



Original Article

Orchids on Phu Kradueng's plateau

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Abstract

Phu Kradueng plateau is the table-top mountain whose altitude ranges from 1,100m to 1,350m and harbors the large area of lower montane coniferous forest and lesser area of lower montane rain forest with many waterfalls. Sporadic floristic exploration has been made for as long as 60 years but no more than 60 species of orchids had ever recorded. Thus, the intensive orchid exploration in Phu Kradueng plateau was conducted from October, 2014 to February, 2016. Together with herbarium specimens and orchid's census data, it was suggested that as many as 111 species of orchids should have been found on the plateau. Thus far, however, only 78 species had been recorded, and as many as 33 species still have not been seen in this study. Possible causes include illegal smuggling of wild orchids, habitat losses and changes caused by severe wild fires and climate changes.

Keywords: orchids, Phu Kradueng National Park, Loei

1. Introduction

Orchidaceae is one of two largest families of flowering plants, consisting of about 27,800 accepted species in 736 recognize genera of 5 subfamilies (Chase *et al.*, 2015; The Plant List, 2015). Orchids distribute world-wide except in desserts (Steven, 2016). In Thailand, Chayamarit *et al.* (2014) enumerated the list of orchids to be 1,169 species. However, since then there had been reports of new species (Gale *et al.*, 2013; Tippayasri & Ngernsaengsaruy, 2012) and new records (Nuammee *et al.*, 2016; Rojchana-umpawan *et al.*, 2014). Many orchids could be found throughout Thailand, though some exhibit restricted range of distribution to certain geographic areas or habitats. Currently, most orchids are disappearing and can only be seen in National Parks, Wildlife

Sanctuaries, Forest Parks, and reserved forest. However, the Orchidaceae in the "Flora of Thailand" has not been completed; reports on area-based "catalogs" of orchids still remain largely undone. Thus far, published works were those in Nam Nao National Park (Tokaew & Chantaranonthai, 2009) and Phu Ruea National Park (Kongbangkerd, 2007) while many remain unpublished, e.g., Khao Khaio, Khao Yai National Park (Buakhlai, 2005), Thung Salaeng Luang National Park (Phueakhlai, 2011), and Phu Luang Wildlife Sanctuary (Kasetluksamee, 2014). Surprisingly, despite reports from nearby national parks and sanctuaries, Phu Kradueng National Park remains under-studied for a long time and thus its assessment on orchid diversity is much needed.

Phu Kradueng National Park (Figure 1) is located in Loei province in northeastern Thailand. The national park covers the area of 348.12 km², of which 60 km² is of heart-shaped plateau top. Geographically, it consists of sandstone, low-altitude mountains surrounding a huge plateau top. The altitude is graduated from 400 to about 1,000 meter and

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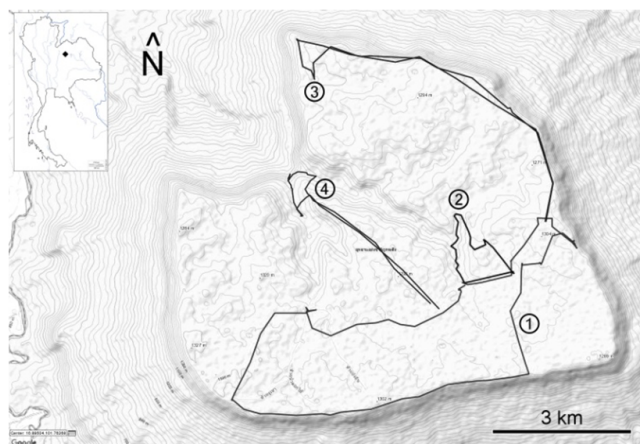


Figure 1. Top view of Phu Kradueng's plateau with the field exploration trails (black). (1) PhraKeaw-Lomsak trail, (2) waterfalls trail, (3) Pha Song Lok trail and (4) Khun Phong waterfall trail.

abruptly nearly plateau top to 1,200 meters above mean sea level (AMSL) with 1,316 meters AMSL at Khok Moei, the summit of the national park (Department of National Park, Wildlife and Plant Conservation [DNP], 2015). Lower montane rain forest occupies two-thirds of area and harbors many waterfalls and large streams. Whilst, lower montane coniferous forest takes up the rest, its canopy is much opened with understory of dominantly grasses, *Pteridium aquilinum* (L.) Kuhn and *Dicranopteris linearis* (Burm.f.) Underw. var.

linearis and interrupted by small-to-large scale sandstone outcrop and dense, low-rise *Melastoma malabathricum* L. It also has small streams passing through (Tourism Authority of Thailand, 2000). Phu Kradueng National Park is also the headwater of Phong River, one of important river systems of the northeast Thailand watersheds.

