22 genera and 57 species of CBG's Rubiaceae collections in the garden (as stated in the CBG catalogue) through exploratory walks. We found and validated 20 genera and 50 species of CBG's Rubiaceae collection exist in the garden (Table 1). The missing Rubiaceae specimens (two genera and seven species) in the garden were considered as died collections.

Table 1. The living collections of Rubiaceae in CBG

No.	Genus	Species	Presence
1	*Aidia*	*Aidia cochinchinensis* Lour.	+
2		*Aidia racemosa* (Cav.) Tirveng.	+
3		*Aidia* sp.	+
4	*Catunaregam*	*Catunaregam spinosa* (Thunb.) Tirveng.	+
5	*Cinchona*	*Cinchona calisaya*	-
6		*Cinchona pubescens* Vahl	+
7		*Cinchona* sp.	+
8	*Coffea*	*Coffea canephor*a Pierre ex A.Froehner	+
9		*Coffea* sp.	+
10	*Gardenia*	*Gardenia jasminoides* J.Ellis	+
11		*Gardenia lamingtonii* F.M.Bailey	+
12		*Gardenia pterocalyx* Valeton	+
13		*Gardenia scandens*	-
14		*Gardenia sootepensis* Hutch.	+
15		*Gardenia* sp.	+
16		*Gardenia thunbergia* Thunb.	+

17	*Hamelia*	*Hamelia patens* Jacq.	+
18	*Hypobathrum*	*Hypobathrum frutescens* Blume	+
19		*Hypobathrum racemosum* (Roxb.) Kurz	+
20		*Hypobathrum* sp.	+
21	*Ixora*	*Ixora grandifolia* Zoll. & Moritzi	+
22		*Ixora javanica* (Blume) DC.	+
23		*Ixora lanceolata* Lam.	+
24		*Ixora parviflora*	-
25		*Ixora* sp.	+
26	*Lasianthus*	*Lasianthus capitatus*	-
27		*Lasianthus inodorus*	-
28	*Mussaenda*	*Mussaenda frondosa* L.	+
29	*Mycetia*	*Mycetia cauliflora* Reinw.	+
30	*Neonauclea*	*Neonauclea cyrtopoda* (Miq.) Merr.	+
31		*Neonauclea excelsa* (Blume) Merr.	+
32		*Neonauclea excelsioides* Ridsdale	+
33		*Neonauclea lanceolata* (Blume) Merr.	+
34		*Neonauclea* sp.	+
35		*Neonauclea superba* (S.Moore) S.Moore	+
36		*Neonauclea ventricosa* Ridsdale	+
37	*Ochreinauclea*	*Ochreinauclea maingayi* (Hook.f.) Ridsdale	+
38	*Pavetta*	*Pavetta indica* L.	-
39		*Pavetta montana* Reinw. ex Blume	+
40		*Pavetta* sp.	+
41	*Psychotria*	*Psychotria angulata* Korth.	+
42		*Psychotria asiatica* L.	+
43		*Psychotria micrantha* Kunth	+
44		*Psychotria montana* Blume	+
45		*Psychotria nervosa* Sw.	+
46		*Psychotria punctata* Vatke	+
47		*Psychotria* sp.	+
48	*Randia*	*Randia* sp.	+
49	*Rondeletia*	*Rondeletia odorata*	-
50	*Rothmannia*	*Rothmannia longiflora* Salisb.	+
51	*Serissa*	*Serissa japonica* (Thunb.) Thunb.	+
52	*Uncaria*	*Uncaria* sp.	+
53	*Urophyllum*	*Urophyllum* sp.	+
54	*Wendlandia*	*Wendlandia densiflora* (Blume) DC.	+
55		*Wendlandia glabrata* DC.	+
56		*Wendlandia* sp.	+
57		*Wendlandia uvariifolia* Hance	+

\+ : Presence
\- : Absence

Currently CBG maintains 20 genera, 50 species, and 116 specimens of Rubiaceae as living collections. As a comparison, Indonesia has approximately 212 species of Rubiaceae (Jansen et al. 1993), meaning that CBG has conserved 10.38% of the Indonesian Rubiaceae. These Rubiaceae collections were collected from two sources: botanical explorations performed throughout Indonesian islands (mostly from western part of Indonesia) and external gifts. Seedlings and seeds were gathered from the wild through botanical exploration. These samples (seedlings and seeds) were then grown in CBG, to be acclimatised with CBG's habitat. After these samples are fully grown and acclimatised (indication of being ready to be planted in the garden), they were then moved from nursery to garden collections. Living collections have their own ID number and all information are recorded in SINDATA.

