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Scientific Article

# SEED AVAILABILITY ASSESSMENT AND SEED COLLECTION OF WILD PLANTS IN SELABINTANA FOREST, MOUNT GEDE PANGRANGO NATIONAL PARK, WEST JAVA

## Penilaian ketersediaan biji dan pengoleksian biji tumbuhan dari hutan Selabintana, Taman Nasional Gunung Gede Pangrango, Jawa Barat

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## Abstrak

Banyak kebun raya telah berkontribusi pada pencapaian Target 8 Strategi Global untuk Konservasi Tumbuhan (GSPC) melalui bank biji untuk jenis liar. Bank biji Kebun Raya Cibodas (KRC) sebagai bagian dari Kemitraan *Millenium Seed Bank* Kew juga mengumpulkan dan menyimpan biji jenis tumbuhan asli Indonesia. Studi ini bertujuan untuk menilai ketersediaan biji di alam dan mengumpulkan biji yang ada di Hutan Selabintana, Taman Nasional Gunung Gede Pangrango, Jawa Barat, untuk disimpan di fasilitas penyimpanan biji dalam jangka panjang di bank biji KRC. Jenis yang ditargetkan untuk pengumpulan biji difokuskan pada jenis pohon asli dengan biji ortodok atau mendekati ortodok berdasarkan daftar Database Informasi Biji (SID). Penilaian pra-pengumpulan dan pengambilan sampel individu dalam suatu populasi menggunakan sampling acak. Empat puluh jenis tumbuhan penghasil biji dilaporkan. Karena keterbatasan jumlah biji di lapangan (kurang dari 250 biji), hanya 33 jenis yang dikumpulkan. Enam jenis ditemukan dengan jumlah besar, yaitu *Begonia isoptera* Dryand. ex Sm., *Begonia* sp., *Ficus fistulosa* Reinw. ex Blume, *Pinanga javana* Blume, *Saurauia pendula* Blume, dan *Symplocos* sp. Sebagian besar biji dikumpulkan dari ketinggian 1.100–1.200 m dpl, di kawasan hutan, berhabitus pohon, dan sebagian besar biji diprediksi toleran terhadap pengeringan (ortodok). Dua jenis tumbuhan, yaitu *P. javana* dan *S. cauliflora* DC., terdaftar dalam Daftar Merah IUCN sebagai jenis terancam. Selanjutnya, penelitian ini menunjukkan bahwa pengumpulan biji berkualitas tinggi diperlukan untuk memastikan konservasi biji dalam jangka panjang.

**Kata kunci: bank biji, kualitas fisik biji, pengumpulan biji**

## Abstract

Many botanic gardens have been contributing to the achievement of Target 8 of the Global Strategy for Plant Conservation (GSPC) through seed banking of wild species. Cibodas Botanic Garden (CBG) seed bank as a part of Kew's Millenium Seed Bank Partnership has also been collecting and banking the seeds of Indonesian native plant species. The study aimed to assess seed availability in nature and collect the available seeds in Selabintana Forest, Mt. Gede Pangrango National Park, West Java, to be stored in the long-term seed storage facility at CBG seed bank. Targeted species for the seed collection were focused on the native trees species with orthodox or approximately-orthodox seeds based on the Seed Information Database (SID) list. Pre-collection assessment and sampling of individuals within a population were using random sampling. Forty seed-producing plant species were reported. Due to the limitation number of seeds in the field (less than 250 seeds), only 33 species were collected. Six species were found with a large quantity of seeds, i.e. *Begonia isoptera* Dryand. ex Sm., *Begonia* sp., *Ficus fistulosa* Reinw. ex Blume, *Pinanga javana* Blume, *Saurauia pendula* Blume, and *Symplocos* sp. Most seeds were collected at 1,100–1,200 m asl, in the forest area, as a tree life form, and majority of the seeds were predicted as desiccation-tolerant (orthodox). Two species, i.e. *P. javana* and *S. cauliflora* DC., were listed in IUCN Red List as threatened species. Furthermore, this study demonstrated that high-quality seed collections are needed to ensure the long-term seed conservation.

**Keywords: physical quality of seeds, seed bank, seed collection**

## INTRODUCTION

Many botanic gardens have been contributing to the achievement of Target 8 of the Global Strategy for Plant Conservation (GSPC) through seed banking of wild species (Oldfield 2009, William & Sharrock 2010, O'Donnell & Sharrock 2017). Target 8 of GSPC calls for "at least 75% of threatened plant species in ex-situ collections, preferably in the country of origin, and at least 20% available for recovery and restoration programs by 2020" (Convention on Biological Diversity 2010). Botanic gardens are the leading institutions for plant conservation through both living plant collection and seed banking, and at least 421 institutions are involved in seed banking of wild plants in 97 countries (O'Donnell & Sharrock 2015). Moreover, botanic gardens around the world manage at least 105,634 species collections (including whole plants, seeds, and tissue cultures), equating to 30% of all plant species diversity and contributing to the long term and efficient storage of plant diversity (Mounce *et al*. 2017).

