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SHORT COMMUNICATION

Flowering and Fruiting Phenology of Tree Species in Mount Papandayan Nature Reserve, West Java, Indonesia

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Abstrak: Mount Papandayan Nature Reserve (MPNR) merupakan kawasan yang kaya dengan biodiversiti; namun demikian natijah daripada aktiviti pembasmian hutan secara berleluasa telah mengakibatkan perlunya penanaman semula pokok di situ dijalankan dengan segera. Apabila penanaman semula direka untuk mengembalikan semula sebahagian daripada biodiversiti, adalah amat penting untuk menggunakan spesies pokok asal dalam kaedah tersebut. Kajian ini bertujuan untuk memberi informasi berkenaan pembungaan dan fenologi pokok-pokok asal. Hal ini kerana informasi sebegini berguna untuk merancang pengumpulan biji benih dan produksi serentak bijih benih di nurseri. Melalui kajian ini, pemantauan telah dijalankan setiap bulan dari Ogos 2009–Julai 2010 dengan merekodkan pokok yang berbunga dan berbuah di sepanjang dua trek survei yang merentasi laluan di tengah-tengah hutan campur MPNR. Data yang dikumpul pula digunakan untuk membina sebuah kalendar fenologi. Dalam kajian ini, 155 pokok dari 43 spesies didapati berbunga atau berbuah. Masa kemuncak berbunga dan berbuah ialah pada bulan Julai (13 spesies berbunga dan 19 spesies berbuah), manakala tahap paling rendah ialah pada bulan Oktober (1 spesies berbunga dan 3 spesies berbuah). Berpandukan kalendar fenologi yang telah dibina, tempoh antara bulan Mac hingga Julai dianggap masa paling sesuai untuk mengumpul bijih benih pokok asal di Mount Papandayan.

Kata kunci: Fenologi Biji Benih, Spesies Asal, Penghutanan Semula, Sifat Biji Benih

Abstract: Mount Papandayan Nature Reserve (MPNR) is an area highly rich in biodiversity, however deforestation has left a vast area urgently in need of reforestation. When reforestation is designed to restore some level of biodiversity, it is imperative that native tree species are used for planting. This research aimed to provide information on the flowering and fruiting phenology of native trees. Such information can be useful to plan seed collection and mass seedling production in the nursery. The observations were conducted each month during August 2009–July 2010 by recording flowering and fruiting trees along two survey track passing through the middle of the mixed forest of MPNR. Data gathered were used to construct a simple phenology calendar. During the study, there were 155 trees of 43 species found flowering or fruiting along the survey track. The peak time of flowering and fruiting was in July (13 species flowering and 19 species fruiting), while the lowest level was in October (1 species flowering and 3 species fruiting). According to the phenology calendar constructed, March to July were considered to be the appropriate time to collect seeds of native trees in Mount Papandayan.

Keywords: Seed Phenology, Native Species, Reforestation, Seed Characteristics

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For the last few decades, deforestation was considered to be the biggest threat for the tropical rain forest ecosystem existence and its function. For the year 2000–2005, Indonesia has lost 1871 million hectares or 2% of its total forest area due to deforestation [Food and Agriculture Organization (FAO 2010)]. Considering the fact that Indonesian rain forest is one of the earth's biodiversity hotspot, comprehensive reforestation efforts will be needed. It is also crucial to design reforestation program, which restores its previous level of biodiversity.

In many cases, reforestation has relied on planting single tree species thus lacking biodiversity restoration supporting efforts (Lamb & Gilmour 2003). The extensive use of introduced species for reforestation was due to the lack of information in silviculture aspects of native species, which commonly are not commercial species. Some researchers have developed criteria for picking excellent native species for reforestation (Goosem & Tucker 1995; Blakesley *et al. 2*002; Vongkanjam *et al. 2*001) including growth character and simple seedling production method. In order to plan seed collection and to produce mass seedling of native tree species in the nursery, information of flowering and fruiting event (phenology) of the species will be ultimately needed.

