The Medicinal Plants of the Subgenus *Protanthium* (Genus *Kaempferia*, Family Zingiberaceae) in Thailand and Laos

Penjun Meechonkit

A Thesis Submitted in Partial Fulfillment of Requirements for
degree of Doctor of Philosophy in Health Sciences
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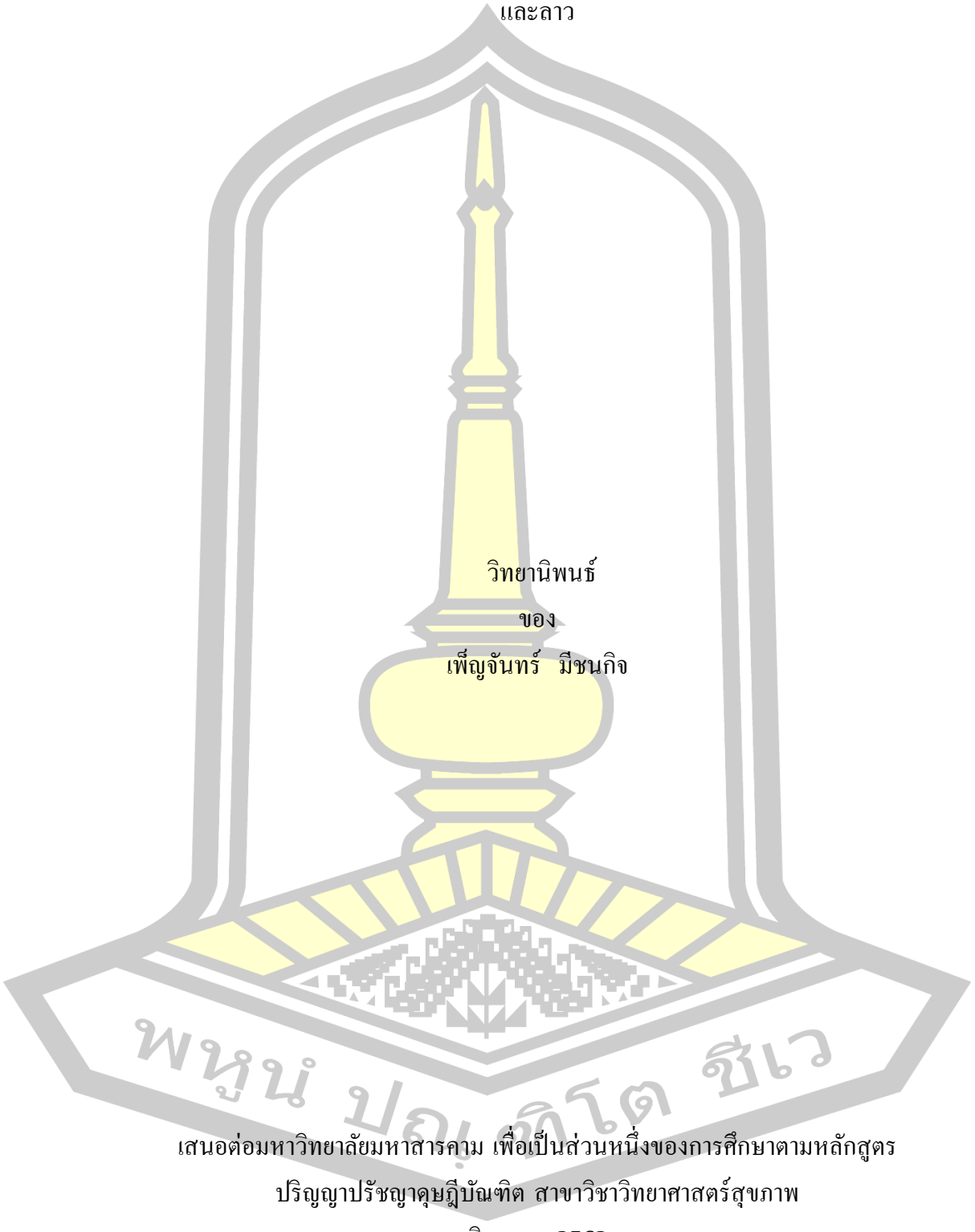

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The examining committee has unanimously approved this Thesis, submitted by Miss Penjun Meechonkit , as a partial fulfillment of the requirements for the Doctor of Philosophy Health Sciences at Mahasarakham University