There have been many, though sporadic, exploration to Phu Kradueng National Parks since 1946, based on investigation of herbarium specimens deposited at the Forest Herbarium (BKF). Yet, there is not report accounting for the diversity of orchids in this national park. Therefore, the primary aim is to enumerate orchids in Phu Kradueng National Park by intensive exploration.

2. Materials and Methods

Field exploration was conducted on plateau top of Phu Kradueng National Park which comprised of two main trails (Figure 1). The first trail was ca. 17 km along lower montane coniferous forest and the second one was ca. 4.8 km along the lower montane rain forest and two more trails to Pha Song Lok trail and Khun Phong Waterfall trail were visited once (Figure 2). To cover all seasons, orchid collection were conducted from October 2014 to February 2016, in total of 12 field collections. Plant were collected for preparing as either dry or spirit specimens followed method of Forman and Bridson (1991), photographed and recorded localities by a global positioning system receiver (Garmin ETrex VISTA HCx). Field notes in fruiting period, host texture or soil type



Figure 2. Vegetation types on the plateau of Phu Kradueng National Park. (A) Lower montane coniferous forest. (B) Area with sandstone outcrop found in the lower montane coniferous forest. (C-D) Lower montane rain forest. (E) Pha Song Lok trail, grassland area intermixed with lower montane rain forest. (F) Khun Phong waterfall trail.

and other ecological information were also recorded. Identification was based on publications of Seidenfaden (1973, 1975, 1977, 1978, 1979, 1982, 1983, 1986) as well as Flora of Thailand Volume 12 Part 1 (Pedersen *et al.*, 2011) and Part 2 (Pedersen *et al.*, 2014). Furthermore, Floras from nearby area also were consulted such as “Flora of China” (Sing-chi *et al.*, 2009). Additionally, herbarium specimens from following herbaria BCU, BKF, BK and KKU were investigated. Voucher specimens were kept in BKF.

3. Results and Discussion

In total, 78 species of orchids were found on Phu Kradueng’s plateau (including the orchid specimens that identified to genera) (Table 1). Orchid specimens belonged to five subfamilies, 36 genera. As many as 69 species are in Epidendroideae of which are *Dendrobium* 12 species and *Bulbophyllum* 11 species. Ochidoideae was found five species in four genera, and one species in each of Apostasioideae, Vanilloideae and Cypridioideae.

3.1 Habitats of orchids

Orchids on plateau of Phu Kradueng National Park were found in three habitats, i.e., 28 epiphytic, 23 terrestrial (including mycotrophic), 21 lithophytic and six as epiphyte and lithophyte (Table 1). Most of epiphytes belong to *Dendrobium* (12 species), as *Dendrobium* is the large genus in Thailand (Goh & Kluge, 1989), and they were found on tree trunk or branches in both vegetation types. In addition, most of orchids found in lower montane coniferous forest were on the high branches of pine tree but in lower montane rain forest most of them were on tree trunk.

In 23 terrestrial species, four species are mycotrophic orchids which were found only in lower montane rain forest. Another six terrestrial species, e.g. *Arundina graminifolia* (D. Don) Hochr. subsp. *graminifolia*, *Habenaria acuífera* Wall. ex Lindl., *Pachystoma pubescens* Blume were found in lower montane coniferous forest especially in very sunny area intermixed with grasses or *Imperata cylindrica* (L.) Raeusch. Although this habitat is less in proportion, 17

Table 1. Orchids found on the plateau top of Phu Kradueng National Park in this study. Abbreviation for Abundance: A = abundance, F = few, R = rare; for Habit: EO = epiphytic orchid, TerO = terrestrial orchid, LO = lithophytic orchid; for Forest type: LMCF = lower montane coniferous forest, LMRF = lower montane rain forest, SO = sandstone outcrop.