Phenology can be defined as scientific study of the seasonal timing of life events. In plants, it is related with dates of plant growth phenomenon, such as flowering, leaf flushing or ripening of fruit (Rathcke & Lacey 1985). There are several reasons to construct the phenological calendar i.e., to unravel data about the ecosystem functioning; to obtain data for crop seasonality and to do farm work in the right season; to observe the relation between temperature or other abiotic factors with phenology; to support conservation of other species related with the plants observed; to determine the proper time for plant seed collection, etc. Studies on phenology have been increasingly developed for the past decades. In many parts of the world, e.g., Australia (Keatley & Fletcher 2003), Japan (Chen 2003), China (Chen 2003), Germany (Menzel 2003), North America (Schwartz & Beaubien 2003), and South America (Morellato 2003) exist databases, which provide long term periodical observations on plant phenology.

This study focused on flowering and fruiting phenology, as part of a bigger research agenda aiming to evaluate performance of native tree species in reforestation at Mount Papandayan Nature Reserve (MPNR) and the surrounding areas. It has been built from the previous forest ecological research conducted in this area since 2004 i.e., Sulistyawati *et al.* (2005, 2006, 2008, 2010) and, Setiawan and Sulistyawati (2008). The research presented in this paper was aimed to document the phenology of native tree species including the timing of flowering and fruiting as well as studying the fruit characteristics. Information on the calendar of flowering and fruiting gathered through this study can then be used to anticipate the timing for seed collection and seedling propagation for reforestation with native trees in the study area.

This research was conducted in MPNR and its surrounding area, located in West Java, Indonesia. The peak of Mount Papandayan is at 7°19'42 S and 107°44'00 W, with elevation up to 2675 m asl. MPNR is one of the conservation area known for its high biodiversity and various vegetation types, i.e., mixed forest, grassland and crater vegetation (Sulistyawati *et al.* 2005). By the decade of 1990s, major deforestation occurred at forest edges that is changing the land

use into horticultural fields. Some of the area has been reforested with native tree species. Data gathered from previous studies (Sulistyawati *et al.* 2005; Setiawan & Sulistyawati 2008; Utami & Sulistyawati 2010) showed that the major type of vegetation in MPNR is mixed forest with 47 tree species, 25 shrub species and 50 herbs species in its interior area. While in forest edge areas, 54 tree species, 16 shrub species and 17 herbs species were found.

The survey tracks covered different parts of MPNR area including the forest edges and interiors (Fig. 1). First survey track passed through the interior part of MPNR extending for 11.3 km from the southern and northern parts. The track covered areas with altitude ranging from 1385 to 2277 m asl. The vegetation in this track consisted of mixed forest and grassland dominated by *Imperata cylindrica*. The second track covered the forest edge, abandoned agricultural fields and plantations extending for 5.1 kilometres of the eastern and western part of MPNR with the altitude ranging from 819 to 1845 m asl. Due to the resource limitation, the first survey track was only able to be visited in August–September 2009 and December 2009–July 2010. Meanwhile, the second track was only able to be visited during October–November 2009 and January–July 2010.