'Seed banked' is referred to 'collections conserved as seed'. Conservative seed banking can only be used for species with desiccation-tolerant seeds; then the seeds are collected, dried, and stored in cold conditions until they are required for research, restoration, or reintroduction (Smith *et al*. 2003, O'Donnell & Sharrock 2015). Seed banks, as a static ex-situ conservation, could maintain specific genetic combinations and generally require less space. Seed banking is also relatively easy to control, and less dependent on other land uses even though it does not apply to species with recalcitrant seeds and vegetatively propagated species (Graudal 1997). Furthermore, seed banking is particularly crucial at a time of rapid global change both for threatened species and, increasingly, for more common species that may be essential in restoration programs (Oldfield 2015).

Cibodas Botanic Garden (CBG) seed bank as a part of Kew's Millenium Seed Bank Partnership contributes to the aim of safeguarding seeds from 25% of the world flora by 2020 through collecting and seed banking of Indonesian native tree species (Hardwick *et al*. 2017). By 2018, CBG seed bank hold 61 accessions covering 57 species, 57 genera, 40 families, and it needs to be increased through the seed exploration programs (Latifah *et al*. 2019).

Selabintana, as a part of Mt. Gede Pangrango National Park, is a pristine forest with low visitor impact and high plant diversity. Seven species of threatened plants were recorded in Mt. Gede Pangrango National Park, i.e. *Calamus adspersus* (Blume) Blume, *Lithocarpus indutus* (Blume) Rehder, *Pinanga javana* Blume, *Rhododendron album* Blume, *Saurauia bracteosa* DC., *S. cauliflora* DC., and *Symplocos costata* Choisy ex Zoll. (Wihermanto 2003). Previous seed collecting in other areas of Mt. Gede Pangrango National Park, i.e. Cibodas and Gunung Putri, resulted in 32 seed species (Zuhri *et al*. 2019). This study aim to assess the seed availability in nature, and to collect the available seeds in Selabintana forest for storing in the long-term seed storage facility at CBG seed bank.

## METHODS

### Study area

Seeds were collected from Selabintana, southern part of Mt. Gede Pangrango National Park, in April 2019 (Figure 1). Selabintana is a forest area located in Sukabumi District, West Java Province, Indonesia, with annual rainfall 2,082 mm. It was dominated by *Altingia excels* Noronha, *Castanopsis argentea* (Blume) A.DC., *Neolitsea cassiifolia* Merr., and *Schima wallichii* Choisy as tree form (Hilwan &

Irfani 2018). Seeds were collected from five locations, namely Cibeureum waterfall track, hiking track, and forests adjacent with a tea plantation, camping ground, and roadside (Table 1).

