The Euphorbiaceae (Spurge Family) in Bogor Botanic Gardens, Indonesia: Diversity, conservation and utilization

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Abstract. Munawaroh E, Yuzammi, Purwanto Y. 2020. The Euphorbiaceae (Spurge Family) in Bogor Botanic Gardens, Indonesia: Diversity, conservation and utilization. Biodiversitas 21: 5021-5031. Euphorbiaceae (Spurge family) is the fourth largest family worldwide, consists of 1,354 species and 91 genera. The family is also a part of the Bogor Botanic Gardens collections. The Gardens have evolved to fulfill its mission through five principal functions: conservation, research, education, tourism, and environmental services. The aims of this study are to reveal the diversity, conservation, and its potential in the Bogor Botanic Gardens. This research was based on direct observation of all members of Euphorbiaceae family in the Gardens, as well as Registration Unit and the Garden’s catalog which were observed for more than 10 years. The Gardens collected 39 genera, 71 species, and 136 specimens where 91 specimens are trees, 38 specimens are shrubs, three specimens are climbers and four specimens are succulents. Most of the collections are native to Indonesia 75.91% (103 specimens) and only 33 specimens (24.09%) from overseas. Amongst native collections have dominated from Java 25.54% (34 specimens), Sumatra 24.08% (33 specimens). The others are from Sulawesi 9.48% (13 specimens), Kalimantan 7.29% (10 specimens), Maluku 6.56% (9 specimens), Papua 2.28% (three specimens), and Nusa Tenggara Timur 0.72% (one specimen). Many species of the family have potentially developed as traditional medicinal plants (11 species), ornamental plants (16 species), spices and vegetable (two species), timbers (14 species), rubber plants (one species), source of energy (two species) and toxic (six species). Several old collections have retained at the Gardens that aged over 75 years, such as Mallotus philippensis (Lam.) Mull. Arg. forma mollis, Acalypha wilkesiana Mull. Arg., Acalypha hispida Burm. var. sanderi (N.E.Br.) I. J. Sm., Acalypha wilkesiana Mull. Arg. forma Montana, Sapium aucuparium Jacq. and Ricinodendron heudelotii (Bail.) Heckel. A map of planting point of the Euphorbiaceae collections is provided.

Keywords: Bogor Botanic Gardens, conservation, diversity, Euphorbiaceae, potential

INTRODUCTION

Forests are important repositories of terrestrial biodiversity and play a key role in influencing socio-ecological and cultural attributes of human societies including livelihood activities of traditional societies living in these areas (Hermann 2006; Baboo et al. 2017; Karki et al. 2017). Biodiversity is essential for human survival and economic well being and for the ecosystem function and stability (Singh 2002). Globally, habitat destruction, over-exploitation, pollution, and species introduction are identified as major causes of biodiversity loss (UNEP 2001; Bargali et al. 2014, 2015; Mourya et al. 2019). The existence of a species in nature largely depends on its regeneration under varied environmental conditions like forest floor conditions; nutrient use efficiency of species and cycling as well as decomposition processes (Bargali 1994, 1995, 1996; Bargali et al. 1992, 1993; Bargali and Singh 1997). These pressures have put the species from their natural habitat to the ex-situ conserving conditions so that the species may be conserved for future generations.

Bogor Botanic Gardens is an ex-situ plant conservation area that has documented collections and its arranged based on classification, bioregion, thematic pattern, or a combination of these patterns. It was founded on May 18, 1817 by G.G. Reinwardt, a botanist from Germany (Hendrian and Witono 2011). As an ex-situ conservation of plant species is an effort to preserve, research and use plants sustainably outside their natural habitat. In more specific the Gardens task and function are to carry out ex-situ plant conservation including to conduct research, to utilize and to develop potential of its collections in sustainable manner, and also to develop ecosystem services. One of the Gardens collections which have potential for further development is the Euphorbiaceae (spurge family).

The Euphorbiaceae is one of the largest and most diverse families of flowering plants, consists of ca. 340 genera and nearly 9000 species worldwide, commonly distributed in tropical regions in the world (Wurdack et al. 2004; Fayed et al. 2019). Most of the members are herbs but some, particularly in the tropics, are trees or shrubs or succulents or even cacti-like (Rahman and Akter 2013). From an ecological point of view, the existence of Euphorbiaceae is of utmost importance for ecosystem balancing. The members of this family are mostly tolerant of various environmental conditions, notably in open and dry areas (Polosakan and Alhamb 2012). Moreover, some
of the members can be used as traditional medicine, food, ornamental plant, poison, rubber, and material for construction (Djarwamingsih 2007). However, the potential of the Euphorbiaceae collection, particularly in the Gardens, for conservation and economic purposes has not yet been fully explored. Therefore, this study aimed to reveal the diversity of the Euphorbiaceae species at the Bogor Botanic Gardens, to conserve it and to list the species with particular potential such as for medicine, ornamental, food, rubber, toxic and material for construction.

MATERIALS AND METHODS

The materials used in this study are based on the cultivated plant at the Bogor Botanic Garden, Indonesian Institute of Sciences, Indonesia. The research was conducted from 2015-2018. The method used was direct observation of all the Euphorbiaceae collections, both are planted in the field and in the nursery. The observations encompassed planting and maintenance of the Euphorbiaceae collections in the Garden and how the collections could grow well for ex-situ conservation purposes. Besides, the data were also obtained from various sources in order to support this study viz. Registration Unit of BBG (accession data, planting data, and death record data), the Garden’s catalog, and literature. Ethnobotany study was obtained from direct observation during field works and from other sources.