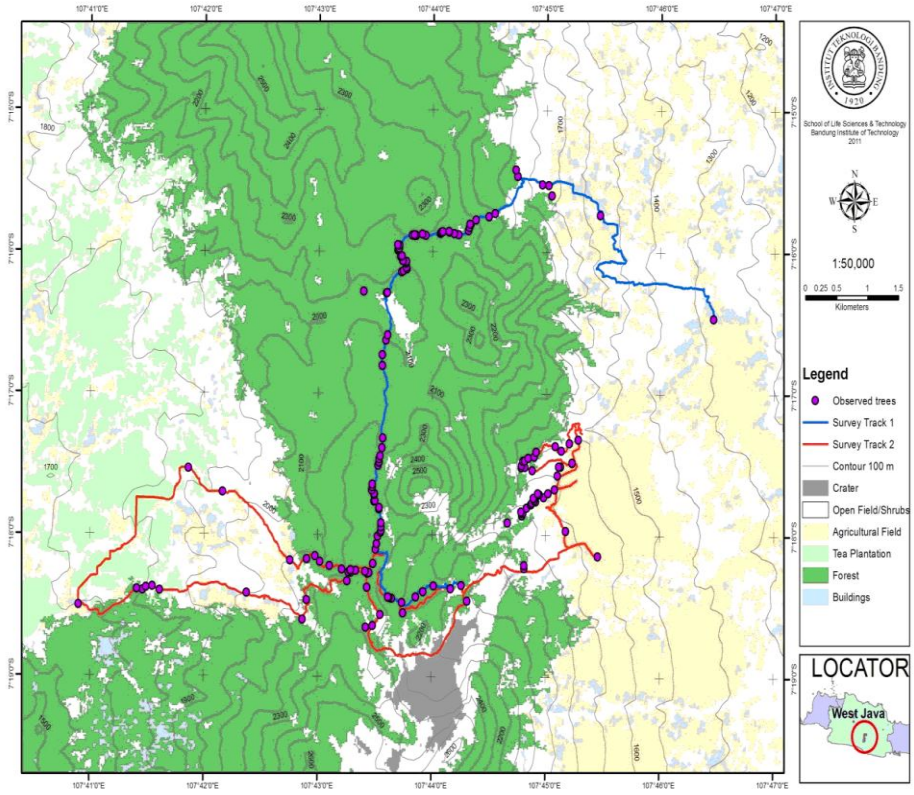

Figure 1: Mount Papandayan area and the coverage of phenology observation survey.

Climatic data for the study were gathered from PT PP London Sumatera Indonesia Tea Plantation located around 8 km from the study area (elevation 1612 m asl). According to the five years climatic data (2004–2009) presented in Figure 2, rainfall tends to get higher in October to April with monthly rainfall ranging from 9–650 mm (rainy season), while from May to September it got lower ranging from 0–175 mm (dry season). But during the study, rainfall data showed different a trend compared with the previous five years data (Fig. 3). The monthly rainfall in May 2010 to July 2010 which was supposed to be low (beginning of dry season) ranged between 228–319 mm, therefore it was difficult to distinguish between rainy and dry season during the study.

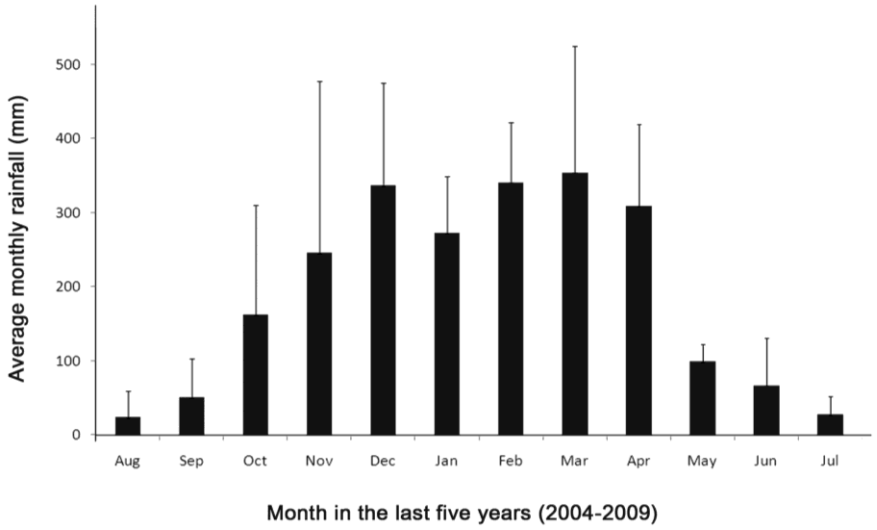

Figure 2: Averange montly rainfall (±SD) in five years (2004–2009).
Source: PT PP London Sumatera.

The phenology data were gathered through surveys conducted monthly from August 2009–July 2010. The surveys focused on observing individual native tree species in the tracks by documenting its period of flowering and fruiting. The individual trees were selected randomly based on the visibility of its flowers and fruits. Every individual tree was then marked in the GPS receiver and observed each month. When it was possible, at least three individuals were chosen to represent a species. However, in several cases, it was rather difficult to observe more than one individual either because of its height or it did not show flowering or fruiting symptoms yet. Therefore many of the species could only be represented by one individual. Several species were found in both tracks (interior and edge), and there were some species found either in interior or edge area.