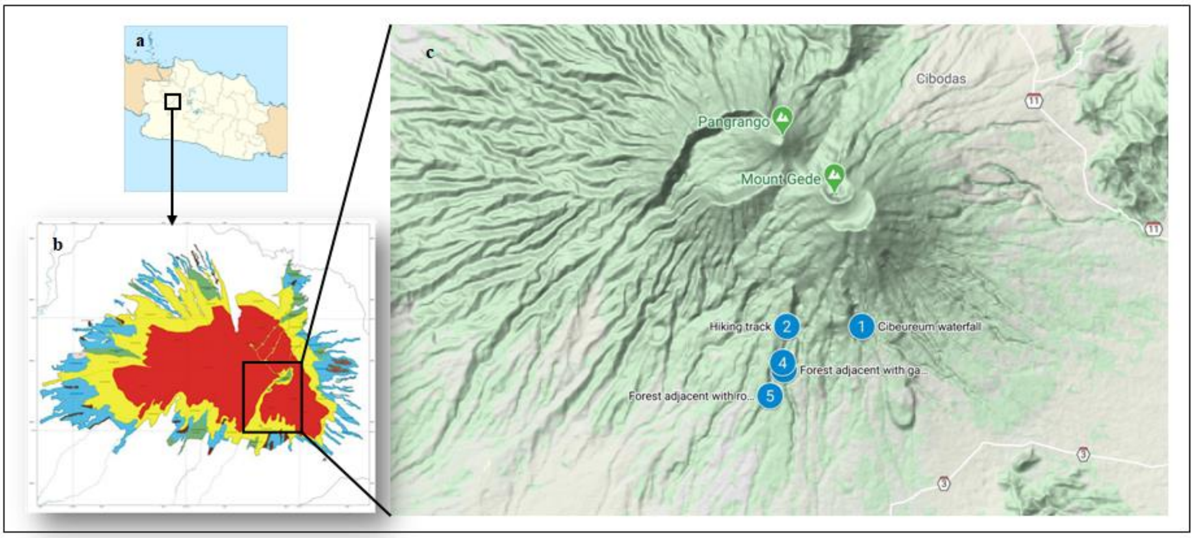


**Figure 1.** Study areas in West Java Province, Sukabumi District: a. West Java Province: rectangle represent Bogor, Cianjur and Sukabumi District; b. Mount Gede Pangrango National Park: rectangle is study area, Resort Selabintana in Sukabumi District; c. Location of seed collection: (1) Cibereum waterfall track, (2) Hiking track, (3) Forest adjacent area with tea garden, (4) Forest around camping grounds, and (5) Forest adjacent area with road. Map layers were downloaded from https://id.wikipedia.org, https://www.google.com/maps and https://www.gedepangrango.org

**Table 1.** Location of seed collection

| Location | Latitude | Longitude | Altitude (m asl) |
|---|---|---|---|
| Cibeureum waterfall track | S 06°49.796' | E 106°58.453' | 1,486 |
| Hiking track | S 06°49.851' | E 106°57.989' | 1,473 |
| Forest adjacent with tea garden | S 06°50.629' | E 106°57.931' | 1,272 |
| Forest around camping grounds | S 06°50.495' | E 106°57.908' | 1,185 |
| Forest adjacent area with road | S 06°51.140' | E 106°57.658' | 1,151 |

**Pre-collection assessment**

Seed availability was assessed to ensure that collection of seeds would not affect their population in nature. A sampling of individuals within a population was random sampling, by which each individual has an equal chance of being selected. Targeted species was determined based on native species which has not been collected yet in CBG seed bank. Furthermore, 10 to 20 seeds were randomly cut-tested to assess the seed quality, i.e. full seeds, empty seeds, infested seeds, and immature seeds, using secateurs. Number of viable seeds for the collection was estimated using the following formula (Way & Gold 2014a):

*Estimated number of viable seeds for collection = Maximum number of seed that can be collected × Percentage of full seeds*

*Maximum number to seed that can be collected = Available population × 20%*

*Available population = Total population × Percentage of full seeds*

*Total population = Estimated number of plants at natural dispersal × Average number of fruits or dispersal units per individual plants × Average number of seeds per fruits or natural dispersal units*

Readiness of population for seed collection was observed by the frequently occurring phenological stage, i.e. vegetative, in bud, flowering, immature seeds, around natural dispersal, and post dispersal. The percentage and number of plants at each stage was observed and estimated.

**Seed collection**

Seed collections were focused on native trees and shrub species with seed storage behaviour predicted as orthodox based on Seed Information Database (SID) list (Royal Botanic Garden Kew 2019) using either the closest species, genus, or family. In addition, those endangered species were also prioritized for collection. Phenological data of targeted species were obtained by selected published books, i.e. Backer & van den Brink (1963), Hatta & Darnaedi (2005), and van Steenis (2010).

The readiness for collecting seed was determined by morphological marker and seed maturity, i.e. fruit color-changes, changes in fruit softness and odor, fruit splitting or breaking open, and seeds already dispersed. Fully ripe fruits were collected manually by plucking of whole fruits using either pole (tree pruner) or secateurs at around their natural dispersal stage. Seeds were removed from fleshy fruits immediately after the field trip to prevent from fermentation process. Collected seeds were stored in cloth bags and kept in a cool, dry place with proper ventilation before dispatched to CBG Seed Bank for drying and storing process.

All seed collections were accompanied by fertile herbarium specimens for plant identification and verification purposes. Data associated with the seed collection were taken, such as habitat information, population characteristics, and information about the plant themselves (Way 2003).