Scientific name	Altitude (m)	Flowering	Fruiting	Abundance	Habit	Forest type
<i>Acanthophippium</i> sp.	1104	N/A	Aug	R	TerO	LMRF
<i>Acriopsis indica</i> Wight	1257-1276	Mar, Aug	N/A	R	EO	LMCF
<i>Aerides falcata</i> Lindl. & Paxton	1227-1272	May	N/A	R	EO	LMCF
<i>Anoectochilus roxburghii</i> (Wall.) Lindl.	1204	Nov-Dec	Dec	A	TerO	LMRF
<i>Anthogonium gracile</i> Wall. ex Lindl.	1271	Nov	N/A	R	TerO	LMRF
<i>Aphyllorchis montana</i> Rchb. f.	1180-1202	Aug	Sep-Oct	A	TerO	LMCF/LMRF
<i>Apostasia nuda</i> R. Br.	1269	Nov	N/A	R	TerO	LMRF
<i>Appendicula cornuta</i> Blume	1200-1300	Oct-Dec, Jul	Jan	A	LO	LMRF
<i>Arundina graminifolia</i> (D. Don) Hochr. subsp. <i>graminifolia</i>	1236	Aug	Aug-Sep	F	TerO	LMCF
<i>Bulbophyllum affine</i> Wall. ex Lindl.	1257	May	N/A	F	EO	LMRF
<i>Bulbophyllum blepharistes</i> Rchb. f.	1237	Oct	N/A	A	LO	SO
<i>Bulbophyllum capillipes</i> Par. & Rchb. f.	1250	Apr	N/A	F	LO	LMRF
<i>Bulbophyllum dayanum</i> Rchb. f.	1241	Dec-Jan	N/A	F	LO	LMRF
<i>Bulbophyllum lobbii</i> Lindl.	1241	Dec-Feb	N/A	A	EO/LO	LMRF
<i>Bulbophyllum morphologorum</i> Kraenzl.	1244	Jan-Feb	N/A	R	LO	LMRF
<i>Bulbophyllum odoratissimum</i> (Sm.) Lindl.	1104	Sep	N/A	F	EO/LO	LMRF
<i>Bulbophyllum orientale</i> Seidenf.	1304	Nov	Dec-Feb	A	LO	LMCF/LMRF
<i>Bulbophyllum rufinum</i> Rchb. f.	1241	Nov	N/A	R	LO	SO
<i>Bulbophyllum spathulatum</i> (Rolfe ex E. Cooper) Seidenf.	1241	Feb-Mar	N/A	R	EO	LMRF
<i>Bulbophyllum</i> sp.	1150	Feb	N/A	F	EO/LO	LMRF
<i>Calanthe cardioglossa</i> Schltr.	1237	Nov	N/A	F	TerO	LMRF
<i>Calanthe lyroglossa</i> Rchb. f.	1207	Oct-Dec	Nov-Mar	R	TerO	LMRF
<i>Calanthe</i> sp.	1104	N/A	Aug	R	TerO	LMRF
<i>Callostylis rigida</i> Blume	1241	Mar-Apr	N/A	A	LO	LMCF
<i>Cephalantheropsis obcordata</i> (Lindl.) Omerod	1186	Nov	N/A	R	TerO	LMRF
<i>Cleisostoma duplicilobum</i> (J. J. Sm.) Garay	1242	Jul	Jul-Aug	R	EO	LMRF