In this study, there were 155 trees from 43 species flowering or fruiting along the two survey tracks. On the first track (interior area), there were 125 trees from 35 species and 21 family observed. Meanwhile on the second survey track

(edge area), there were 30 trees from 23 species and 17 family observed. The list of species found is presented in Table 1.

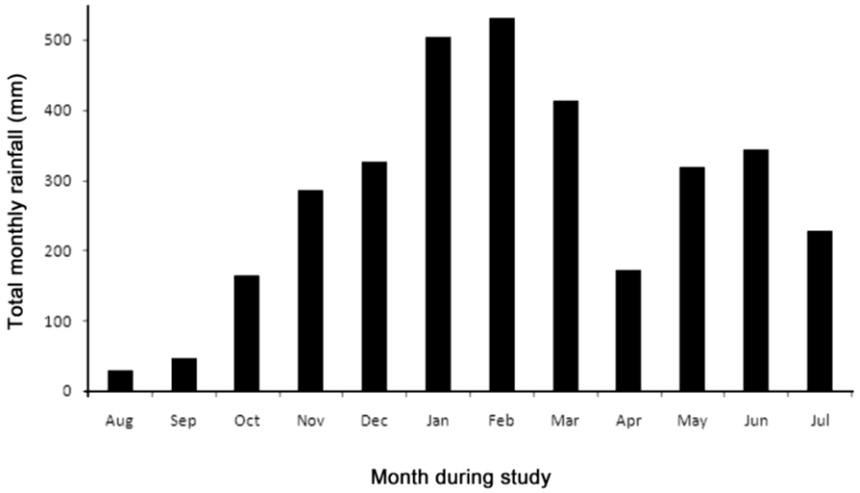

Figure 3: Monthly rainfall during the study period (August 2009–July 2010).
Source: PT. PP London Sumatera.

Table 1: Tree species observed during the study.

Family/Species	No. of trees observed	No. of trees found in interior	No. of trees found in edge	Fruit type
Aceraceae				
Acer laurinum Hassk.	3	3	0	Samara
Actinidiaceae				
Saurauia pendula Blume	1	1	0	Berry
Araliaceae				
Macropanax dispermus (Bl.) O.K.	14	14	0	Drupe
Schefflera lucescens (Bl.) Vig.	2	2	0	Drupe
Cunoniaceae				
Weinmannia blumei Planch.	1	0	1	Capsule
Elaeocarpaceae				
Acronodia punctata Bl.	4	1	3	Drupe
Escalloniaceae				
Polyosma ilicifolia Bl.	5	4	1	Berry

(*continued on next page*)

Table 1: (*continued*)

Family/Species	No. of trees observed	No. of trees found in interior	No. of trees found in edge	Fruit type
Euphorbiaceae				
Omalanthus populneus (Geisel.) Pax.	6	6	0	Capsule
Glochidion arborescens Bl.	1	1	0	Capsule
Fabaceae				
Acacia deccurens Willd.	11	11	0	
Fagaceae				
Lithocarpus cf. *piriformis*	1	0	1	Nut
Lithocarpus dolichocarpa Rehder	1	0	1	Nut
Lithocarpus sp.	2	2	0	Nut
Lithocarpus elegans (B.) Hatus ex. Supadmo	4	4	0	Nut
Lithocarpus sundaicus (Blume) Rehder	2	0	2	Nut
Juglandaceae				
Engelhardia spicata Lech. Ex. Bl.	5	4	1	Nut
Hammamelidaceae				
Distylium stellare O.K.	4	2	2	Capsule
Lauraceae				
Cinnamomum parthenoxylon Meisn.	4	3	1	Drupe
Cinnamomum burmanni (Nees) Blume	1	1	0	Berry
Litsea citrata Blume	5	4	1	Drupe
Magnoliaceae				
Manglietia glauca Bl.	1	0	1	Samara
Melastomataceae				
Astronia spectabilis Bl.	2	2	0	Capsule
Kibessia azurea Bl.	1	1	0	Berry
Mimosaceae				
Albizia lophantha (Willd.) Bth.	5	5	0	Pod
Moraceae				
Ficus fistulosa Reinw. Ex.	2	2	0	Drupe
Ficus ribes Reinw.	1	0	1	Drupe
Ficus padana Burm.f.	1	0	1	Drupe