**RESULTS AND DISCUSSION**

**Assessing seed availability and seed collecting**

Seed-producing plant species studied at Selabintana are provided in Table 2. Fourty seed-producing plant species belong to 23 families were recorded. Due to the limitation of the availability of seeds in nature, only 33 species were collected. Seven species were not in optimum time for seed harvesting. They yielded small amount of seeds. Those species are *Acronychia pedunculata* (L.) Miq., *Alpinia* sp., *Antidesma tetrandum* Blume*, Ardisia villosa* Roxb.*, Arisaema filiforme* (Reinw.) Blume*, Pavetta montana* (Reinw.) Blume*,* and *Polyalthia subcordata* (Blume) Blume. Six species were found in a large quantity of seed availability, more than a million seeds, i.e. *Begonia* sp.*, B. isoptera, Ficus fistulosa* Reinw. ex Blume, *P. javana, S. pendula,* and *Symplocos* sp. This may be related to a lot of number of seeds per fruit or quantity of fruits per individual plant (Table 2). Ideally, between 5,000 to 10,000 viable seeds were sampled from a population, however there were few species that produced less than that, i.e *Camellia sinensis* (L.) Kuntze, *Hedychium roxburghii* Blume, and *Sloanea sigun* (Blume) K. Schum with yielded approximately 2,000 seeds. Way & Gold (2014b) stated that a minimum number of 500 seeds in a population is adequate to be collected for basic collection, in case of loss of wild population.

Most species were found to be orthodox, whilst only three species were likely to be recalcitrant. At the optimum stage of development, orthodox seeds will have acquired desiccation tolerance and yet will not have lost viability due to aging (Way 2003). Eventhough some species were predicted as desiccation sensitive (recalcitrant), such as *P. javana, A. villosa* and *Breynia microphylla* (Kurz ex Teijsm. & Binn.) Müll.Arg., those seeds were still collected for further study of storage behaviour and germination trials. Desiccation sensitive seeds are not suitable to be stored in conventional seed banks, such as CBG seed bank, because it would easily lost their viability after drying. Therefore, cryopreservation technique is recommended to successfully long-term storage for the ex-situ conservation of non-orthodox species (Hill *et al*. 2012, Walters *et al*. 2013).

The number of plant sampled varied from 10 to 100% of its population. It cannot be avoided to harvest seeds from all plants in a population. Because either some of the plants produced a low number of fruits per individual plant, or it was found as a single individual plant in the field, such as *Hedychium roxburghii* Blume*, Polyalthia subcordata* (Blume) Blume, and *Antidesma tetrandum* Blume. In that case, it was needed to collect few seeds from every tree or repeat seed collections for later that year or in subsequent years.

Most species bear full seeds (100%), whilst only five species found between 30 to 90% (Table 2). Some of them were found either in an immature stage, empty seeds or infested/damaged seeds by insect and fungi, for example *Breynia microphylla, Camellia sinensis, Oreochnide rubescens, Sloanea sigun,* and *Viburnum* sp. These empty or damaged seeds were obviously inviable for germination tests.

The result of cut-test technique could provide useful information: (1) it provides evidence of whether the seed quality is acceptable, and (2) collectors may be better prepared to select a collecting technique that minimizes the presence of any empty or damaged seeds in the collection (Way 2003).

The number of seeds per fruit (Table 2) varied among species in the same family, such as Actinidiaceae (116–560 seeds per fruit), Moraceae (92–1,280 seeds per fruit), Rubiaceae (1–500 seeds per fruit), Urticaceae (7–500 seeds per fruit). However, among species within a family show similar number of seeds per fruit, for example Arecaceae (one seed per fruit), Begoniaceae (500 seeds per fruit), Phyllanthaceae (one to four seeds per fruit), and Primulaceae (one seed per fruit). Number of seeds is correlated with phylogeny and seed size. Moreover, some studies explained seed size and number variation among species had a strong phylogenetic component (Jacobsson & Eriksson 2000, Olejniczak *et al.* 2018). The variation in seed number per fruit may be caused by trade-off against seed size, and it might have a minor role in explaining the maintenance of variation in seed size and amount (Fenner & Thompson 2005). Moreover, the allocation of resources to reproduction does not vary significantly between species (Gnan *et al.* 2014).

Correlation between the number of seed species with elevation, land use, life form, or seed storage behaviour were represent at Figure 2. The number of species bearing fruits/seeds were found abundantly at 1,100–1,200 m asl, and then the number of species were decreased along with the the increase of elevation. Furthermore, mainly seeds were collected from forest area rather than other land use. Most seeds were collected from a tree life form, whilst others were raised from shrub (32.5%), herb (22.5%), climbing herb (2.5%) and woody climber (5%). Twenty nine species had seeds which were predicted as desiccation-tolerant (orthodox), while few species were likely identified as desiccation sensitive (recalcitrant), i.e. *A. fuliginosa, A. villosa, P. javana, P. subcordata,* and *S. sigun.* Meanwhile, *B. microphylla* probably as an intermediate seed. Seed storage behavior refers to the capacity of seeds to survive desiccation (Hong *et al.* 1998). As a conventional seed bank, CBG seed bank, only stored desiccation-tolerant seeds, i.e.g. *S. pendula, S. cauliflora, B. isoptera, B. bracteata,* and *C. paludosa.* Desiccation sensitive seeds can only be stored in cryopreservation facility for long-term storage of seed, because of its longevity dropped as response to reduced seed moisture content and temperature (Baskin & Baskin 2001).