Based on literature and field survey, there were 22 native Rubiaceae species in CBG's garden collection. From these 22 species, five species were already utilised and cultivated as ornamental plants while eight species are not utilised yet for ornamental purposes but has the potency (based on Silva (2009) criteria) (Table 2). These species are *Gardenia pterocalyx* Valeton, *Hypobathrum frutescent* Blume, and *Hypobathrum racemosum* (Roxb.) Kurz, *Mycetia cauliflora* Reinw. *Pavetta montana* Reinw. ex Blume, *Psychotria angulata* Korth., *Psychotria Montana* Blume, and *Wendlandia densiflora* (Blume) DC.

Table 2. Aesthetic characters to determine potential ornamental plants of native Rubiaceae

Species	Aesthetic characteristics				
	Flowers	Leaves	Scent	Visual structure	OP
Aidia racemosa (Cav.) Tirveng.	+				+
Catunaregam spinosa (Thunb.) Tirveng.				+	-
Gardenia pterocalyx Valeton	+		+	+	+
Hypobathrum frutescens Blume				+	+
Hypobathrum racemosum (Roxb.) Kurz				+	+
Ixora grandifolia Zoll. & Moritzi	+			+	+
Ixora javanica (Blume) DC.	+			+	+
Ixora lanceolata Lam.	+			+	+
Mussaenda frondosa L.		+			+
Mycetia cauliflora Reinw.				+	+
Neonauclea cyrtopoda (Miq.) Merr.					
Neonauclea excelsa (Blume) Merr.					
Neonauclea excelsioides Ridsdale					
Neonauclea lanceolata (Blume) Merr.					
Neonauclea superba (S.Moore) S.Moore					
Neonauclea ventricosa Ridsdale					
Ochreinauclea maingayi (Hook.f.) Ridsdale					
Pavetta montana Reinw. ex Blume	+			+	+
Psychotria angulata Korth.				+	+
Psychotria montana Blume	+				+
Wendlandia densiflora (Blume) DC.		+		+	+
Wendlandia glabrata DC.					

OP: Ornamental Potential
+: aesthetic aspect

Catunaregam spinosa (Thunb.) Tirveng. has an aesthetic visual structure (Table 2), but it has spines all over its stem (Figure 1), making it unsuitable for ornamental plant because it is potentially harmful for human. Most cultivated Rubiaceae genera that are utilized as ornamental plants are *Gardenia*, *Mussaenda*, and *Ixora*. Other genera are not known for their potentials. This is probably because no introduction nor dissemination of information regarding their beauty compared to introduced species (Lowenstein & Minor 2016; Sanyaolu *et al.* 2018). The other possible explanation is that there are no hybrid products of native species that bring out the potential such as conspicuous flowers, pathogen resistance or easy to grow hybrid (Vita et al. 2015). Given many ornamental potential are from exotic plants, gardeners are also need to be informed

about invasive species that can potentially harm our environment (Dehnen-schmutz & Conroy 2018).

These potential native ornamental of CBG's Rubiaceae species are *Gardenia pterocalyx*, *Hypobathrum racemosum, Pavetta montana*, *Psychotria angulata,* and *Wendlandia densiflora*. *Gardenia pterocalyx* is already proposed in IUCN Redlist as vulnerable due to fragmented and declining of habitats (Low & Wong 2007). This species grows in tropical swamp forest or riparian area. CBG has tried to acclimatize it and turns out that the plant grow well in the sub-montane wet climate. Its flowers have white corolla, later turning into yellow and ultimately bright orange (Figure 1a). Such conspicuous flowers making it suitable as ornamental plants. Its original life-form is shrub (Eriksson & Bremer 1991), and can grow up to 2-3 meters.

FIGURE 1. Aesthetic characters of Rubiaceae CBG collections. (a) *Gardenia pterocalyx* flower in orange color, (b) *Hypobathrum racemosum* leaves, young leaves are red that gradually turns to green, (c) *Pavetta montana* white flowers, (d) *Psychotria angulata* visual structure, (e) *Psychotria angulata* Flowers and shiny leaves, (f) *Wendlandia densiflora* inflorescence white flowers, and different colours between young and mature leaves.