(*continued on next page*)

Table 1: (*continued*)

Family/Species	No. of trees observed	No. of trees found in interior	No. of trees found in edge	Fruit type
Myricaceae				
Myrica javanica Reinw. ex Bl.	1	1	0	Drupe
Myrtaceae				
Syzygium glomeruliferum Amsh.	1	1	0	Berry
Syzygium gracile (Korth.) Amsh.	7	5	2	Berry
Pittosporaceae				
Pittosporum moluccanum (Lam.) Miq.	1	0	1	Capsule
Podocarpaceae				
Dacrycarpus imbricatus (Blume) de Laub.	5	4	1	Cone
Podocarpus neriifolius D. Don.	2	2	0	Nut
Proteaceae				
Helicia serrata (R. Br.) Bl.	4	3	1	Nut
Helicia cf. javanica	1	1	0	Nut
Rubiaceae				
Lasianthus spp.	2	2	0	
Psychotria montana Bl.	1	1	0	Drupe
Rutaceae				
Acronychia laurifolia Bl.	12	11	1	Drupe
Symplocaceae				
Symplocos fasciculata Zoll.	4	3	1	Drupe
Symplocos theaefolia D. Don	2	1	1	Drupe
Theaceae				
Eurya acuminata DC.	4	3	1	Capsule
Pyrenaria serrata Bl.	10	10	0	Berry
Schima wallichii (DC.) Korth.	8	4	4	Capsule
TOTAL	155	125	30	

Based on one-year observation on both tracks, the number of species found flowering fluctuated each month ranging from 1–13 species. Figure 4 shows the fluctuation of flowering event during the study. October was the month when the least number of species were found flowering (1 species). Meanwhile, the peak of flowering occurred in July whereby 13 species were found flowering.

Fruits were also present each month during the one-year observation on both tracks. There were 3–21 species found to produce fruit each month. As presented in Figure 4, there were fluctuations in the numbers of species found fruiting during the study. The number of species found to produce fruit was considered to be low in August–November. The number increased in the next month until it reached a sharp peak in July.

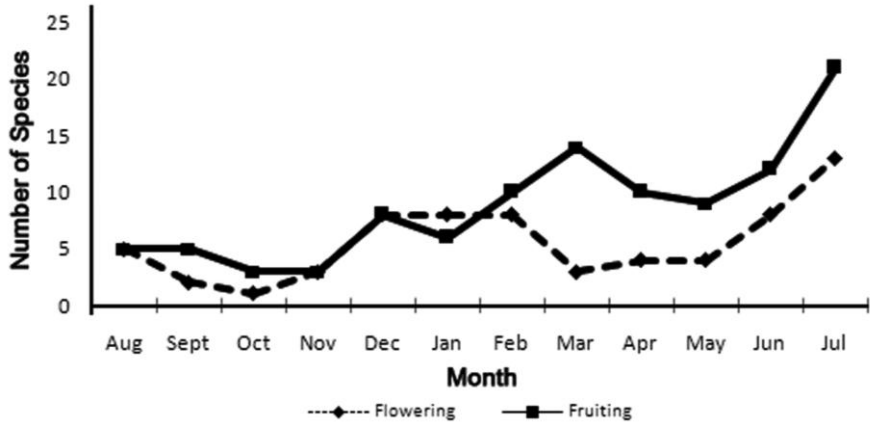

Figure 4: Number of species flowering and fruiting from August 2009–July 2010.

The flowering and fruiting period seemed to have quite a different pattern. According to the observation made during the study, fruiting period seems to last longer than flowering period. During the study, it was rather difficult to observe flowering compared to fruiting. This might be due to lack of visibility of flower compared with fruits, either because of the weather, tree height, or size. Therefore, data of flowering species gathered tended to be underestimated. Although the overall flowering and fruiting pattern cannot be clearly identified, the most notable phenomenon was both events reached their peaks in July. This phenomenon of peak time of flowering and fruiting period was also noted in other works (Anderson *et al*. 2005; Kikim & Yadava 2001; Gunter *et al. 2*008).