RESULTS AND DISCUSSION

The diversity of Euphorbiaceae at the Bogor Botanic Gardens

Recent study on molecular phylogenetic have been segregated the Euphorbiaceae sensu lato (s.l.) into five families by many taxonomists, for instance, Webster (1994), Wurdack et al. (2004), Fayed et al. (2019), based on the most advance molecular taxonomy in conjunction with the morphology. These five families split off from Euphorbiaceae s.l. are Phyllanthaceae, Putranjivaceae, Pandanaceae, Picrodendraceae, and Euphorbiaceae sensu stricto (s.s.).

Figure 1. Euphorbiaceae collections planted at the Bogor Botanic Gardens of Bogor Tengah Sub-district, Bogor City, West Java, Indonesia (red-purple tiny dots)
## Table 1. Euphorbiaceae collections at the Bogor Botanic Gardens, West Java, Indonesia

| Genera           | Species                      | Habitus | Origin | Planting year | No. of spec. | Bed numbers |
|------------------|------------------------------|---------|--------|---------------|--------------|-------------|
| Acalypha         | hispida Burm.F               | S       | India  | 1993          | 1            | XVI.I.G.32  |
|                  | hispida Burm.F var. sanderi (N.E.Br.) J.J Smith | S       | India  | 1924          | 2            | XVI.I.I.11a |
|                  | wilkesiana Müll Arg.         | S       | W. Java| 1924          | 1            | XIX.I.D.16  |
|                  | wilkesiana Müll Arg.         | S       | Maluku | 1924          | 2            | XIV.G.11-11a|
|                  | wilkesiana Müll Arg.         | S       | Australia | 1924       | 1            | XVI.I.G.5   |
|                  | wilkesiana Müll Arg. forma illustris | S       | W. Java| 1924          | 1            | XXIV.A.XII.20|
|                  | wilkesiana Müll Arg. forma montana | S       | W. Java| 1924          | 1            | XXI.A.VI.15 |
| Alchornea        | rugosa (Lour.) Müll Arg.     | S       | W. Java| 2013          | 1            | VIII.F.113  |
| Aleurites        | moluccanus (L.) Willd.       | T       | NTT    | 1995          | 1            | IX.A.92a    |
| Balakata         | baccata (Roxb.) Esser        | S       | Sumatra: | 2005         | 1            | IX.E.91     |
|                  |                              |         | Lampung|               |              |             |
| Blumeodendron    | tokbrai (Blume) Kurz         | T       | S. Kaliman: | 1924        | 1            | IX.C.144    |
|                  |                              |         | T     | Sumatra: Ac:eh | 1924        | IX.A.98     |
| Botryosphora     | genericulata (Miq.) Beumeex Airy Shaw | T       | Sumatra:Lampung | 2005     | 1            | IX.C.186    |
| Cephalomappa     | mallotocarpus J.J. Smith     | T       | W. Java| 2005          | 2            | VIII.F.50-50a|
| Cleidion         | speciflorum (Burm. f.) Merr. | T       | W. Java| 1997          | 2            | IX.A.88-88a |
| Codianum         | variegatum Blume             | S       | W. Sumatra | 2007        | 1            | II.F.124    |
|                  | variegatum Blume var. celebica | S     | Sumatra: | 2007         | 1            | XXIV.A.VI.26|
|                  |                              |         | S.E. Sulawesi | 2012         | 1            | XV.J.B.XXIII.22|
| Croton           | argyratus Blume              | T       | Java: Banten | 1965        | 1            | XV.C.64a    |
|                  |                              |         | T     | S. Kaliman: | 1995        | 2            | IX.C.154: XVI.L.15 |
|                  | caudatus forma multit glandulosus | W.Ci. | Java | 1965          | 2            | XV.C.17-17a |
|                  |                              |         | T     | SE Asia:    | 1995        | 1            | XVI.LD.36   |
|                  |                              |         | S     | Sumatra: Ac:eh | 2003        | 1            | IX.C.174    |
| Elateriospermum   | tapos Blume                  | T       | E. Kaliman: | 2007        | 2            | IX.C.194-195a|
| Endospermum       | moluccanum (Teijm. &Binn) Becc. | T       | Papua | 2004        | 1            | XXV.B.40    |
| Euphorbia        | lactea Haw                   | Sc.     | SE. India | 1995        | 1            | II.O.I.37   |
|                  | neriifolia L.                | Sc.     | SE. India | 2006        | 3            | II.O.I.47-47a-47b |
|                  | pulcherrima (Graham) Wild. ex Klotzsch | S       | Mexico | 1982    | 1            | XXIV.A.II.5  |
|                  | Tirucalli L.                 | S       | Africa | 1971         | 1            | II.O.I    |
|                  | tithymaloides (L.) Poit      | S       | W. Java | 2002          | 1            | XXIV.B.XVI.12|
| Exoecaria        | agallocha L.                 | S       | S. Sumatra | 2009       | 2            | IX.D.310-310A|
|                  |                              |         | S     | Sumatra: Lampung | 2007 | 1            | XXIV.B.XVI.10|
| Galeria          | filiformis (Blume) Pax       | T       | Sumatra:Lampung | 2006        | 2            | VII.B.44-44a|
