

Diversity of Araceae in Mixed Deciduous Forest at Khlong Wang Chao National Park, Thailand

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Abstract— Araceae species were surveyed and studied in mixed deciduous forest (MDF) by strip plot method, 50 plots, size 10 m x 10 m, along the two nature trails in Khlong Wang Chao National Park, Kamphaeng Petch Province in north-central Thailand from May 2018 to February 2019, along Khlong Wang Chao Waterfall Nature Trail, at 220-290 meters above mean sea level (m amsl), and Khlong Samow Klauy Waterfall Nature Trail at 220-300 m amsl. Fourteen species in eight genera were recorded; *Amorphophallus* 5 species, *Alocasia* and *Colocasia* 2 species each, *Arisaema*, *Hapaline*, *Lasia*, *Scindapsus* and *Typhonium* had only one species in each. The top five of highest importance value index (IVI%) in the wet season were *Scindapsus officinalis* (Roxb.) Schott, *Hapaline benthamiana* Schott, *Colocasia esculenta* (L.) Schott, *Lasia spinosa* (L.) Thwaites and *Amorphophallus paeoniifolius* (Dennst.) Nicols (79.80, 58.36, 19.35, 15.18 and 9.52%, respectively). Four species were evergreen and found all year, but other ten species were deciduous and disappear in the dry season.

Index Terms— Araceae, diversity, ecology, importance value index, mixed deciduous forest

1 INTRODUCTION

Araceae diversity and distribution in three national parks of Chiang Mai Province in northern Thailand; Doi Inthanon, Doi Suthep-Pui and Mae Takhrui National Park were studied during 2013-2018. Fourteen genera and 33 species were recorded in deciduous dipterocarp forest (DDF), mixed deciduous forest (MDF), dry evergreen forest (DEF), lower montane forest (LMF) and upper montane forest (UMF) along the elevation at 300-2,565 meters above mean sea level (m amsl). Twenty species were terrestrial, seven species were epiphyte and 3 species were aquatic plants [1], [2], [3].

Kamphaeng Petch Province in north-central Thailand has three national parks; Khlong Wang Chao, Khlong Lan and Mae Wong National Park, located on apart of Thanon Thongchai Range, and rest from northern to southern Thailand. Khlong Wang Chao National Park, 747 square kilometers, has located on Amphoe Kosumpee Nakorn and Amphoe Khlong Lan in Kamphaeng Petch Province and Amphoe Wang Chao in Tak Province. This national park has been constructed by Thailand Government on August 29th, 1990 and was disturbed by local people before. The highest peak is 1,898 meters above mean sea level (m amsl). Average temperature is 26°C, average rainfall is 1,318 mm/year [4]. This area is importance for being the upstream forest of central Thailand. The canals and waterfalls in this area flow into the Ping River [5], the most importance river in northern Thailand which flow into the Chao Phraya River, the biggest river in central Thailand [6].

Almost forest type of this national park is mixed deciduous forest (MDF), and the other parts are montane forest (MF), dry

evergreen forest (DEF), dry dipterocarp forest (DDF), grassland, natural forest restoration area, agricultural area and abandoned farmland (Fig.1).

The local people and hill tribes nearby could not be permitted to collect wild plants or hunt wildlife for their daily life or trading. This national park also has the resort and camping area for service people, student and pupils who need to study on the natural areas [4]. Plant species always distribute along the canals and waterfalls and must be disturbed by the visitors trampling or flash flood and soil erosion in the rainy season or forest fire by people in the summer like the other national parks.

From the national park reported, the record about Araceae diversity and ecology was still not done. Thus, the project for survey and study about aroid ecology for comparing to the three national parks in Chiang Mai Province were planned and recorded.