There are a number of factors, which may influence the timing of flowering and fruiting including rainfall, moisture, temperature and photoperiod (Anderson *et al*. 2005; Kikim & Yadava 2001; Gunter *et al. 2*008). It seems that the pattern of fruiting and flowering in this study may coincide with the fluctuation of rainfall. During the relatively high rainfall months (wet season), intensity of the number of species producing flower and fruit were high; November–March and May–July (Fig. 3). A study in Northern Thailand tropical dry forest also showed that peak of fruiting and flowering of tree species coincided with the beginning of dry season or wet season (Elliott *et al.* 1994). Furthermore, Elliott *et al.* (1994) stated that this phenomenon may be due to different species reproduction strategy. The implication of this findings will be helpful to design proper treatment to break seed dormancy. For example, seeds produced during the dry season might respond to dessication or heat treatment, whereas those produced during the rainy season might respond well to soaking. However, further data collection will be needed to support this findings, considering the fact that a different rainfall pattern existed during the study compared with the previous five year data (Figs. 2 and 3).

With the 43 species found during the survey, a simple phenology calendar containing information on flowering and fruiting was constructed (Table 2). From the 36 species found fruiting, two different types were observed

i.e., species which produce fruit for 1–3 months (short period) and species that produce fruit for more than 4 months (long period). Most of the tree species in this study belong to the short period group (25 species), that is *Acacia decurrens*, *Albizia lopantha*, *Astronia spectabilis, Cinnamomum parthenoxylon, Dacrycarpus imbricatus, Distylium stellare, Ficus padana, Ficus ribes*, *Helicia cf. javanica, Helicia serrata, Kibessia azurea, Lasianthus spp.,Lithocarpus cf. piriformis, Lithocarpus sundaicus, Lithocarpus dolichocarpa, Lithocarpus elegans, Lithocarpus sp., Manglietia glauca, Myrica javanica, Pittosporum moluccanum, Polyosma illicifolia, Psychotria montana, Saurauia pendula, Schefflera lucescens* and *Symplocos fasciculata*. Meanwhile, 11 species belong to the long period, i.e. *Acronodia punctata*, *Acronychia laurifolia, Engelhardtia spicata*, *Eurya acuminata*, *Ficus fistulosa, Litsea citrata, Macropanax dispermus, Omalanthus populneus, Pyrenaria, serrata, Schima walichii* and *Syzygium gracile.*

The exact timing of flowering and fruiting could be site specific (Anderson *et al*. 2005; Kikim & Yadava 2001; Gunter *et al. 2*008). Several studies in Southeast Asia area has documented flowering and fruiting period of several tree species which were also found in this study. Few species i.e., *P. serrata* (Boer *et al.* 1999) and *A. spectabilis* (Aguilar *et al.* 1999) were documented to have flowering and fruiting period throughout the year, which is similar with the findings on this study. However, different results were also shown for *D. imbricatus* (Sunarno *et al.* 1999), *S. wallichii* (Broer & Sosef 1999), and *S. gracile* (Haron 1999). This shows that even within the same tropical region in Southeast Asia and in a typical ecosystem, the timing of flowering and fruiting might be site specific.

As mentioned before, the phenology calendar can be used as guidance for seed collection. Based on this study (Table 2), the most appropriate time to collect seeds in MPNR starts from February–July in which most of the species (43) were fruiting. However, further study with longer period of observation will be needed to confirm the exact timing of flowering and fruiting.

From the discussion above, several points are concluded: 1) there were 155 trees from 43 species found flowering and/or fruiting along the two survey tracks during August 2009–July 2010; 2) number of species found flowering and fruiting seems to fluctuate throughout the year with both peaks occurring in July 2010; 3) the high number of species found flowering and fruiting were in the months with high rainfall (wet season); 4) most of the species were found to produce fruit in a short period of time (1–3 months) during the study; 5) February to July were considered to be the appropriate time to collect seeds of native trees in Mount Papandayan.