| Hancea           | subpeltata (Blume) M. Aparicio ex | S     | W. Sumatra | 2009 | 1        | VIII.F.94 |
|                  | S.E.C.Sierra, Kulju & Welzen |         |         |               |              |             |
| Hevea            | brasiliensis (Will. Ex A. Juss.) Müll Arg. | T      | Brazil | 1996        | 1            | IX.C.132    |
|                  | confusa Hemscl.              | T       | Jambi  | 1996         | 1            | VIII.F.101  |
|                  | pacificaflora (spruce ex Benth.) Müll Arg. | T | Guiana | 2004 | 2            | VIII.F.75-75A|
|                  | spruceana (Benth.) Müll Arg. | T       | Baiul  | 1980         | 1            | IX.A.13     |
|                  |                              |         | Brazil | 1980         | 1            | VIII.E.28   |
| Homonoia         | jovense (Blume) Müll Arg.    | T       | Java   | 1982         | 2            | IX.A.26-26a |
| Hura             | crepitans L.                 | T       | W. Java | 1964         | 1            | XVII.L.79   |
|                  | polyandra Bailey             | T       | Mxico | 1983         | 2            | XXV.A.215-215b|
| Jatropha          | curcas L.                    | S       | W. Indies | 1977        | 1            | XXV.B.XVI.11|
|                  | gossypifolia L.              | S       | Africa | 1977         | 1            | XXV.B.XVI.4 |
|                  | multifida L.                 | S       | W. Java | 1996         | 1            | XXIV.A.XII.13|
|                  | podagrica Hook.f.            | S       | C. America | 1998        | 1            | II.O.VII.42, 124 |
| Joannesia        | princeps Vell.               | T       | Brazil  | 2005         | 1            | IX.C.172.187|
| Macaranga        | conifera Müll Arg.           | T       | W. Sumatra | 2007        | 3            | VIII.F.100.100a; |
|                  |                              |         |         |               |              | I05A.309b  |
|                  | gigantea Müll Arg.           | T       | S.E. Sulawesi | 1995 | 1            | IX.D.238    |
|                  | hypoleuca Müll Arg.          | T       | W. Kalimantan | 1996      | 1            | VIII.F.92   |
|                  | javanica Müll Arg.           | T       | Sumatra: Riau | 2009      | 1            | IX.D.31a    |
|                  | pruinosa Müll Arg.           | T       | Sumatra: Jambi | 2002      | 2            | IX.C. 166-166a|
|                  | triloba (Reinw. Ex Blume) Müll Arg. | T | Sumatra: Jambi | 1998      | 1            | VIII.F.95   |
| Mallotus          | borneensis J.J. Sm.          | S       | W. Kalimantan | 2000      | 1            | IX.C.163    |
floribundus (Blume) Müll Arg.  T  SE Sulawesi  2014  2  VIII.F.83  
T  SE. Sulawesi  2014  1  IX.C.158  
T  Bangka Island  1924  1  IX.C.102a  
S  N. Sulawesi  2014  1  IX.C.115  
T  W. Kalimantan  1995  1  IX.C.159  
nudiflora (L.) Kulju & Welzen  T  W. Sumatra  1924  2  X.E.40-40a  
peilata (Geisel.) Müll Arg.  T  W. Java  1995  1  IX.C.151  
T  W. Sumatra  2002  1  VIII.E.44  
philippensis (Lam.) Mull. Arg.  T  Philippines  1981  1  IX.A.81a  
philippensis (Lam.) Müll Arg.forma  T  Philippines  1922  1  VIII.E.27  
mollis  T  Sumatra;  1995  1  IX.C.153  
raffidula (Miq.) Müll Arg.  S  N. Sulawesi  2007  1  VII.E.165  
S  W. Sumatra  2009  1  IX.C.207a  
Manihot  esculenta Crantz  S  N. Maluku: Ternate  2008  2  XV.J.B.116-26A  
S  S. America  1997  1  XXIV.B.XVII.2  
Melanolipsis  multiglandulosa Rech.f.  N. Sulawesi  1998  2  X.A.92.93  
Neosertocentra  kingii (Hook. f) Pax & Hoffm  T  W. Java  1080  2  IX.A.6-6a  
Omphalea  papuana Gage  W.CI.  Papua  1980  1  XV.G.122  
Paracron  pendula (Hassk) Airy Shaw  T  W. Sumatra  2008  4  IX.A.104-104a.b.c  
T  N. Sulawesi  2002  2  IV.F.169-169a  
T  Maluku: Ambon  1964  1  VIII.E.76a  
Pimelodendron  amboinicum Hassk  T  SE. Sulawesi  2012  1  XXIV.B.56  
macrophum J.J. Smith  T  SE. Sulawesi  2012  1  XV.J.B.XIX.21  
S.  N. Sumatra  2009  1  IX.C.127  
zoanthoyne J.J. Smith  T  Kalimantan  1981  1  XXIV.A.65  
Reutealis  trisperma (Blanco) Airy Shaw  T  W. Java  1964  4  XXV.A.243a-d  
Ricinodendron  heudeiotti (Bail.) Heckel  T  Africa  1965  1  IX.A86  
T  W. Java  1965  2  IX.C.201-201a  
Sapium  aucuparium Jacq  T  W. Indies  1964  1  XX.C.71  
Shirakiospis  Indica (Willd) Esser  T  S. Sulawesi  1996  1  VII.E.8  
T  W. Java  1993  2  XXIV.34-34a  
Spathiostemon  javensis (Blume) Müll Arg.  T  Java  1982  2  IX.A.26-26a  
Srophioblanca  finbriicalyx Boerl.  T  Maluku: Ambon  1996  2  VIII.F.43-43A  
Sumbaviopsis  albicans (Blume) J.J.Sm.  T  Java  1988  2  VIII.F.81.IX.A.95  
Suregada  glomerulata (Blume) Baill.  T  Java  1996  2  VIII.F.4.IX.C.124  
Trigonostemon  anomalus Merr.  T  Sumatra: Bengkulu  1996  2  VILE.41..47  
T  W. Sumatra  1924  2  X.E.40-40a  
Vernicia  montana Lour.  S  Papua  2009  1  XV.J.B.XX.7  
S  W. Java  1981  1  XIL.B.VIII.57  
longifolia Baill.  S  W. Sumatra  2002  2  XLB.XVII.270-270a  
serratus Blume  T  Sumatra: Jambi  2003  1  XXL.161  
T  W. Java  1989  1  XX.C.97-97a  