Table 1. Continued

Scientific name	Altitude (m)	Flowering	Fruiting	Abundance	Habit	Forest type
<i>Coelogyne fuscescens</i> Lindl.	1200-1240	Sep-Oct	N/A	R	EO/LO	LMRF
<i>Coelogyne flaccida</i> Lindl.	1269	Feb-Mar	Apr	A	LO	LMCF/LMRF
<i>Coelogyne rigida</i> C. S. P. Parish & Rchb. f.	1104	Jun-Jul	N/A	F	LO	LMRF
<i>Coelogyne trinervis</i> Lindl.	1237	Sep-Oct	Oct	A	LO	SO
<i>Crepidium</i> sp.	1268	N/A	N/A	R	TerO	LMRF
<i>Cryptostylis arachnites</i> (Blume) Hassk.	1239	May, Aug	N/A	R	TerO	LMRF
<i>Cymbidium bicolor</i> Lindl.	1244	Apr	May	F	EO	LMCF
<i>Cymbidium dyanum</i> Rchb. f.	1250	Aug	Sep-Oct	R	EO	LMRF
<i>Cymbidium seidenfadenii</i> (P. J. Cribb & Du Puy) P. J. Cribb	1287	Nov	N/A	R	TerO	LMCF
<i>Dendrobium acinaciforme</i> Roxb.	1237	May	N/A	F	EO	LMCF
<i>Dendrobium christyanum</i> Rchb. f.	1224	May, Aug	Jun-Apr	A	EO	LMCF
<i>Dendrobium chrysotoxum</i> Lindl.	1250	Apr	N/A	F	EO	LMCF
<i>Dendrobium draconis</i> Rchb. f.	1231	Feb	N/A	R	EO	LMCF
<i>Dendrobium ellipsophyllum</i> Tang & F. T. Wang	1100-1200	Dec, Apr	N/A	R	EO	LMRF
<i>Dendrobium farmeri</i> Paxton	1250	Apr	N/A	R	EO	LMCF
<i>Dendrobium henryi</i> Schltr.	1180	Jul-Aug	N/A	R	EO/LO	LMRF
<i>Dendrobium lindleyi</i> Steud.	1237	Mar-Apr	N/A	R	EO	LMRF
<i>Dendrobium signatum</i> Rchb. f.	1272	Apr	N/A	R	EO	LMCF
<i>Dendrobium sinense</i> Tang & F. T. Wang	1268	Sep-Nov	Oct-Apr	F	EO	LMCF
<i>Dendrobium trigonopus</i> Rchb. f.	1250	Mar-May	Apr-May	A	EO	LMCF
<i>Dendrobium</i> sp.	1272	Jun	N/A	F	EO	LMCF
<i>Doritis pulcherrima</i> Lindl.	1237	May-Aug	Jul-Mar	A	LO	SO
<i>Eria lasiopetala</i> (Willd.) Ormerod	1191	Aug	Sep-Oct	A	LO	SO
<i>Eria pannea</i> Lindl.	1241	Apr-May	N/A	A	EO/LO	LMRF
<i>Eria siamensis</i> Schltr.	1150	Feb	N/A	R	EO	LMRF
<i>Gastrochilus rutilans</i> Seidenf.	1206	Oct	N/A	R	EO	LMRF
<i>Gastrodia exilis</i> Hook. f.	1100-1200	Sep-Oct	Oct	F	TerO	LMRF
<i>Habenaria rhodocheila</i> Hance subsp. <i>rhodocheila</i>	1237	Jun-Aug	Jul-Oct	A	LO	LMRF
<i>Habenaria acutifera</i> Wall. ex Lindl.	1272	Oct-Nov	Nov	R	TerO	LMCF
<i>Lecanorchis nigricans</i> Honda	1206	Jul	Aug-Jan	A	TerO	LMRF
<i>Liparis balansae</i> Gagnep.	1206	Jul-Aug	N/A	R	LO	LMRF
<i>Liparis caespitosa</i> (Thouars.) Lindl.	1104	Aug	Aug	F	LO	LMRF
<i>Liparis luteola</i> Lindl.	1100-1200	Dec-Jan	Jan	F	LO	LMRF
<i>Luisia curtisii</i> Seidenf.	1237	Feb-Apr	Apr-May	A	LO	SO
<i>Luisia psyche</i> Rchb. f.	1262	May	N/A	R	EO	LMCF
<i>Mycaranthes floribunda</i> (D. Don) S. C. Chen & J. J. Wood	1241	Feb-Apr	May	F	EO	LMRF
<i>Nephelaphyllum</i> sp.	1198	N/A	N/A	R	TerO	LMRF
<i>Pachystoma pubescens</i> Blume	1264	Mar	N/A	F	TerO	LMCF
<i>Paphiopedilum villosum</i> (Lindl.) Stein var. <i>villosum</i>	1250	Dec-Feb	Feb	R	LO	LMCF
<i>Phaius indochinensis</i> Seidenf. & Ormerod	1266	Nov	Nov-Dec	R	TerO	LMRF
<i>Phaius tankervilleae</i> (Banks) Blume	1250	Feb-Mar	N/A	F	TerO	LMCF
<i>Pholidota articulata</i> Lindl.	1252	May	Jun-Aug	A	EO	LMCF
<i>Pholidota convallariae</i> (C. S. P. Parish & Rchb. f.) Hook. f.	1250	Apr	N/A	R	EO	LMRF
<i>Pholidota imbricata</i> Lindl. ex Hook.	1204	Aug	N/A	A	LO	LMRF
<i>Pinalia eriopsidobulbon</i> (C. S. P. Parish & Rchb. f.) Kuntze	1227	May	N/A	F	EO/LO	LMRF
<i>Polystachya concreta</i> (Jacq.) Garay & H. R. Sweet	1250	Jun	Jun	R	EO	LMCF
<i>Tainia viridifusca</i> (Hook.) Benth. & Hook. f.	1200-1250	Dec-Feb	N/A	R	TerO	LMCF
<i>Thrixspermum centipeda</i> Lour.	1243-1268	May-Aug	Jun-Dec	A	EO	LMCF
<i>Trichotomia dasyphylla</i> (C. S. P. Parish & H. G. Reichenbach)	1232-1309	May	Jun	A	EO	LMCF
<i>Tuberolabium rhopalorrhachis</i> (Rchb. f.) J. J. Wood	1200	May	May	R	EO	LMRF
Unknown mycotrophic orchid	1200-1240	N/A	Nov-Dec	R	TerO	LMRF
<i>Zeuxine affinis</i> (Lindl.) Benth. ex Hook. f.	1236	Feb-Mar	Apr	A	TerO	LMRF