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TITLE The Medicinal Plants of the Subgenus *Protanthium* (Genus *Kaempferia*, Family Zingiberaceae) in Thailand and Laos

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ABSTRACT

The medicinal plants in subgenus *Protanthium*, genus *Kaempferia* are belonged to the family Zingiberaceae which contain 60 species worldwide. Their locations included the tropical areas of Africa, India, South-East Asia with the center of distribution reported in Thailand. Many medicinal plants in this genus have the potential which can be researched and developed into useful things. This study aimed to study taxonomy, palynology and molecular information of subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos. The subgenus was revised based on investigation of herbarium specimens and living specimens in their natural habitats. The results revealed the subgenus *Protanthium* containing 13 species in Thailand and 1 species in Lao. In total 14 species found in this study, there are 8 species which were newly reported for the first time. They were *K. doisaketensis* Picheans., Meechonk. & Yupparach, *K. grandis* Picheans. & Meechonk., *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan , *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, *K. nakhonsawanensis*, Picheans., Meechonk. & Yupparach., *K. occidentalis* Picheans., Meechonk. & Phokham, *K. takensis* Picheans. & Meechonk. and *K. uttaraditensis* Picheans. & Meechonk. Special emphasis was made on the *K. uttaraditensis* that its flora was very fragrant and bloomed at night, making this plant as a potential medicinal species. Keys to the species with botanical description, distribution, and illustrations of all taxa are provided. The results of palynology found that the pollen grains are subspheroidal shapes and smooth exine all species. Phylogenetic tree of 9 taxa found in Thailand and Laos were also constructed, and the results confirmed morphological determination.

Keyword : Protanthium, Zingiberaceae, Thailand, Laos

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CHAPTER 1
INTRODUCTION

1.1 Background

The genus *Kaempferia* L. can be roughly classified into two groups: The *K. rotunda* and *K. galanga* group. The *K. rotunda* group or the subgenus *Protanthium* is characterized by a short multiflorous inflorescence that appears before the leaves; lamina of this genus was divided two types, i.e., blades not prostrate and horizontal and near the ground, while the latter group comprises species in which the inflorescence has few flowers and is terminal on the leaf-shoots. The genus *Kaempferia* is an early described genus in the family Zingberaceae. The Zingberaceae is an important family of monocotyledonous plants in the world. About 60 genera and ca. 1,500 species of Zingberaceae are represented. (Sirirugsa, 1999). The majority of them were found in the tropical zone of Asia. General characteristics of the plants in this genus are perennial herbs with rhizomes (Picheansoonthon & Koonterm, 2008). The family Zingberaceae were reported in Thailand that there are about 20 genera and ca. 200 species (Larsen, 1996; Larsen & Larsen, 2006). The genus *Kaempferia* L. has long been distributed in tropical Africa, India and throughout Southeast Asia (Sirirugsa, 1989). This genus is comprised of approximately 60 species globally, of which, more than 20 species were reported in Thailand (Techaprasan, 2010). Many species in this genus are used as food and herbal medicines; for example, Wan Pro Hom (ว่านเปราะหอม), Wan Krachai Dum (ว่านกระชายดำ), Wan Thao Nang Haeng (ว่านเต่าหนังแห้ง) (Chuakul & Boonpeng, 2003; Picheansoonthon & Koonterm, 2008). Some of the plants in this genus can be used as elements of rituals based on beliefs; for example, Wan khum-dong (ว่านคุ้มดง), Wan Kam-Bang (ว่านกำบัง) (Picheansoonthon & Koonterm, 2008). Many medicinal plants in this genus have the potentials deserved to be further researched and developed into useful thing from now on.

A large amount of medicinal plant in the genus *Kaempferia* are found in Thailand and Laos. Their morphological appearances are very similar and can make a misunderstanding. The subgenus *Protanthium* are very various so it is difficult to

identify real species of them. Although some study were reported but some doubts about them still occur and only studying them by using a morphological method is not enough. At present, molecular knowledge is used for studying plant taxonomy and others. The genus *Kaempferia* has been studied in genetic makers using various DNA fingerprinting methods such as RAPD. AFLP, and PCR-RFLP in order to accurately confirm. (Tong-a-ram et al., 2005; Kunthonluxsamee, 2008; Theanphong, 2013). As for palynological study, these plants were studied by means of scanning electron microscopy (SEM); for example, the study of plants in a family Convolvulaceae and Bignoniaceae. (Saensouk, 2011). For the family Zingberaceae, there are a few studies such as the study of *Curcuma gracillima* (Saensouk, 2000), *Zingiber idae* (Triboun et al., 2002).