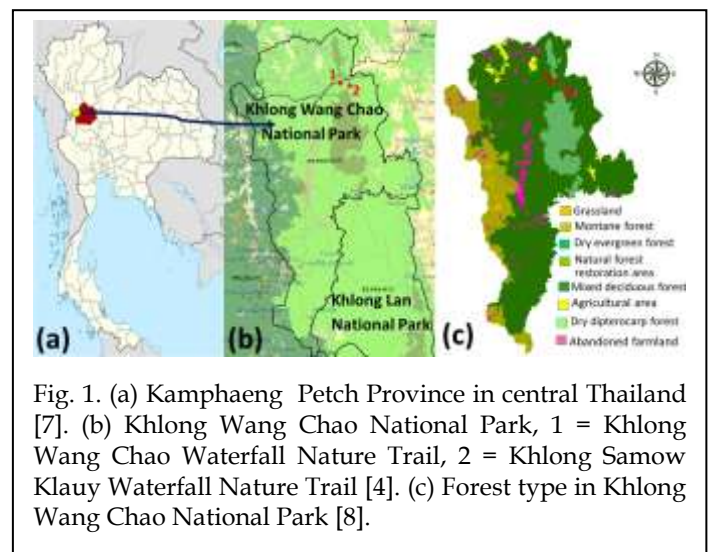


Fig. 1. (a) Kamphaeng Petch Province in central Thailand [7]. (b) Khlong Wang Chao National Park, 1 = Khlong Wang Chao Waterfall Nature Trail, 2 = Khlong Samow Klauy Waterfall Nature Trail [4]. (c) Forest type in Khlong Wang Chao National Park [8].

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2 MATERIALS AND METHODS

2.1 Study site

The study sites were surveyed and recorded in May 2018 along the two nature trails of Khlong Wang Chao National Park, Amphoe Kosumpee Nakorn, Kamphaeng Petch Province in north central Thailand.

The data were recorded three times in the permanent strip plots in July and November 2018, and January 2019. The strip plot method was used in each nature trail, the 50 plots, each plot size was 10 m x 10 m along 1) Khlong Wang Chao Waterfall Nature Trail started at 16°30'08" N 99°09'52" E, at 220-290 m amsl, and 2) Khlong Samow Klauy Waterfall Nature Trail started at 16°30'11" N 99°10'04" E, at 220-300 m amsl (Fig. 1.).

Soil along the nature trail in MDF was loamy skeletal, dark brown, well drained, shallow surface with high organic matter, thick litter layer under shade of trees, covered by sand stone around 10%. Soil along the canals and waterfalls was sandy and stony. All of study plots were cover by stone around 70-90%.

Five dominance tree species species in the top canopy were Teak (*Tectona grandis* Linn.f.), Burma padauk (*Pterocarpus macrocarpus* Kurz), Iron wood (*Xylia xylocarpa* Taub. var. *kerrii* Nielsen), Rosewood (*Dalbergia oliveri* Gamble ex Prain.) and Black Rosewood (*Azelia xylocarpa* (Kurz) Craib). Bamboos; *Gigantochloa albolocciata* (Munro) Munro and Tinwa bamboo (*Cephalostachyum pergracile* Munro) found in middle canopy, Many bushes and terrestrial plants were on the forest floor [4], [9], [10].

2.2 Data collection

Data were observed and recorded four times in summer, rainy season and winter during May 2018 to January 2019. The seasonal change and Araceae species; individual number, habit and life forms were surveyed, recorded, photographed and collected for herbarium specimen.

2.3 Data analysis

Species diversity and species number were calculated to species index by Shannon-Wiener Index, H' at (1) [11].

$$H' = - \sum_{i=1}^S pi \ln pi \quad (1)$$

where, H' = the Shannon index; S = number of species; pi = the proportion of individuals or abundance of the i^{th} species; \ln = log base e .

The important value index (IVI%) of each species was used to evaluate the dominant species in the study site [12].

$$IVI\% = RD + RF \quad (2)$$

where, RD = relative density; RF = relative frequency.

2.4 Classification

Species were identified and classified to established dichotomous key of Araceae in this national park by comparing to the standard taxonomy textbook [13], [14], journal [15], [16] and website [17], [18].

3 RESULTS AND DISCUSSION

3.1 The seasonal change

It rained very hard in the rainy season and flash flood happened many times in October, 2018. Some study plots along the canals were disturbed and many plants were disappeared from the study site.

In dry season, the weather is cold and drought in the winter, but very hot in the summer. Many Araceae species were not found because very high light intensity and drought in the dry season. The distribution of some species still showed densely under shade of trees and nearby the canals. Soil moisture in each season is also the main effect to Araceae distribution like the reported in Doi Inthanon National Park [1], Doi Suthep-Pui National Park [2] and Mae Takhrui National Park [3].