terrestrial orchids prefer shady habitat and very humid to intense sunlight whereas the other six species prefer *vice versa*.

Throughout the lower montane coniferous forest, there are the small-to-large scale sandstone outcrops where extreme temperature occurs between day and night (Gorbushina, 2007). Orchids can survive and have reproductive success on this sandstone outcrop and are considered as true lithophytes, e.g. *Bulbophyllum blepharistes* Rchb. f., *Coelogyne trinervis* Lindl., *Doritis pulcherrima* Lindl., *Eria lasiopetala* (Willd.) Ormerod, and *Luisia curtisii* Seidenf. These orchids are abundant and occupy vast area of outcrops. It seems likely that lichen grows along orchids on sandstone performed as supporter to lithophytic orchids (Favero-Longo & Piervittori, 2010).

3.2 Phenology of orchids

Most of orchids were blooming once a year, the greatest bloom is in May when it is the beginning of rainy season and twelve species were blooming. In November, at the onset of dry season, ten orchid species were bloomed, and at its peak in April, another ten orchid species were flowered. However, compare to the nearby area, Phu Ruae National Park (Anuraktragoon, 2013), flowering period of some species are very different. For examples, *Dendrobium christyanum* Rchb. f. in Phu Ruae National Park was bloomed in September but at the plateau of Phu Kradueng it bloomed mostly in May and a few in August. While *Dendrobium ellipsophyllum* Tang & F.T. Wang at Phu Ruae National Park was flowered in April to September but at the plateau of Phu Kradueng it flowered in December and once more in April. Both species are orchids that produce inflorescences at least twice a year, with a few months apart. Interestingly, these National Parks are separated by less than 100 kilometers, yet some orchids exhibit different flowering periods. Since Phu Kradueng National Park had faced with anomalous climate over the past five years, coupled with the lowest rainfall (Suriyachaiwatthana, unpublished data), thus it was likely that both humidity and temperature had affected on the shifting of flowering times of some orchids on the plateau during that period.

Out of 78 species here, eleven terrestrial orchids will be in resting period after flowering time. Most of these were found in lower montane rain forest (eight species), and 3 species were found in lower montane coniferous forest. These orchids will produce leaves 1-2 months before flowering time and after flowering or fruiting, none of vegetative parts remain.