Note: T: Tree, S: Shrub, W.CI.: Wood Climber, Sc: Succulent. Sources: The Registration Unit database and the Gardens Catalogue (Sari et al. 2010)

In general, the Euphorbiaceae s.l. collections at the Bogor Botanic Gardens (BBG) have been cultivated since 1922. Most of the collections were collected throughout the Indonesian lowland forests, some of them were obtained from overseas via seed exchange among other botanic gardens in the world. The number of genera and species presented in Euphorbiaceae s.l. as cited in the Garden’s Catalogue (Sari et al. 2010) were 54 genera, 136 species (eight are still spp.), and 235 specimens in total. Since the family has been split into five families thus an evaluation through the Gardens’ collections resulted in 39 genera, 71 species, and 136 specimens (Table 1). Some of the members have separated to be Phyllantaceae family such as genera Actephila, Antidesma, Aporosa, Baccaurea, Bischofia, Breynea, Bridelia, Cleistanthus, Galearia, Glossidion, Margaritaria, Phyllanthus, and Saururus. Moreover, the genus Drypetes segregated into Putranjivaceae family and Galearia into Pandanaceae family. As can be seen in Figure 1, the members of Euphorbiaceae (here used only Euphorbiaceae for the rest of this paper) have been cultivated at the Bogor Botanic Gardens in several bed numbers. However, it is suggested to do revision on the Garden’s Catalogue as well as name tags on the Gardens collections.
Figure 3. The number of Euphorbiaceae specimens has cultivated at the Bogor Botanic Gardens, West Java, Indonesia collected throughout Indonesian forests.

Figure 4. The number of Euphorbiaceae specimens has cultivated at the Bogor Botanic Gardens, West Java, Indonesia obtaining from overseas.

Habitus of the Euphorbiaceae family

The Euphorbiaceae family displays remarkable range of vegetative growth from woody plant to succulent. The growth forms represent at the BBG including tree, shrub, vines/climber, and succulent. In this case, the number of trees of Euphorbiaceae collections at the BBG is 92 specimens, of which 56 specimens have stem diameter over than 25 cm (from 20 genera and 24 species), such as Aleurites molucceus (L.) Willd., Blumeodendron tokbrai (Blume) Kurz, Cephalomapha malloticarpa J.J. Smith, Croton argyratus Blume, Endospernum moluccanum (Teijsm. & Binn), Hevea brasiliensis (Will. Ex A. Juss) Müll Arg., H. confuse Hemsl., Joanesia princeps Vell., Macaranga conifer Müll Arg., M. gigantea Müll Arg., M. triloba Reinw. Ex Blume) Müll Arg., Melanolepis multiglandulosa Reich.f., Neoscortechina kingie (Hook. f) Pax & Hoffm, Pinelodendron amboinicum Hassk, Reutilis trifolium (Blanco) Airy Shaw, Rhychnodendron heudelotii (Bail.) Heckel, Sapium aucuparium Jacq, Shirakiopsis indica (Willd) Esser, Strophio Blanchia fimbricalyx Boerl., Sumbaviopsis albicans (Blume) J.J.Sm., Suregudla glomerulata (Blume) Baill. and Vernicia Montana Lour.

The rest of Euphorbiaceae collections growth forms at the Gardens are shrubs (38 specimens), climbers (3 specimens), and succulents (4 specimens) (Figure 2).

It should be noted that slightly over 60% of the tree's forms having stem diameter more than 25 cm which indicated the Gardens enable to maintain their collections in excellent condition. Thus, this indicates that ex-situ conservation of the Euphorbiaceae family at the BBG has been successful, in accordance with one of its functions.

Source locations of the collections

As mentioned above, the number of specimens of the Euphorbiaceae in the Gardens is 136 specimens of which 104 specimens mostly obtained from flora exploration throughout Indonesian forests. There are 35 specimens (25.54%) from Java, Sumatra is represented by 33 specimens (24.08%), Sulawesi is represented by 13 specimens (9.48%), Kalimantan is represented by 10 specimens (7.29%), Maluku is represented by nine specimens (6.56%), West Papua is represented by three specimens (2.18%) and East Nusa Tenggara is represented only one specimen (0.72%). Meanwhile, the Gardens also cultivated a number of specimens of the Euphorbiaceae from overseas, including Brazil (four specimens), Southeast Asia (five specimens), Africa tropic (three specimens), Mexico (three specimens), Central America (two specimens), India (three specimens), Malaya (three specimens), Philippines (three specimens), West Indies (two specimens), Australia (two specimens) and Guiana (two specimens) (Table 2, Figure 4).
Table 2. The number of the Euphorbiaceae family cultivated at the Bogor Botanic Gardens, West Java, Indonesia from overseas, together with the planting year