3.2 Araceae diversity

Four species in three genera were evergreen; *Alocasia acuminata* Schott, *Colocasia esculenta* (L.) Schott, *Colocasia* sp. and *Lasia spinosa* (L.) Thwaites. The other ten in five genera were deciduous; *A. hypnosa* J.T.Yin, Y.H. Wang & Z.F.Yu, *Amorphophallus krausei* Engl., *A. macrorhizus* Craib, *A. muelleri* Blume, *A. paeoniifolius* (Dennst.) Nicols., *Amorphophallus* sp., *Arisaema maxwellii* Hett. & Gusman, *Hapaline benthamiana* Schott, *Scindapsus officinalis* (Roxb.) Schott and *Typhonium trilobatum* (L.) Schott (Table 1). One species of *Amorphophallus* and *Colocasia* in each could still not identified species.

Colocasia esculenta, *Colocasia* sp. and *Lasia spinosa* were helophyte, always grew along the canals and the waterfalls. *Alocasia hypnosa* was geophyte and/or lithophyte, *Scindapsus officinalis* was epiphyte and/or lithophyte. The other nine species were geophyte (Table 1).

From the recorded in mixed deciduous forest of Mae Takhrui, Doi Suthep-Pui and Doi Inthanon National Park, found 10 species in seven genera, four species in three genera and four species in four genera, respectively (Table 2), while in this study was found 14 species in eight genera (Table 1).

The results showed that diversity and distribution of Araceae in the same elevation and forest type were difference if not in the same latitude. The species diversity should be higher at the lower latitude than the upper latitude which average temperature was also higher. T. B. Croat reported in 1988 that Araceae diversity was lower at the high latitude from 36° south latitude to temperate region latitude in America or New Worlds [19].

3.3 Species index

Species index between seasons were difference. This value was highest in the wet season, and lower in dry season. The data in Khlong Wang Chao Waterfall Nature Trail were 1.33 in the wet season and decreased to 1.09 and 0.21 in the dry season. In Khlong Samow Klauy Waterfall Nature Trail, the data were 1.28 and decreased to 1.36 and 0.93 in the same time. The values were vary to season like the reports in three national parks in Chiang Mai [1], [2], [3].

TABLE 1 Araceae species in Khlong Wang Chao National Park, habit, life form and the importance value index (IVI%) in July 2018.

Species	Habit ^a	Life form ^b	IVI%
1. <i>Alocasia acuminata</i> Schott	E	Geo	3.11
2. <i>Alocasia hypnosa</i> J.T.Yin, Y.H. Wang & Z.F.Yu	D	Geo/ Lith	0.75
3. <i>Amorphophallus krausei</i> Engl.	D	Geo	1.32
4. <i>Amorphophallus macrorrhizus</i> Craib	D	Geo	4.29
5. <i>Amorphophallus muelleri</i> Blume	D	Geo	4.71
6. <i>Amorphophallus paeoniifolius</i> (Dennst.) Nicols.	D	Geo	9.52
7. <i>Amorphophallus</i> sp.	D	Geo	2.10
8. <i>Arisaema maxwellii</i> Hett. & Gusman	D	Geo	0.84
9. <i>Colocasia esculenta</i> (L.) Schott	E	Helo	19.35
10. <i>Colocasia</i> sp.	E	Helo	0.66
11. <i>Hapaline benthamiana</i> Schott	D	Geo	58.36
12. <i>Lasia spinosa</i> (L.) Thwaites	E	Helo	15.18
13. <i>Scindapsus officinalis</i> (Roxb.) Schott	D	Epi/ Lith	79.80
14. <i>Typhonium trilobatum</i> (L.) Schott	D	Geo	- ^c
Total			200

^a Habit; E = evergreen, D = deciduous

^b Life form; Geo = Geophyte, Helo = Helophyte, Epi = Epi-phyte, Lith = Lithophyte

^c No data for this species because found this species outside study plot.

3.4 The importance value index

The importance value index (IVI%) could show the highest species number and individual number of each species. In the rainy or wet season, in June 2018, the top five IVI% (Table 1) were *Scindapsus officinalis* (79.80%), *Hapaline benthamiana* (58.36%), *Colocasia esculenta* (19.35%), *Lasia spinosa* (15.18%) and *Amorphophallus paeoniifolius* (9.52%).

In the winter or dry season, from 2018 to 2019, *Colocasia esculenta* had highest IVI% (78.40 and 151.78%, respectively) while many species had very low value or only 0% because of the dormancy. This dominance species also show highest IVI% along the canals and rivers in the arid season like the reported in Doi Suthep-Pui and Mae Takhray National Park [2], [3].