However, there are three orchids that their flowers have not yet been found during intensive field explorations, only fruits or vegetative parts were collected. The first is a mycotrophic orchid whose fruits appear from October to November. The others are species of *Nephelaphyllum* and *Crepidium*, both are terrestrial.

3.3 Reproductive success

About 55% of orchids (43 species) found on the plateau had no success in pollination, judging from no fruits were found (noted as N/A in Table 1). Most of orchids employ wide array of insects as pollinators (Neiland & Wilcock, 1998), however in field explorations, orchid's visitors such as ants and bees were only observed (Figure 3). Moreover, some orchids are known to utilize another strategies of pollination such as andrombophily (pollinated by rain splashes), e.g. in *Acampe rigida* (Buch.-Ham ex Sm.) P.F. Hunt (Fan *et al.*, 2012) and *Liparis loeselii* (L.) Rich. (Catling, 1980). During 2013-2015, Phu Kradueng experienced long period of drought (Suriyachaiwatthana, unpublished data), possibly due to the climate change, which made impact as lower and shorter rainfall leading to low density of available pollinators (Kamaljit & Dayanandan, 1998) and low or abnormal fruit sets (Bernhardt & Edens-Meier, 2010; Jacquemyn *et al.*, 2009). Accordingly, it is suggested that the factors contribute to low reproductive success may be due to the lack of pollinators and climate change.

3.4 New locality

Apostasia nuda R. Br. was the only species from Apostasioideae found on the plateau top of Phu Kradueng National Park. *A. nuda* R. Br. is distributed in Thailand, Myanmar, Cambodia, Malay Peninsula, and Vietnam but its range is not higher 14.5°N latitudes (Larsen & Vogel, 1972). In previous reported, this species was found in eastern to peninsular part of Thailand, with the upper limit is in Khao Khiao, Nakhonratchasima province (Buakhlai, 2005) where is about the same latitude in Vietnam (Averyanov & Averyanova, 2013). Thus, this study extends the upper limit of *A. nuda* R. Br. to its geographic distribution range. However, its population size in Phu Kradeung National Park remains unknown as accessing hazardous areas is not allowed for safety reasons.

3.5 Previous records of orchids in Phu Kradueng National Park

After much consideration on photographs exhibited at the visitor center, Wang Kwang substation, it was suggested



Figure 3. Visitors found in some orchids (A) A bee visited *Phaius indochinensis* Seidenf. & Ormerod. (B) An ant visited *Eria siamensis* Schltr.

that as many as 60 species of orchids were sighted. However, some have never been found during this intensive field exploration such as *Dendrobium thyrsiflorum* Rchb. f. ex André, *Eria javanica* (Sw.) Blume, *Hygrochilus parishii* (Veitch & Rchb. f.) Pfitzer. Furthermore, indirect, less reliable information gathered from several web sites/web boards/blogs showed a number of orchids not being collected by authors for examples, *Dendrobium parishii* Rchb. f., *Paphiopedilum concolor* (Bateman) Pfitzer, *Spathoglottis affinis* de Vriese. The contradiction is that Siripong Kormanee (pers. comm.), a park ranger, insists that *Paphiopedilum villosum* (Lindl.) Stein var. *villosum*, not *Paphiopedilum concolor*, inhabits Phu Kradueng National Park. Based on information herein, 17 more species should be found on plateau (Appendix A). More reliable information was obtained from herbarium specimens deposited at BKF, accounting for 54 species. Thirty-six species are still found but 16 species have not been found in this study (Table 2).

In total, as many as 33 species may be lost or remains uncovered (Figure 4). There are three reasons accounting for: the first is that many species might be lost due to habitat changes or destroyed, especially terrestrial or lithophytic orchids near the ground, by wild fires that always happen on the plateau top and surrounding mountains every year. After fires, succession is from lower montane forest to lower montane coniferous forest or grassland intermixed with *Pteridium aquilinum* (L.) Kuhn, *Dicranopteris linearis* (Burm. f.) Underw. var. *linearis*, and *Melastoma malabathricum* L. For example in 2013, Phu Kradueng National Park suffered the most severe of forest fires at 64 times and destroyed the area of 1.26 km² in just one incidence (Figure 5) (Suriyachaiwatthana, unpublished data); it occurred along one of field exploration trails. The second reason is due to orchid

smuggling by some huntsmen or even travelers as there are many inaccessible routes to the national park. The last one is that these orchids are in hazardous area where wild elephants roam, and permission to access such area has not been granted due to safety reason. For example Siripong Kormanee, a park ranger, found *Calanthe masuca* (D. Don) Lindl. during