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Table 2: Phenology calender of 44 tree species from August 2009–July 2010.

		Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1	*Acacia decurrens* Willd.												
	Flowering												
	Fruiting												
2	*Acer laurinum* Hassk.												
	Flowering												
	Fruiting												
3	*Acronodia punctata* Bl.												
	Flowering												
	Fruiting												
4	*Acronychia laurifolia* Bl.												
	Flowering												
	Fruiting												
5	*Albizia lophantha* (Willd.) Bth.												
	Flowering												
	Fruiting												
6	*Astronia spectabilis* Bl.												
	Flowering												
	Fruiting												
7	*Cinnamomum burmanni* (Nees) Blume												
	Flowering												
	Fruiting												
8	*Cinnamomum parthenoxylon* Meisn.												
	Flowering												
	Fruiting												
9	*Dacrycarpus imbricatus* (Blume) de Laub.												
	Flowering												
	Fruiting												
10	*Distylium stellare* O.K.												
	Flowering												
	Fruiting												
11	*Engelhardia spicata* Bl.												
	Flowering												
	Fruiting												

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Table 2: (*continued*)

		Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
12	*Eurya acuminata* DC.												
	Flowering												
	Fruiting												
13	*Ficus fistulosa* Reinw. Ex.												
	Flowering												
	Fruiting												
14	*Ficus padana* Burm.f.												
	Flowering												
	Fruiting												
15	*Ficus ribes* Reinw.												
	Flowering												
	Fruiting												
16	*Glochidion arborescens* Bl.												
	Flowering												
	Fruiting												
17	*Helicia cf. javanica*												
	Flowering												
	Fruiting												
18	*Helicia serrata* (R. Br.) Bl.												
	Flowering												
	Fruiting												
19	*Kibessia azurea* Bl.												
	Flowering												
	Fruiting												
20	*Lasianthus spp.*												
	Flowering												
	Fruiting												
21	*Lithocarpus cf. piriformis*												
	Flowering												
	Fruiting												
22	*Lithocarpus sundaicus* (Blume) Rehder												
	Flowering												
	Fruiting												

(*continued on next page*)

Table 2: (*continued*)

		Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
23	*Lithocarpus dolichocarpa* Rehder												
	Flowering												
	Fruiting												
24	*Lithocarpus elegans* (B.) Hatus ex. Supadmo												
	Flowering												
	Fruiting												
25	*Lithocarpus* sp.												
	Flowering												
	Fruiting												
26	*Litsea citrata* Blume												
	Flowering												
	Fruiting												
27	*Macropanax dispermus* (Bl.) O.K.												
	Flowering												
	Fruiting												
28	*Manglietia glauca* Bl.												
	Flowering												
	Fruiting												
29	*Myryca javanica* Reinw. ex Bl.												
	Flowering												
	Fruiting												
30	*Omalanthus populneus* (Geisel.) Pax.												
	Flowering												
	Fruiting												
31	*Pittosporum moluccanum* (Lam.) Miq.												
	Flowering												
	Fruiting												
32	*Podocarpus neriifolius* D. Don.												
	Flowering												
	Fruiting												
33	*Polyosma illicifolia* Bl.												
	Flowering												
	Fruiting												

(*continued on next page*)

Table 2: (*continued*)

		Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
34	*Psychotria montana* Bl.												
	Flowering												
	Fruiting												
35	*Pyrenaria serrata* Bl.												
	Flowering												
	Fruiting												
36	*Saurauia pendula* Blume												
	Flowering												
	Fruiting												
37	*Schefflera lucescens* (Bl.) Vig.												
	Flowering												
	Fruiting												
38	*Schima wallichii* (DC.) Korth												
	Flowering												
	Fruiting												
39	*Symplocos fasciculata* Zoll.												
	Flowering												
	Fruiting												
40	*Symplocos theaefolia* D. Don												
	Flowering												
	Fruiting												
41	*Syzygium glomeruliferum* Amsh.												
	Flowering												
	Fruiting												
42	*Syzygium gracile* (Korth.) Amsh.												
	Flowering												
	Fruiting												
43	*Weinmannia blumei* Planch.												
	Flowering												
	Fruiting												

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