| Origin          | Species name                             | Planting year | Number of specimens |
|-----------------|------------------------------------------|----------------|---------------------|
| Australia       | Acalypha wilkesiana Müll Arg.            | 1924           | 2                   |
| Brazil          | Hevea brasiliensis (Will. Ex A. Juss) Müll Arg. | 1996           | 1                   |
|                 | Hevea pauciflora (spruce ex Benth.) Müll Arg. | 1980           | 1                   |
|                 | Hevea spruceana (Benth.) Müll Arg.       | 1980           | 1                   |
|                 | Jatropha princeps Vell.                  | 2005           | 1                   |
| Central America | Jatropha podagrica Hook.f.               | 1998           | 2                   |
|                 | Manihot esculenta Crantz.                | 1997           | 1                   |
| Guiana          | Hevea confusa Hemsl.                     | 2004           | 2                   |
| India           | Acalypha hispida Burm. F.                | 1993           | 1                   |
|                 | Acalypha hispida Burm. var. sanderi (N.E.Br.) J. J. Smith | 1924           | 2                   |
| Malaya          | Acalypha wilkesiana Müll. Arg. forma montana | 1924           | 2                   |
|                 | Codiaeum variegatum Blume                | 1995           | 1                   |
| Mexico          | Euphorbia pulcherrima (Graham) Wild ex Klotzsch | 1982           | 1                   |
|                 | Hura polyandra Baill.                    | 1983           | 2                   |
| Philippines     | Mallotus philippensis (Lam.) Müll Arg.   | 1981           | 1                   |
|                 | Mallotus philippensis (Lam.) Müll Arg. forma mollis | 1922           | 2                   |
| Southeast Asia  | Croton tiglium L.                        | 1995           | 1                   |
|                 | Euphorbia lactea Haw. forma cristata     | 1995           | 1                   |
|                 | Euphorbia nerifolia L.                  | 2006           | 3                   |
| Tropic Africa   | Euphorbia tirucali L.                   | 1971           | 1                   |
|                 | Jatropha gossypifolia L.                 | 1977           | 1                   |
|                 | Ricinodendron heudelotii (Bail.) Heckel | 1965           | 1                   |
| West Indies     | Jatropha curcas L.                       | 1977           | 1                   |
|                 | Sapium aucuparium Jacq.                 | 1964           | 1                   |

Based on Registration Unit Data of BBG recorded that Mallotus philippensis (Lam.) Müll. Arg. forma mollis was introduced to the Gardens from the Philippines in 1922. In the following next two years (1924) three species were again introduced to the Gardens viz. Acalypha wilkesiana Müll. Arg. (Australia), Acalypha hispida Burm. var. sanderi (N.E.Br.) J. J. Sm (India) and Acalypha wilkesiana Müll. Arg. forma montana (Malaya). From 1964 to 1983, the director of the Gardens visited many botanic gardens in the world and brought several Euphorbiaceae collections such as, Jatropha gossypifolia L., Euphorbia tirucali L., and Ricinodendron heudelotii (Bail.) Heckel (Africa tropic), Sapium aucuparium Jacq. and Jatropha curcas L. (West Indies), Hevea pauciflora (spruce ex Bent.) Mull. Arg., Hevea spruceana (Benth.) Müll. Arg. (Brazil), Euphorbia pulcherrima (Graham) Wild ex Klotzsch and Hura polyandra Baill. (Mexico). From 1990 to 2006, nine species have been added to the Gardens' collections from overseas that were Acalypha hispida Burm.f. (India), Codiaeum variegatum Blume (Malaya), Croton tiglium L., Euphorbia lactea Haw. forma cristata and Euphorbia nerifolia L. (Southeast Asia), Hevea brasiliensis (Will. ex A. Juss) Müll. Arg. and Jatropha princeps Vell. (Brazil), Jatropha podagrica Hook.f. and Manihot esculenta Crantz. (Central America), Hevea confusa Hemsl. (Guiana) (Table 2). In addition, the Euphorbiaceae collections have increased from 1970 to 2005 through seed exchanged programs between BBG and other botanic gardens around the world. However, this program had been discontinued since 2007 until now. Hence, additional collections usually donated from overseas.

The age of Euphorbiaceae collections at the BBG

Based on the age of Euphorbiaceae collections are divided into six groups (Figure 5), viz. the ages of 1-10 years (four genera, six species, seven specimens), the ages of 11-20 years (20 genera, 31 species, 55 specimens), the ages of 21-30 years (12 genera, 18 species, 27 specimens), the ages of 31-40 years (11 genera, 12 species, 21 specimens), the ages of 41-50 years (two genera, three species, three specimens) and the ages of over 50 years (eight genera, 13 species, 24 specimens). The age of 11-20 years is the greatest number of specimens among others, because flora explorations throughout Indonesian forests have been extensively carried out during those years. Moreover, the policy of the director of BBG strongly supported this activity, in accordance with other government institutions collaboration, such as forestry.

The Euphorbiaceae collections that have aged over 50 years old grew well in BBG until now, such as Acalypha grandis Benth., A. hispida Burm.f. A. wilkesiana Müll. Arg., Alchornea rugosa (Lour.) Müll.Arg., Blumeodendron tokbrai (Blume) Kurz, Hura crepitans L., Mallotus floribundus (Blume) Müll. Arg. M. rufidulus (Miq.) Müll.Arg., M. philippensis (Lam.) Müll. Arg. forma mollis, Pinelodendron amboinicum Hassk, Ricinodendron heudelotii (Bail.) Heckel. This because the collections have well maintained and supported with suitable environmental factors as well.
Conservation status

*Joannesia princeps* Vell, *Pimelodendron amboinicum* Hassk, and *Cleidion speciflorum* (Burm.f.) Merr. are considered as Vulnerable (VU) based on IUCN (2001). The other species, *Alchornea rugosa* (Lour) Müll.Arg, *Balakata baccata* (Roxb.) Esser, *Homonoia javensis* (Blume) Müll. Arg. and *Suregada glomerulata* (Blume) Baill., are recognized Least Concern (LC) and Not Evaluated (NE) for *Macaranga javanica* (Blume) Müll. Arg.