Two species have been including in the IUCN Red List, i.e. *P. javana* and *S. cauliflora*. These species were found abundant as fruits, seedlings and adult plants in the humid and closed forest of Selabintana. Both species also found in other areas of Mt. Gede Pangrango National Park (Zuhri *et al*. 2019) and 27 seed species (33.75%) were added as new seed collection of native plants from Mt. Gede Pangrango.

**Fruiting period**

The percentage of mature fruits during the observations were presented in Figure 3. The fruiting period was not determined by the amount of readiness of the population for seed-collecting. *M. cauliflora,* which was found throughout its natural dispersal (100%) but the availability of their viable seeds in nature were merely 29,000 seeds. On the other hand, *S. pendula,* which only be found 20% at around natural dispersal, but their seed availability for collection was very high, i.e. 3,628,800 seeds. It could probably be caused by the number of fruits per individual plant of *S. pendula* which was higher than *M. cauliflora*, with the amount 3,240 fruits and 58 fruits respectively, although both of them had a lot of tiny seeds per fruit, approximately 500 seeds. Both of them usually found in the edge area in West Java sub-montane forest as a treelet life form. *S. microphylla*, the same genus with *S. pendula*, was recorded as the longest duration of flowering and fruiting, i.e. 4.4 months for flowering and 2.4 months for flowering-fruiting (Dewi *et al.* 2019). Fruiting period is useful to predict harvest time for seed storing to support *ex-situ* conservation and restoration activity. Moreover, phenological studies which include vegetative and reproductive phases is needed to estimate natural dispersal in the certain area.