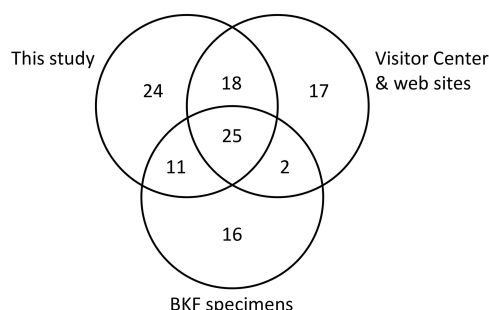


Figure 4. Number of orchid species previously collected and sighted in Phu Kradueng National Park and that in this study.



Figure 5. Wild fire of Phu Kradueng National Park in 2016 (A) Fire destroyed a large area on the plateau of Phu Kradueng National Park (B) Area was clear after fire passed. Photographs by and courtesy of Tipmongkol Kaemongkolsuk.

Table 2. Orchid specimens that were collected from Phu Kradueng National Park in previous explorations as deposited at BKF but authors could not collect new material in this study.

Species	Collected year	Collector No.	Altitude (m)
<i>Bulbophyllum corallinum</i> Tixier & Guillaumin	1958	T. Smitinand 5027	1,200
<i>Bulbophyllum hirtum</i> (Sm.) Lindl.	1958	T. Smitinand 4991	1,300
<i>Eria amica</i> Rchb. f.	1951	T-P 355	1,300
<i>Geodorum recurvum</i> (Roxb.) Alston	1948	Din 479	1,300
<i>Habenaria dentate</i> (Sw.) Schltr.	1948	Dee Bumpheng 336	1,300
<i>Habenaria khasiana</i> Hook. f.	1954	T. Smitinand 1865	1,300
<i>Habenaria reflexa</i> Blume	1989	T. Smitinand 5849	1,200
<i>Habenaria rumphii</i> (Brongn.) Lindl.	1959	T. Smitinand 6120	1,300
<i>Lecanorchis malaccensis</i> Ridl.	2008	S. Suddee, <i>et al.</i> 3584	1,220
<i>Luisia recurva</i> Seidenf.	1951	T. Smitinand 353	1,300
<i>Panisea uniflora</i> (Lindl.) Lindl.	2012	S. Suddee, <i>et al.</i> 4338	1,300
<i>Pecteilis susannae</i> (L.) Raf.	1969	S. P. <i>et al.</i> 36	N/A
<i>Peristylus densus</i> (Lindl.) Santapau & Kapadia	1948	Dee Bumpheng 236	1,300
<i>Peristylus goodyeroides</i> (D. Don) Lindl.	1952	Dee Bumpheng 577	1,300
<i>Pholidota pallida</i> Lindl.	1982	T. 31224	1,200-1,300
<i>Tainia wrayana</i> (Hook. f.) J.J. Sm.	2008	S. Suddee, <i>et al.</i> 3585	1,220

routine patrol in such area but no specimens has been collected.

Herbarium specimens has been proven to be valuable information for long-term studies (Chauvel *et al.*, 2006; Delisle *et al.*, 2003; Gallagher *et al.*, 2009; Mandák *et al.*, 2004; Primack & Miller-Rushing, 2012; Primack *et al.*, 2004), and in this case it shows that some orchids that found since 1946 still exist in this area such as *Dendrobium acinaciforme* Roxb., *D. christyanum* Rchb. f., *Doritis pulcherrima* Lindl., *Eria lasiopetala* (Willd.) Ormerod, *Habenaria acuífera* Wall. ex Lindl., and *Paphiopedilum villosum* (Lindl.) Stein. var. *villosum*. These indicate the success of recruitment of new generations and the concrete evidence for native orchids on the plateau. Thus, it is applicable that the outcome from this study is for better monitoring program and recruitment of native orchids to Phu Kradueng National Park.