Uses and potential of Euphorbiaceae collections at BBG

Indonesian people have been used in various plant species for their daily life. Each of the communities has different knowledge to manage and to use of plant diversity which grew in their surrounding homes. These differences have been influenced by the level of cultures, the geographical and ecosystem conditions, the external communities’ impact, and the effects of climate changed.

Many species in Euphorbiaceae family have been used by Indonesian people as ingredients of traditional medicines, as foodstuffs, as building materials, as energy source and firewoods, as ornamental plants and other necessities. Almost all parts of the plant have been used, for example, root, stem, bark, leaf, flower, fruit, and seed (Djarwarningsih 2007). Euphorbiaceae collections at the BBG which have potential economic as followed (Table 3): as traditional medicines (11 species), as ornamental plants (16 species), as ingredients and vegetables (two species), as natural dyes for woven cloth (three species), as building materials (14 species), as a source of energy (two species) and as toxics (six species).

Traditional medicines

There are 11 species (*Acalypha wilkesiana*, *Hevea brasiliensis*, *Jatropha curcas*, *J. gossypifolia*, *J. multifida*, *J. podagrica*, *Joannesia princeps*, *Macaranga gigantea*, *M. triflora*, *M. hypoleuca*, and *Ricinodendron heudelotii*) are found at the BBG that can be used as traditional medicines (Table 4). These are usually applied to cure several diseases such as eczema, stroke, rheumatism, wound, toothache, swelling, itching, indigestion, gout, acne, cough, and malaria. In addition, *J. gossypifolia* contains several chemical compounds such as, fat acid, glucose, alkaloid, amino acid, coumarin, steroid, flavonoid, lignan, protein, saponin, tannin, and terpenoid that can relieve the symptoms of eczema, itching, wound and diarrhea (Oduola et al. 2005; Ogundare 2007; Cabobianco et al. 2009), while *J. multifida* is known to heal wounds, swelling, eczema, and indigestion (Anonymous 2020). Moreover, Tchoundjeu and Atangana (2006) mentioned that *R. heudelotii* can be used to heal cough, malaria, stomach-ache, and rheumatism.

It is noted that four species (*A. wilkesiana*, *H. brasiliensis*, *J. gossypifolia*, and *J. multifida*) would be the best remedy for eczema (Gotep et al. 2010). A mix of two kinds of species can be used to heal several diseases, for example: swelling (a mix of *J. multifida* and *M. gigantea*), rheumatic (a mix of *H. brasiliensis* and *R. heudelotii*), and digestive disorders (a mix of *J. multifida* and *R. heudelotii*). Peng et al. (2011) stated that leaf decoction of *H. brasiliensis* is used for stroke treatment, while acne can be treated by pounded a leaf of *M. triflora* then smeared it. Moreover, Batin and Carandang (2010) mentioned that the sap of *J. curcas* can be cure toothache by dripping it.
Table 3. The potential of species Euphorbiaceae cultivated at the Bogor Botanic Gardens, West Java, Indonesia for use as medicines, as ornamentals, as vegetables, as ingredients, as dyes, as constructions, as rubbers, as sources of energy, and as toxics

| Genera       | Species                                      | Medicine          | Ornamental | Vegetable | Ingredient | Dye | Building material | Rubber | Energy source | Toxic |
|--------------|---------------------------------------------|-------------------|------------|-----------|------------|-----|-------------------|--------|--------------|-------|
| Acalypha     | gosseffiana Masters                         |                   |            |           |            |     |                   |        |              |       |
|              | grandis Benth.                               |                   |            |           |            |     |                   |        |              |       |
|              | hispida Burm.f.                              |                   |            |           |            |     |                   |        |              |       |
|              | hispida Burm.f var. sanderi (N.E.Br.) J.J. Sm. |                   |            |           |            |     |                   |        |              |       |
|              | wilkesiana Müll Arg.                         |                   |            |           |            |     |                   |        |              |       |
| Aleurites    | moluccanus (L.) Willd                       |                   |            |           |            |     |                   |        |              |       |
| Blumeodendron| tokbrai (Blume) Kurz                         |                   |            |           |            |     |                   |        |              |       |
| Codiaeum     | variegatum Blume                            |                   |            |           |            |     |                   |        |              |       |
| Endospernum  | moluccanum (Teijsm. & Binn) Becc.           |                   |            |           |            |     |                   |        |              |       |
| Excoecaria   | cochinchenensis Lour                        |                   |            |           |            |     |                   |        |              |       |
| Euphorbia    | lactea Haw                                  |                   |            |           |            |     |                   |        |              |       |
|              | nerifolia L.                                |                   |            |           |            |     |                   |        |              |       |
|              | pulcherrina (Grahamen) Wild ex Klotzsch      |                   |            |           |            |     |                   |        |              |       |
|              | tirucali L.                                 |                   |            |           |            |     |                   |        |              |       |
|              | racemosa (Reinw. Ex. Bl) Müll Arg.          |                   |            |           |            |     |                   |        |              |       |
|              | tithymaloides (L.) Poit                     |                   |            |           |            |     |                   |        |              |       |
| Hevea        | brasiliensis (Will. Ex A. Juss) Müll Arg.   |                   |            |           |            |     |                   |        |              |       |
|              | confusa Hems.                               |                   |            |           |            |     |                   |        |              |       |
|              | pauciflora (spruce ex Benth.) Müll Arg.      |                   |            |           |            |     |                   |        |              |       |
|              | spruceana (Benth.) Müll Arg.                |                   |            |           |            |     |                   |        |              |       |
| Hura         | crepitans L.                                |                   |            |           |            |     |                   |        |              |       |
| Jatropha      | curcas L.                                   |                   |            |           |            |     |                   |        |              |       |
|              | sapida Bedd.                                |                   |            |           |            |     |                   |        |              |       |
|              | multifida L.                                |                   |            |           |            |     |                   |        |              |       |
|              | podagrica Hook.f.                           |                   |            |           |            |     |                   |        |              |       |
| Joannesia    | princeps Vell.                              |                   |            |           |            |     |                   |        |              |       |
| Macaranga    | gigantea Müll Arg.                          |                   |            |           |            |     |                   |        |              |       |
|              | triloba (Reinw. Ex Blume) Müll Arg.         |                   |            |           |            |     |                   |        |              |       |
|              | hypoleuca Müll Arg.                         |                   |            |           |            |     |                   |        |              |       |
| Manihot      | esculenta Crantz                            |                   |            |           |            |     |                   |        |              |       |
| Melanolepis  | multiglandulosa Reich. f.                   |                   |            |           |            |     |                   |        |              |       |
| Pimelodendron| amboinicum Hassk.                           |                   |            |           |            |     |                   |        |              |       |
| Reutealis    | trisperma (Blanco) Airy Shaw                |                   |            |           |            |     |                   |        |              |       |
| Ricinodendron| heudelotii (Bail.) Heckel                   |                   |            |           |            |     |                   |        |              |       |
| Shirakiospis | indica (Wild) Esser                         |                   |            |           |            |     |                   |        |              |       |
| Sumbaviopsis | albicans (Blume) J.J. Smith                 |                   |            |           |            |     |                   |        |              |       |