As mentioned before, a foundation knowledge concerning the study of taxonomy, the molecular study of medicinal plant and the study by scanning electron microscopy. All studies shows an important role in helping to identify the plant species which leads to the understanding of the evolutional relation between plants that their related species have not been identified, the understanding of correct medicinal plant selection for uses researching and developing Thai wisdom. Thus, a study of medicinal plants in the subgenus *Protanthium* is important and necessary for building standards of Thai herbs into international standards in the future.

1.2 Research Objectives

The purposed objectives of this research study are as the following.

1. To study taxonomy of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos.

2. To study palynology by using scanning electron microscopy of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos.

3. To study molecular information of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos.

1.3 Scope of Research

This research study covered identification of plants of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos which included taxonomy, palynology by scanning electron microscopy, and molecular study. The DNA was extracted, amplified, and sequenced, the results of which were analyzed and the phylogenetic relationship was proposed.

1.4 Research sites

1. All of herbarium specimens of the genus *Kaempferia* in major Herbaria.
2. Type locations of the genus focused on taxa in Thailand and Laos.
3. Faculty of Medicine, Mahasarakarm University and Faculty of Sciences, Mahidol University.

1.5 The benefits expected

1. To get the data of taxonomy of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos.
2. To get the data of palynology of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos.
3. To get the data of molecular information of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos.

CHAPTER 2
LITERATURE REVIEW

2.1 Plant Taxonomy

Zingberaceae is an important family in the world, comprises around 1,500 species (Sirirugsa, 1999). In Thailand, there are about 20 genera and 200 species (Larsen,1996; Larsen and Larsen, 2006). This family consists of four tribes: tribe Hedychieae, i.e. the genera *Boesenbergia, Caulokaempferia, Cautleya, Curcuma, Curcumorpha, Heniffia, Hedychium, Kaempferia, Scaphochlamys* and *Stahlianthus*; tribe Zingibereae, i.e. the genus *Zingiber*; tribe Alpinieae, i.e. the genera *Alpinia, Amomum, Elettariopsis, Etlingera, Geostachys, Hornstedtia* and *Pomereschia*; tribe Globbeae, i.e. the genera *Gagneppainia* and *Globba*. The genus *Kaempferia* were found in Thailand, general people called Sakun wan, it consists of many kinds of wan such as Wan krachai dam, Wan Karchae-chan (Picheansoonthon & Koonterm, 2008). The genus *Kaempferia* was established in 1753 (Linnaeus, 1753), it is divided into 2 groups: a group of *Kaempferia rotunda* and a group of *Kaempferia galanga.* The former group is characterized by a short multiflorous inflorescence that appears earlier before the leaves or Spring-bloomed *Kaempferia* (Phokham et al., 2013) such as *K. rotunda, K. grandifolia, K. lopburiensis K. udonensis* and *K. xiengkhoungensis*. The latter group is characterized by inflorescence terminal on the leaf-shoots such as *K. parviflora, K. filifolia, K. fallax, K. elegans*. The genus *Kaempferia* consists of 4 subgenera according to the report of Flora of British India are *Sincorus* Horan., *Protanthium* Horan., *Monolophus* Wall. and *Stachyanthesis* Benth. The subgenus *Sincorus* Horan., i.e. *K. galanga, K. marginata, K. angustifolia, K. ovalifolia, K. speciosa, K. pandurata, K. prainiana, K. roscoeana, K. praviflora, K. involucrata, K. andersoni* and *K. concinna*. The subgenus *Protanthium* Horan., i.e. *K. rotunda* and *K. candida*. The subgenus *Monolophus* Wall., i.e. *K. siphonantha, K. elegan, K. macrochlamys, K. linearis, K. sikkimensis, K. secunda* and *K. parvula*. The subgenus *Stachyanthesis* Benth., i.e. *K. scaposa* (Baker, 1890). Moreover, The plant in the

genus *Kaempferia* are similar to the genera *Baesenbergia Caulokaempferia* and *Camptandra* (Picheansoonthon & Koonterm, 2008).