In this study, *Typhonium trilobatum* was not in the study plot. Then, the data of individual species were not recorded for calculation to species index and IVI%.

3.5 Phenology and dispersal

Flowering and fruiting of Araceae in this protected area found clearly on the ground under shade of trees and bamboo in the rainy season by white and tiny inflorescences of *Hapaline benthamiana* and showed the tiny white fruits later. *Arisaema maxwellii* and *Colocasia esculenta* were flowering and fruiting in the rainy season and fruits were ripe in the winter. *Amorphophallus*

TABLE 2 Araceae species in mixed deciduous forest (MDF) of Mae Ta Khrai, Doi Suthep-Pui and Doi Inthanon National Park were reported during 2013 to 2018 [1], [2], [3].

Species	Mae Ta Khrai	Doi Suthep-Pui	Doi Inthanon
1. <i>Alocasia acuminata</i> Schott	✓	✓	-
2. <i>Alocasia hypnosa</i> J.T.Yin, Y.H. Wang & Z.F.Yu	✓	-	-
3. <i>Alocasia navicularis</i> (K.Koch & C.D.Bouché)	-	✓	-
4. <i>Amorphophallus krausei</i> Engl.	✓	-	-
5. <i>Amorphophallus macrorrhizus</i> Craib	✓	-	✓
6. <i>Colocasia esculenta</i> (L.) Schott	✓	✓	✓
7. <i>Hapaline benthamiana</i> Schott	✓	-	-
8. <i>Homalomena aromatica</i> (Spreng.) Schott	✓	-	-
9. <i>Lasia spinosa</i> (L.) Thwaites	✓	-	✓
10. <i>Lemna</i> sp.	-	✓	-
11. <i>Rhaphidophora chevalieri</i> Gagnep.	✓	-	-
12. <i>Rhaphidophora peepla</i> (Roxb.) Schott	✓	-	-
13. <i>Typhonium roxburghii</i> Schott	-	-	✓

macrorrhizus and *A. paeoniifolius* were flowering in the late summer to early rainy season and fruits were ripe in the late winter to early summer. *Lasia spinosa* showed flowering and fruiting in the dry season to the rainy season. The time of flowering and fruiting were the same like the study in three national parks in Chiang Mai Province [1], [2], [3].

3.6 Key to Araceae species

In this study, many species did not show the inflorescences and infructescences in data collection periods because it was not flowering and fruiting season and many plants were still young [20]. Thus, leaf morphology, stem morphology and life form of Araceae were identified and classified to establish dichotomous key (Fig. 2., Fig. 3.).

- 1. Simple leaf.....2
- 1. Compound leaf.....9
- 2. Aerial stem, epiphyte or lithophyte.....*Scindapsus officinalis*
- 2. Underground stem, geophyte, helophyte or lithophyte.....3
- 3. Young and mature leaf shape different.....4
- 3. Young and mature leaf shape not different.....5
- 4. Petiole prickle, leaf dark green, mature leaf margin pinnatifid.....*Lasia spinosa*
- 4. Petiole smooth, leaf pale green to bluish green, mature leaf three lobes.....*Typhonium trilobatum*
- 5. Petiole white to dark green, geophyte or lithophyte.....6
- 5. Petiole pale green to purplish green, helophyte.....8
- 6. Petiole white, leaf number 1-2, leaf green, green and white or green and grey.....*Hapaline benthamiana*
- 6. Petiole pale green or dark green, leaf numerous, leaf bright green or dark green.....7