Table 4. The usage of Euphorbiaceae family as traditional medicines

| Species                                      | Diseases                                      | Material used | Usage          |
|---------------------------------------------|-----------------------------------------------|---------------|----------------|
| Acalypha wilkesiana Müll Arg.               | Eczema, stroke, and rheumatic                  | Leaf          | Rubbed         |
| Hevea brasiliensis (Will. ex A. Juss) Müll Arg. | Eczema, stroke, and rheumatic                  | Leaf          | Rubbed or boil |
| Jatropha curcas L.                          | Wounds and toothache                          | Stem sap      | Rubbed         |
| Jatropha gossypifolia L.                    | Wounds, eczema, hives, and diarrhea            | Sap           | Dripped        |
| Jatropha multifida L.                       | Wound, swelling, eczema, and digestive disorders | Sap           | Rubbed         |
| Jatropha podagrica Hook. f.                 | Gout, fish poison                             | Sap           | Rubbed and diluted |
| Joannesia princeps Vell.                   | Wound and hives                               | Stem bark     | Mashed         |
| Macaranga gigantea Müll Arg.               | Wound and swelling                            | Root          | Boil           |
| Macaranga triloba (Reinw. ex Blume) Müll Arg. | Wound and swelling                            | Root          | Boil           |
| Macaranga hypoleuca Müll Arg.              | Fever                                         | Bark, root, young twig | Mashed, rubbed |
| Ricinodendron heudelotii (Bail.) Heckel.  |                                               | Bark          | Boil           |
Ornamental plant

It is recorded that 16 species of Euphorbiaceae collections at the BBG have potential as ornamental plants and also as hedges, namely Acalypha godseffiana, A. grandis, A. hispida, A. hispida var. sanderi, A. wilkesiana, Codiaeum variegatum, Excoecaria cochinchinensis, Euphorbia laetia forma cristata, E. nerifolia, E. pulcherrima, Euphorbia tirucalli, E. racemosa, E. tithymaloides, Jatropha multifida, J. podagrica and J. Sapida. As already known that several Acalypha species have an economic value notably in Malesia. Both A. hispida and A. wilkesiana are widely cultivated as ornamental plants in South East Asia. Brown-leaved or variegated specimens of A. wilkesiana are popular and often grown as hedges, whereas A. hispida is preferred for its very red pistillate inflorescences (Sagun et al. 2010).

Ingredients and vegetables

Two species of the Euphorbiaceae family have been recognized as food ingredient and as vegetable, namely Manihot esculenta and Aleurites moluccanus, respectively (Adhil et al. 2019). A. moluccanus (candlenut) has long been used as a spice. However, this species seems less popular nowadays, even though some communities are still cultivated it in their gardens, yards, or in agroforestry areas, particularly in eastern parts of Indonesia: Maluku, Nusa Tenggara Timur, and Nusa Tenggara Barat, for instance. However, candlenut has been household income generated for these communities (Purwanto and Cosiaux 2016).

Natural dyes

At least three species which are cultivated at the BBG can be used as natural dyes, notably for woven cloth, namely Aleurites moluccana, Macaranga gigantea, and Jatropha curcas. Yellow color can be obtained from the pulp of flesh fruit of A. moluccana, whereas green color is obtained from the leaf of M. gigantea (Seran and Hana 2018). Meanwhile, a green color is gained from a leaf of J. curcas and black color is obtained from its seeds (Hariyanto 2017).