**Table 2.** Seed-producing plant species found at Selabintana, Mt. Gede-Pangrango National Park, West Java

| No. | Family | Species | % Plants sampled | % Plants producing seed | Physical quality of seeds (% full seeds) | Avg. Number of seeds per fruit | Avg. Number of fruits per individual plant | Avaliability seeds to collect |
|---|---|---|---|---|---|---|---|---|
| 1 | Actinidiaceae | *Saurauia pendula* Blume | 100 | 100 | 100 | 560 | 3,240 | 3,628,800 |
| 2 | Actinidiaceae | *Saurauia cauliflora* DC. | 70 | 80 | 100 | 116 | 891 | 206,712 |
| 3 | Adoxaceae | *Viburnum* sp. | 100 | 100 | 60 | 4 | 237,600 | 342,144 |
| 4 | Annonaceae | *Polyalthia subcordata* (Blume) Blume* | 100 | 100 | 100 | 1 | 17 | 34 |
| 5 | Araceae | *Arisaema filiforme* (Reinw.) Blume * | 100 | 100 | 100 | 1 | 25 | 50 |
| 6 | Arecaceae | *Pinanga coronata* (Blume ex Mart.) Blume | 20 | 100 | 100 | 1 | 1,568 | 31,360 |
| 7 | Arecaceae | *P. javana* Blume# | 50 | 100 | 100 | 1 | 2,880 | 5,760,000 |
| 8 | Aristolochiaceae | *Aristolochia* sp. | 100 | 100 | 100 | 1 | 10,752 | 10,752 |
| 9 | Asteraceae | Sp. 1 | 10 | 100 | 100 | 5 | 9,920 | 248,000 |
| 10 | Balsaminaceae | *Impatiens platypetala* Lindl. | 20 | 80 | 100 | 43 | 5 | 21,500 |
| 11 | Begoniaceae | *Begonia* sp. | 40 | 100 | 100 | 500 | 280 | 1,400,000 |
| 12 | Begoniaceae | *Begonia bracteata* Jack | 40 | 100 | 100 | 500 | 5 | 10,000 |
| 13 | Begoniaceae | *Begonia isoptera* Dryand. ex Sm. | 40 | 100 | 100 | 500 | 280 | 1,400,000 |
| 14 | Commelinaceae | *Commelina paludosa* Blume | 40 | 50 | 100 | 27 | 154 | 16,632 |
| 15 | Cucurbitaceae | *Melothria leucocarpa* (Blume) Cogn. | 100 | 80 | 100 | 16 | 23 | 368 |
| 16 | Elaeocarpaceae | *Sloanea sigun* (Blume) K. Schum | 100 | 100 | 30 | 4 | 7,740 | 2,786 |
| 17 | Gesneriaceae | Sp. 2 | 20 | 100 | 100 | 500 | 240 | 72,000 |
| 18 | Melastomataceae | *Medinilla speciosa* Blume | 50 | 100 | 100 | 189 | 156 | 29,484 |
| 19 | Moraceae | *Ficus fistulosa* Reinw. ex Blume | 40 | 100 | 100 | 1.280 | 850 | 2,176,000 |
| 20 | Moraceae | *Ficus ampelas* Burm.f. | 100 | 100 | 100 | 400 | 81 | 64,800 |
| 21 | Moraceae | *Ficus cuspidata* Reinw. ex Blume | 100 | 100 | 100 | 92 | 5,616 | 310,003 |
| 22 | Phyllanthaceae | *Antidesma tetrandum* Blume* | 100 | 100 | 100 | 1 | 250 | 150 |
| 23 | Phyllanthaceae | *Breynia microphylla* (Kurz ex Teijsm. & Binn.) Müll.Arg. # | 100 | 100 | 50 | 4 | 13,248 | 13,248 |
| 24 | Primulaceae | *Ardisia fuliginosa* Blume | 40 | 100 | 100 | 1 | 4,389 | 17,556 |
| 25 | Primulaceae | *Ardisia villosa* Roxb.*# | 50 | 100 | 100 | 1 | 50 | 200 |
| 26 | Primulaceae | *Rapanea hasseltii* (Blume ex Scheff.) Mez | 100 | 100 | 100 | 1 | 54,054 | 54,054 |
| 27 | Rubiaceae | *Lasianthus* sp.1 | 67 | 100 | 100 | 1 | 2,550 | 5,100 |
| 28 | Rubiaceae | *Lasianthus purpureus* Blume | 50 | 100 | 100 | 4 | 17,017 | 136,136 |
| 29 | Rubiaceae | *Lasianthus capitatus* Blume | 50 | 100 | 100 | 11 | 324 | 21,384 |
| 30 | Rubiaceae | *Lasianthus* sp.2 | 50 | 100 | 100 | 5 | 2,448 | 12,240 |
| 31 | Rubiaceae | *Mycetia cauliflora* Reinw. | 100 | 100 | 100 | 500 | 58 | 29,000 |
| 32 | Rubiaceae | *Pavetta montana* Reinw. ex Blume * | 50 | 40 | 100 | 4 | 30 | 120 |
| 33 | Rutaceae | *Acronychia pedunculata* (L.) Miq.* | 100 | 100 | 100 | 1 | 250 | 150 |

| No. | Family | Species | % Plants sampled | % Plants producing seed | Physical quality of seeds (% full seeds) | Avg. Number of seeds per fruit | Avg. Number of fruits per individual plant | Avaliability seeds to collect |
|---|---|---|---|---|---|---|---|---|
| 34 | Symplocaceae | *Symploccos* sp. | 100 | 100 | 100 | 22 | 313,600 | 4,139,520 |
| 35 | Theaceae | *Camellia sinensis* (L.) Kuntze | 30 | 100 | 70 | 2 | 10 | 1,960 |
| 36 | Urticaceae | *Boehmeria diversifolia* (Blume) Miq. | 100 | 100 | 100 | 120 | 1,680 | 201,600 |
| 37 | Urticaceae | *Oreochnide rubescens* (Blume) Miq. | 33 | 100 | 90 | 7 | 18,496 | 209,745 |
| 38 | Urticaceae | *Procris* sp. | 40 | 100 | 100 | 500 | 27 | 27,000 |
| 39 | Zingiberaceae | *Hedychium roxburghii* Blume | 50 | 50 | 100 | 320 | 3 | 1,920 |
| 40 | Zingiberaceae | *Alpinia* sp. | 67 | 100 | 100 | 25 | 1 | 25 |

* Seeds were not collected; # Seeds predicted as desiccation sensitive (recalcitrant)

Both *F. fistulosa* and *S. sigun* had low number fruits at around natural dispersal. However, the availability for collecting seed of *F. fistulosa* was much higher than *S. sigun*, i.e. 2,176,000 and 2,786 seeds, respectively. It could be caused by number of seeds per fruit of *F. fistulosa* was higher than *S. sigun.* As a member of Moraceae family, *F. fistulosa* has many minute fruits inside the *syconia* where it attached in their stems (*cauliflora*). In the tropical forest ecosystem, it played role as a keystone species because of it is fruiting throughout year and served as a food for birds. Furthermore, collecting mature fruits is important for ensure high viability of seed during storing. Gold (2014) stated immature seeds, RH 85–100%, will not have acquired maximum storage potential but with careful handling they can be ripened until reach maximum longevity.