Hypobathrum frutescens has symmetrical branch architecture, white inflorescence flowers with pale green corolla. This species can be found in variety of habitats. It was found naturally on slope of mountain in Sumatra, Java, and Lesser Sunda Island (Mulyaningsih & Ridsdale 2002). The *H. racemosum* also has symmetrical branch architecture, red leaves that will gradually turn to green and white flower inflorescence

making it suitable for ornamental plants (Figure 1b). It can be found in several islands of Indonesia, Sumatra, Java, Borneo/Celebes, where they grow in riparian area and also in secondary forest.

Pavetta montana has inflorescence flowers with hemispherical shape in its full bloom (Figure 1c). The flowers have white color, jasmine-like fragrant, and tubular corolla (Hawthorne 2013). It was reportedly found in Mount Gede and Mount Pangrango (Mutaqien & Zuhri 2011). This spesies is a woody shrubs, it can grow up to 3 meters. Its natural habitat is highland.

Psychotria angulata has terminal inflorescence flower. The flowers inflorescence are white in color with tubular corolla, and green calyx. Its fruits are bright yellow, very contrast with their leaves thus bring out aesthetic visual characters (Figure 1d &1e). *Psychotria angulata* is naturally found in tropical highland, it was reportedly found in Sumatra, Java, and Sumbawa (Wiriadinata *et al.* 2013). The fruits are green then turn to yellow and later red when ripe, hence its beautiful aspect is its fruits. Both Psychotria and Pavetta have the ability to fixed nitrogen in their leaves by endosymbionts with bacteria (Grobbelaar & Groenewald 1974; Lemaire et al., 2012). Plants of genus Pshycotria are commonly used as traditional medicinal plants as treatment for bronchitis, cough and stomach ache. Planting these species in home garden can give two benefits of medicinal and ornamental.

Wendlandia densiflora has white inflorescence flowers, grow densely forming beautiful sight. Its leaves also change its color gradually from red to green (Figure 1f). Its habitus is tree that can grow up to 15 m. As well as ornamental, it can be used as shade tree. On the ither hand, *Wendlandia glabrata* has white inflorescence flowers but not as dense as *W. densiflora*. Its leaves are also changing color from red to green. People in India consider it as an edible leafy vegetable (Pfoze et al. 2012). It also grows as a tree, up to 15 m. These two species can be found naturally in tropical highland.

Ornamental plants play a significant role as pathways of invasive species dispersal (Gaertner et al., 2017; Hulme et al., 2017). Most economically cultivated plants are introduced species (Mayer et a*l.* 2017; Mayett-moreno et al., 2018). Consecutively, these introduced species will altere native species grown in home gardens. CBG as plant conservation institution has the urge in proposing which native species can be used as ornamental and also conducting risk assessments of invasive potentials (Dullinger et al., 2017; Early et al., 2016; Gordon et al., 2016). More domestication research should be implemented to bring out the potentials as ornamental plants for these native plant species that were taken from their wild ecosystems and are now growing as collections in CBG. These plants' beauty aspects were not really shown and developeded. Furthermore, similar study on other families must also be taken to bring out the potentials of native ornamental plant species of Indonesia.

4. Conclusion

CBG has collected 22 genera and 57 species of Rubiaceae recorded in SINDATA and catalogues. Through garden inspection we found 20 genera and 50 species of living collection, absent species were considered died. These 50 species were then shortlisted, and it was found that there were 22 native species of Rubiaceae. From these 22 species, five species are widely known and cultivated as ornamental plants, while eight species are considered as potential ornamental plants. These species are *Gardenia pterocalyx* Valeton, *Hypobathrum frutescens* Blume, *Hypobathrum racemosum* (Roxb.) Kurz, *Mycetia*

cauliflora Reinw, *Pavetta montana* Reinw. ex Blume, *Psychotria angulata* Korth, *Psychotria montana* Blume, and *Wendlandia densiflora* (Blume) DC. This study demonstrated that there is promising potential from lesser-known native Rubiaceae species for ornamental use. CBG should conduct more research about native species potential as ornamental plants, not only the biodiversity, but also their phenology, pathogen resistance, and easy to grow hybrid to attract customers.

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