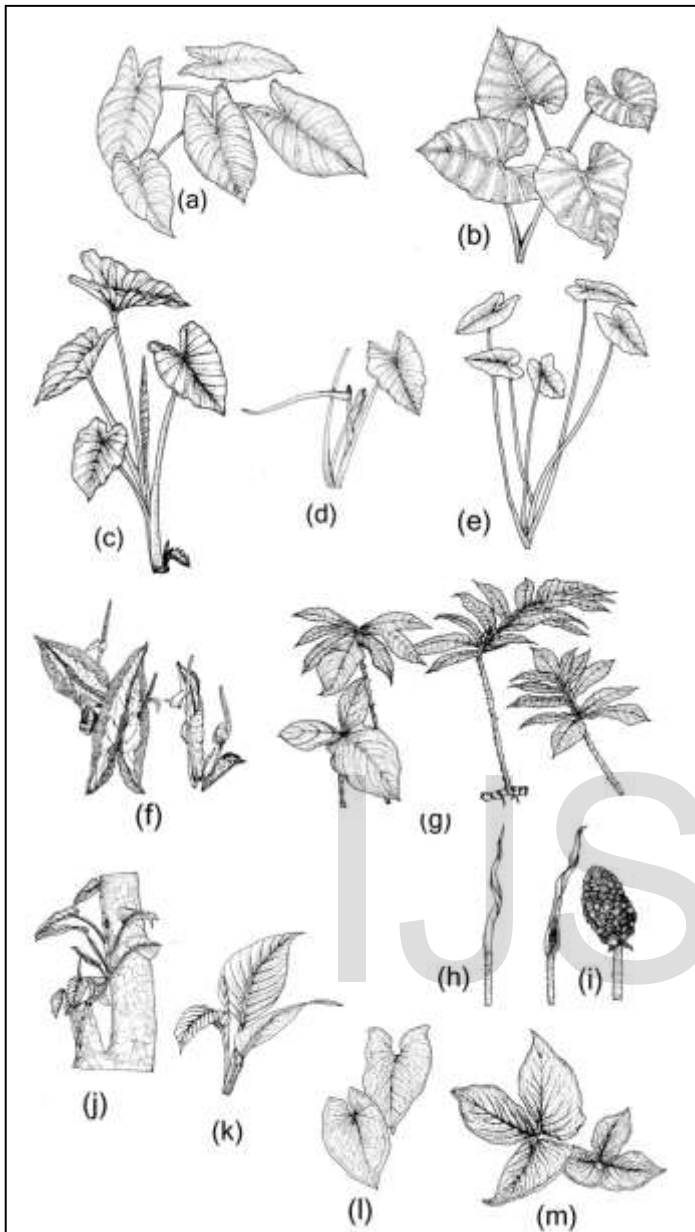


Fig. 2. Araceae, simple leaf. (a) *Alocasia acuminata* Schott (b) *Alocasia hypnosa* J.T.Yin, Y.H. Wang & Z.F.Yu (c)-(d) *Colocasia esculenta* (L.) Schott (d) Inflorescence (e) *Colocasia* sp. (f) *Hapaline benthamiana* Schott with inflorescence and infructescence (g)-(i) *Lasia spinosa* (L.) Thwaites (g) Young leaves had no lobes and mature leaves had many pinnately lobes (h) Inflorescence (i) Ripe fruits on infructescence (j)-(k) *Scindapsus officinalis* (Roxb.) (j) Epiphyte life form. (k) Shoot tip. (l)-(m) *Typhonium trilobatum* (L.) Schott (l) Young leaves had no lobes. (m) Mature leaves with three lobes.