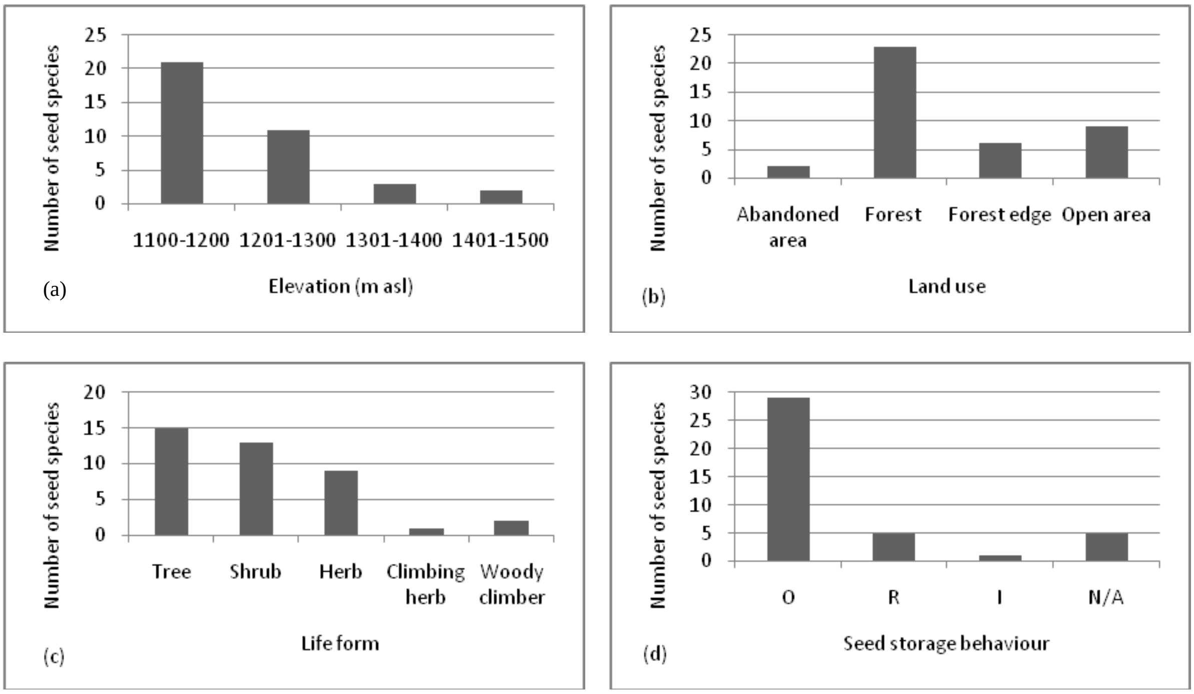


**Figure 2.** Number of seed species in relation with (a) elevation, (b) land use, (c) life form, and (d) seed storage behavior (O: orthodox; R: recalcitrant; I: intermediate; N/A: not available)