Building materials (timbers)

There are 14 species of the Euphorbiaceae collections at the BBG that can be used as timbers, namely Aleurites moluccanus, Endospermum mollucanum, Hevea brasiliensis, H. confusa, H. pauciflora, H. spruceana, Hura crepitans, Joannesia princeps, Melanolepis multiglandulosa, Pinelodendron macrocarpum, Shirakiopsis indica, and Sumbaviopsis albicans. The timbers are utilized, notably local communities, to build a hut or a shelter in their gardens. Mostly are used as poles, building frames, or boards. Even though it is lesser-known timbers; however, it could substitute the commercial timbers for building due to limited availability. Aleurites moluccanus, Endospermum mollucanum, Hevea confusa, H. pauciflora, Pinelodendron amboinicum, and Sumbaviopsis albicans are among timbers species in Euphorbiaceae family that are usually utilized for roof, roof-truss, post, and pillar (Martawijaya et al. 2005; Soerianegara and Lemmens 1994; Lemmens et al. 1995; Sosef et al. 1998). On the other hand, Hevea spruceana, Hura crepitans, Joannesia princeps, Melanolepis multiglandulosa, Pinelodendron macrocarpum, and Shirakiopsis indica are used for boards (Sosef et al.1998).

Poisonous plants

Six species of the Euphorbiaceae possess poisonous sap, such as Excoecaria cochinchinensis, its sap can kill fish in a short time (Dalimarta 2007), Euphorbia laetica has a perilous sap when gets into the eyes and the sap of Euphorbia tirucalli can be used as insecticide (Arneti and Putri 2016). Other species (Euphorbia tithymaloides and Jatropha gossypifolia) contain a fairly high toxin (Karyati and Adhi 2018). The other, Jatropha curcas, has been investigated primarily as a source of oil. The seed cake that remains after oil extraction is an excellent source of plant nutrients. However, the presence of high levels of toxic substances and anti-nutrients limits the further applications of J. curcas oil and meal. (Haas and Mittelbach 2000). J. curcas oil and its extract can exhibit insecticidal effects, pesticidal effects, and anticyclococal activity and also offer the potential for snail-killing effects (Chumkaew et al. 2003; Makkar and Becker 2009; Diwani et al. 2009).

Collections value of the Euphorbiaceae at the BBG

Ecological value

Several genera in the Euphorbiaceae family have an important role in terms of land rehabilitation and reforestation of degraded areas, such as Hevea, Hura, and Pinelodendron. The species in these genera well adapted to surrounding areas therefore reforestation activities increased. In addition, the species also provided ecosystem services value (an ability to absorb carbon dioxide). Moreover, from an aesthetic value, the species showed great beauty as ornamental plants.

Economic value

Usage value of a plant species is divided into direct and indirect where both are crucial for community life, particularly in providing the daily needs (Purwanto et al. 2011). In Euphorbiaceae, several species can be used as a commercial commodity due to a high aesthetic value. Those are from genera Acalypha, Codiaeum, Excoecaria Euphorbia, Jatropha for instance, which have been wide traded (Chandra and Sitanggang 2007; Karyati & Adhi 2018).

The other species in Euphorbiaceae family is Manihot esculenta (cassava) that has been long time cultivated in Indonesia. It grows well from coastland up to mountain at an altitude of 1700 asl. This cassava can serve as a dessert or as main food during famine times. Besides, ethanol can be generated from its tuber and it becomes an industrial product (Prihandana et al. 2007). Another species is candlenut (Aleurites moluccana), which is native to Indonesia, notably in Maluku Islands and eastern part of Indonesian archipelago. It has been well-known since Dutch Era and became one of popular spices and medicine as well. It is easy to propagate by using polyculture in
agroforestry system or mixed cropping. Besides, it is an excellent species for reforestation and rehabilitation of degraded land purposes.

The usage of Euphorbiaceae plant species as traditional medicine has long been used by Indonesian communities, in particular, to deal with daily health problems. The communities usually grow various kinds of medicinal plants in their gardens. Consequently, supply of these raw materials is easily available and less health costs.

Development of Euphorbiaceae collections at the BBG

As an ex-situ conservation institution, BBG has to fulfill and maintain its collections properly. However, just maintaining the collections is not sufficient effort without exploring their potential values whether as ornamental plants or others. The genera Acalypha, Jatropha, Aleurita, Hura, Macaranga, and Ricinodendron for instance, are among potential genera as ornamental plants in Euphorbiaceae family. Species in those genera then selected for development and propagation purposes and would make a worthwhile contribution to the communities. Several Indonesian native species, Aleurites moluccana for example, have been widely developed as a spice. Others are also propagated for reforestation and rehabilitation in land degradation.

Conservation

Plant conservation activity takes priority over any other tasks of the BBG, furthermore, research, and domestication are followed. Cultivation, propagation, and maintenance of the collections is a form of conservation activities including the Euphorbiaceae collections at the BBG as well. To increase the collections, therefore, the exploration activities have to continuously carry out throughout Indonesian forests every year, which is recommended.

In conclusion, the Euphorbiaceae family has been segregated into five families viz. Phyllanthaceae, Putranjivaceae, Pandanaceae, Picrodendraceae, and Euphorbiaceae. Four of them are found at the BBG except for Picrodendraceae. Currently, the Euphorbiaceae collections at the BBG are classified into 39 genera and 136 specimens where 91 specimens are trees, 38 specimens are shrubs, three specimens are climbers and four specimens are succulents. Mallotus philippensis (Lam.) Mull. Arg. forma mollis was firstly introduced to BBG in 1922, originated from Philippines. Various species in Euphorbiaceae family can be utilized as traditional medicine (11 species), ornamental (16 species), spices and vegetables (two species), rubbers (one species), timbers (14 species), source of energy (two species), and toxics (six species). Euphorbiaceae collections have been successfully cultivated at the BBG. This proved that BBG has been carried out an ex-situ conservation very well.

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