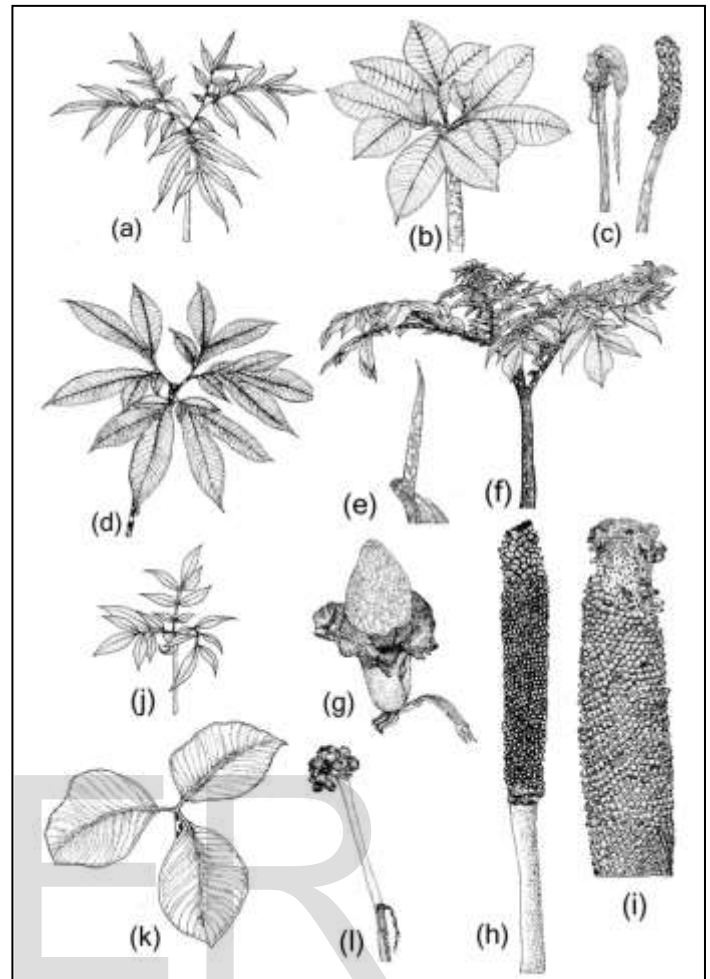


Fig. 3. Araceae, compound leaf. (a) *Amorphophallus krausei* Engl. (b)-(c) *Amorphophallus macrorhizus* Craib (b) Mature leaf (c) Young and mature fruits on infructescence. (d) *Amorphophallus muelleri* Blume (e)-(i) *Amorphophallus paeoniifolius* (Dennst.) Nicols. (e) Young leaf in bract (f) Mature leaf (g) Inflorescence (h) Young fruit on infructescence (i) Ripe fruits on infructescence (j) *Amorphophallus* sp. (k)-(l) *Arisaema maxwellii* Hett. & Gusman (k) Mature leaf. (l) Ripe fruits on infructescence.

- 7. Petiole pale green, leaf glossy bright green, geophyte or Lithophyte, leaf shape deltoid.....*Alocasia hypnosa*
- 7. Petiole dark green, leaf dark green, geophyte, leaf shape lanceolate to ovate.....*Alocasia acuminata*
- 8. Leaf pale green to green, smooth with white glaucous, margin undulate.....*Colocasia esculenta*
- 8. Leaf glossy dark green, margin entire to less wavy*Colocasia* sp.
- 9. Leaflet number 3, dark glossy green.....*Arisaema maxwellii*
- 9. Leaflet numerous, green, dark green or bluish green.....10
- 10. Petiole smooth surface.....11
- 10. Petiole rough surface.....13
- 11. Petiole without stripe or scatter.....*Amorphophallus* sp.
- 11. Petiole with stripe or scatter.....12

12. Brown or white scatter, brown and global bulbils on petiolules.....*Amorphophallus muelleri*
12. Dark green stripe or scatter, no bulbils on petiolules.....*Amorphophallus krausei*
13. Petiole surface scale or hairy, scatter white, reddish brown, purplish red, leaflet bluish green.....*Amorphophallus macrorrhizus*
13. Petiole surface papillae, scatter pale green to blackish green, leaflet green.....*Amorphophallus paeoniifolius*

3.7 The utilization

The local people nearby the national park could not pick wild plants in the national park for any utilization, was same as in Doi Suthep-Pui National Park [2]. This protected area is suitable for vegetation conservation and giving knowledge about ecology and wild plants species to the people.

However, most of Araceae species in Thailand are still in the status at least concern (LS) by the category of the international Union for Conservation of Nature and Natural Resources (IUCN) in the IUCN Red List of Threatened Species [21]. The threats by people or anthropogenic disturbances to Araceae was also reported in Mexico [22]. Sustainable conservation should be the best plan for the stable of diversity and distribution of Araceae and any wild plants.

4 CONCLUSION

Araceae species in MDF at 220-300 m amsl of two nature trails at Khlong Wang Chao National Park were found 14 species in eight genera. Species index and species number were highest in the rainy season. The dominant species in the wet season was *Scindapsus officinalis*, but in the dry season was *Colocasia esculenta* Schott. The seasonal change showed the effect on Araceae habit, life form and habitat.

ACKNOWLEDGEMENT

We would like to thank to the Faculty of Liberal Arts and Science, the Faculty of Forestry, Kasetsart University, the research team and local people from Khlong Wang Chao National Park, Kamphaeng Petch Province, The Department of National Parks, Wildlife and Plant Conservation, families and friends in Thailand. This work was supported by a grant from the Department of Botany, Faculty of Liberal Arts and Science, Kasetsart University, Kamphang Saen Campus, Nakhon Pathom Province.

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