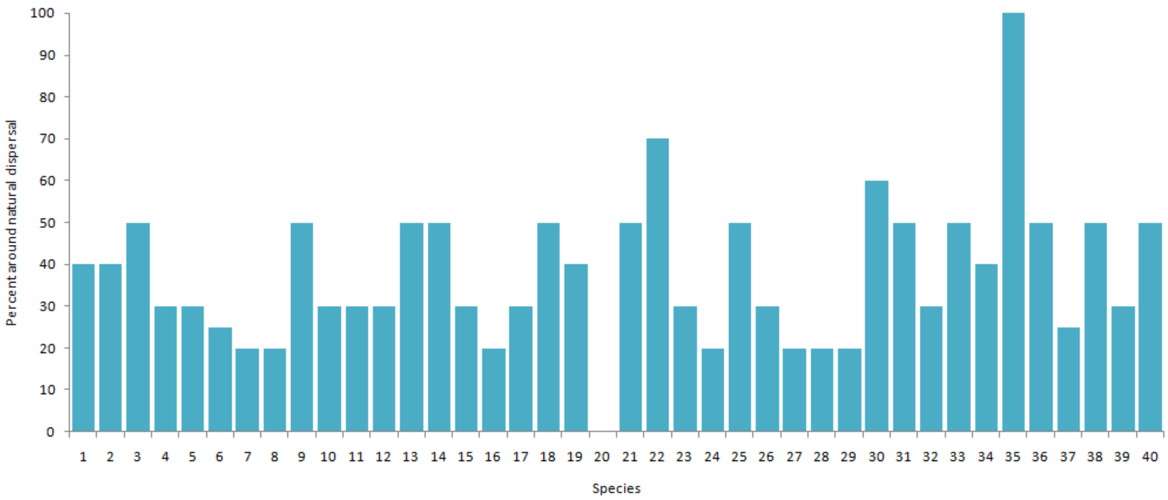


**Figure 3.** Mature fruit percentage of seed-producing plant species growing in Selabintana, based on an observation in April 2019
Seed species: 1. *Hedychium roxburghii;* 2. *Oreochnide rubescens;* 3. *Viburnum* sp.*;* 4. *Pinanga coronata;* 5. *Lasianthus* sp.1*;* 6. *Pinanga javana;* 7. *Alpinia* sp.*;* 8. *Saurauia pendula;* 9. *Ardisia fuliginosa;* 10. *Begonia* sp.*;* 11. *Ficus cuspidata;* 12. *Impatiens platypetala;* 13. *Sloanea sigun;* 14. *Lasianthus purpureus;* 15. Gesneriaceae (Sp.2)*;* 16. *Begonia bracteata;* 17. *Saurauia cauliflora;* 18. *Medinilla speciosa;* 19. *Procris* sp.*;* 20. *Arisaema filiforme;* 21. *Ardisia villosa;* 22. *Lasianthus capitatus;* 23. *Commelina paludosa;* 24. *Begonia isoptera;* 25. *Rapanea hasseltii;* 26. *Boehmeria diversifolia;* 27. *Aristolochia* sp.*;* 28. Asteraceae (Sp.1)*;* 29. *Pavetta montana;* 30. *Lasianthus* sp.2*;* 31. *Ficus fistulosa;* 32. *Breynia microphylla;* 33. *Ficus ampelas;* 34. *Melothria leucocarpa;* 35. *Mycetia cauliflora;* 36. *Polyalthia subcordata;* 37. *Camellia sinensis;* 38. *Acronychia pedunculata;* 39. *Symplocos* sp.*;* 40. *Antidesma tetrandum*

**Seed conservation implications**

In order to maintain the survival of natural population, assessing a high-quality seed collections are needed to ensure a long term seed conservation through a careful post-harvest handling. This was to avoid useless effort of collecting seeds, for example the loss of viability during collecting trip, and also to ensure that seeds arrive at a seed bank in good condition (Gold 2014). Therefore, assessing seed maturity during the fruiting period and seed-cut test are important steps to avoid collecting the immature, empty, and damaged seeds.

Understanding the best time to collect seed in the fields is essential to prevent a small number of available seeds and minimum quality seeds in nature by making a preliminary trip, benefiting information from a local guide, and estimating the fruiting period based on available literatures. Moreover, assessing a population is needed to ensure that seed collections arriving at seed banks have the highest possible initial viability and are sufficient quantity for long-term conservation (Way & Gold 2014a).

Besides, this study illustrates the importance of assessing seed viability through population assessment, readiness of population for seed collecting, and physical quality of seeds to make decisions to collect or not to collect seeds. Yet, in the case of low availability of seeds, multi-year collecting are needed to maintain their availability in the nature, such as *Acronychia pedunculata, Antidesma tetrandum, Ardisia fuliginosa, Arisaema filiforme,* and *Polyalthia subcordata*. Due to the limitation of information accessed in the field, seed-collecting of recalcitrant seeds can not be avoided, i.e. *Ardisia villosa, Pinanga javana,* and *Sloanea sigun,* which desiccation sensitive. Finally, this study contributes to more effective and rationalized seed collecting from the wild for long-term storage purposes.

**CONCLUSIONS**

Forty seed-producing plant species were recorded from the Selabintana forest. Seed collection from 33 species of them were carried out. Some species were found in large quantities, i.e. *Begonia isoptera, Begonia* sp.*, Ficus fistulosa, Pinanga javana, Saurauia pendula,* and *Symplocos* sp. Most seeds were collected at 1,100–1,200 m asl in the forest area as a tree life form, and the majority predicted as desiccation-tolerant (orthodox). Two species, i.e. *Pinanga javana* and *Saurauia cauliflora,* were listed in the IUCN Red List as threatened species. The assessing seed viability through population assessment, the readiness of population for seed collecting, and the physical quality assessment are needed to obtain high-quality seed collections for long term seed conservation.

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