3.6 Abundance and conservation

Thirty-five orchid species on plateau are classified into rare status to the area whereas 22 species are abundance and 20 are few (Table 1). Where “rare” is noted, it means those orchids were found only one population and one site on the plateau such as *Apostasia nuda* R. Br., *Gastrochilus rutilans* Seidenf., *Luisia psyche* Rchb. f., *Phaius indochinensis* Seidenf. & Ormerod., *Tainia viridifusca* (Hook.) Benth. & Hook. f.

It is recommended that orchids found no more than ten plants on the plateau must be protect and conserve such as *Cleisostoma duplicilobum* (J. J. Sm.) Garay, *Cymbidium seidenfadenii* (P. J. Cribb & Du Puy) P. J. Cribb, *Tuberolabium rhopalorrhachis* (Rchb. f.) J. J. Wood. However, conservation of wild orchids on Phu Kradueng National Park is difficult to manage, because a large number of visitors. This national park is the 44th place of tourists visiting from 128 national parks in Thailand (DNP, 2014). Also, it is normally destroyed by forest fires every year as mentioned previously. Therefore, conservation process should manage focusing on preventing orchid's habitat, and reducing disturbed area. Furthermore, reintroduce of rare species from another national park is another effective way to increase orchid's populations on the plateau, which is successful in other area e.g. in Australia (Smith *et al.*, 2009) and in Singapore (Yam *et al.*, 2010), but it is importance to aware and carefully of this procedure.

3.7 Threatened species

Two species are enlisted as threatened species, namely *Gastrochilus rutilans* Seidenf., an endemic orchid with endangered status (Maneeanakekul & Sookchaloem, 2012) and *Phaius indochinensis* Seidenf. & Ormerod, a rare and endangered species of Thailand (Plant Genetic Conservation Project, 2016). Moreover, Thailand Red Data based on IUCN had listed 3 more species including *Calanthe cardioglossa* Schltr. with a rare status, *Cymbidium seidenfadenii* (P. J. Cribb & Du Puy) P. J. Cribb and *Paphiopedilum villosum* (Lindl.)

Stein var. *villosum* as vulnerable status (Pooma *et al.*, 2005). Accordingly, it is urgent to maintain specific habit for these orchids so that it can flourish in the area.

4. Conclusions

The intensive field exploration coupled with herbarium specimens deposited at BKF and, to less extend, indirect information at the Visitor Center suggested that 111 species of orchids might have thrived on the plateau top of Phu Kradueng National Park in the past. However, it is also indicated that not only the diversity of orchids may be declining but also the population of each species is reducing. The major contributors including wild fires, illegal smuggling and climate change are more intensified every year and may hinder efforts for *in situ* orchid conservation. Nonetheless, the outcome of this work will surely serve as the base line for the long-term monitoring program and conservation on the diversity of orchid in Phu Kradueng National Park.

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Appendix A

Orchids that have been reported as being present in Phu Kradueng National Park. Species determination was based on photographs at the Visitor Center, Wang Kwang substation and from several websites/web boards/blogs.

1. *Bulbophyllum bittnerianum* Schltr.
2. *Bulbophyllum parviflorum* Parish & Rehb. f.
3. *Bulbophyllum pteroglossum* Schltr.
4. *Cleisostoma linearilobatum* (Seidenf. & Smitin.) Garay
5. *Coelogyne brachyptera* Rehb. f.
6. *Dendrobium compactum* Rolfe ex W.Hackett
7. *Dendrobium heterocarpum* Lindl.
8. *Dendrobium parishii* Rehb. f.
9. *Dendrobium thyrsiflorum* Rehb. f. ex André
10. *Epipogium roseum* (D. Don) Lindl.
11. *Eria javanica* (Sw.) Blume
12. *Hygrochilus parishii* (Veitch & Rehb. f.) Pfitzer
13. *Ornithochilus difformis* (Wall. ex Lindl.) Schltr.
14. *Otochilus fuscus* Lindl.
15. *Podochilus microphyllus* Lindl.
16. *Schoenorchis gemmata* (Lindl.) J. J. Sm.
17. *Spathoglottis affinis* de Vriese