In the early period of discovering, the genus *Kaempferia* were reported for 15 species (Larsen,1996; Sirirugsa, 1992). Afterwards, some reports revealed many new species in the genus *Kaempferia* such as *K. grandifolia* (Saensouk & Jenjittikul, 2001) *K.sisaketensis* (Picheansoonthon & Koonterm, 2009a) *K. lopburiensis* (Picheansoonthon, 2010) *K. saraburiensis K. koratensis* (Picheansoonthon, 2011). In 2013, 21 species of plants in the genus *Kaempferia* was reported (Theanphong, 2013). In the latter time, 2 new species found and reported were *K. picheansoonthonii K. udonensis* (Phokham et al., 2013). Afterwards, a new species found and reported was *K. noctiflora* (Nopporncharoenkul et al., 2017). The reported of plants in the genus *Kaempferia* discovered in Thailand can be summarized that there are 24 species as follows:

1. *Kaempferia angustifolia* Roscoe
2. *K. elegans* Wall.ex Bak.
3. *K. fallax* Gagnep.
4. *K. filifolia* Larsen
5. *K. galanga* L.
6. *K. glauca* Ridl.
7. *K. grandifolia* Saensouk & Jenjittikul
8. *K. koratensis* Picheans.
9. *K. laotica* Gagnep.
10. *K. larsenii* Sirirugsa
11. *K. lopburi*ensis Picheans.
12. *K. marginata* Caray
13. *K. parviflora* Wall. ex Bak.
14. *K. picheansoonthonii* Wongsuwan & Phokham
15. *K. pulchra* Ridl.
16. *K. roscoeana* Wall.
17. *K. rotunda* L.
18. *K. saraburiensis* Picheans.

19. *K. siamensis* Sirirugsa
20. *K. sisaketensis* Picheans. & Koonterm
21. *K. speciosa* (J. Koenig) Thunb.
22. *K. spoliata* Sirirugsa
23. *K. udonensis* Picheans. & Phokham
24. *K. noctiflora* Noppornc. & Jenjitt.

According to the report of the discovery of plants in the genus in Laos was presented in the book entitled Checklist of the Vascular plants of Lao PDR, it revealed that there are 8 species (Newman et al., 2007). Afterwards, some report revealed that 5 new species in the genus *Kaempferia* of the world found are *Kampferia champasakensis* (Picheansoonthon & Koonterm, 2008) *K. sawanensis* (Picheansoonthon, 2009) *K. gigantiphylla* and *K. attapeuensis* (Picheansoonthon & Koonterm, 2009b) and *K. xiengkhoungensis* (Phokham et al., 2013). The result of the reports about the discoveries of plants in the genus *Kaempferia* in Laos can be summarized that there are 13 species as follows:

1. *Kaempferia angustifolia* Roscoe
2. *K. attapeuensis* Picheans. & Koonterm
3. *K. champasakensis* Picheans. & Koonterm
4. *K. elegans* Wall.ex Bak.
5. *K. fallax* Gagnep.
6. *K. fissa* Gagnep.
7. *K. galanga* L.
8. *K. gigantiphylla* Picheans. & Koonterm
9. *K. harmandiana* Gagnep.
10. *K. laotica* Gagnep.
11. *K. rotunda* L.
12. *K. sawanensis* Picheans. & Koonterm
13. *K. xiengkhoungensis* Picheans. & Phokham

At present, medicinal plants in the *Kaempferia rotunda* L. group in Thailand and Laos are reported that there are 6 species as follows:

1. *Kaempferia rotunda* L., sp. Pl.: 3. 1753.

2. *K. grandifolia* Saensouk & Jenjittikul, Nord. J. Bot. 21: 139-142. 2001
3. *K. lopburiensis* Picheans., J. Jpn. Bot. 85: 148-152. 2010
4. *K. udonensis* Picheans. & Phokham, J. Jpn. Bot. 88: 297-308. 2013
5. *K. xiengkhoungensis* Picheans. & Phokham, J. Jpn. Bot. 88: 297-308. 2013
6. *K. noctiflora* Noppornc. & Jenjitt., Phytotaxa. 316 (1): 067-072. 2017.

2.2 Palynology

Many genera of plants in the family Zingiberaceae were studied by mean of a palynological method. In 1993, pollens of 18 species of plants in the genus Zingiber were studied. The pollen morphology was classified into 2 groups, spherical pollen with a cerebroid surface and a group of ellipsoidal pollen with a spiro-striate surface; for example, *Zigiber kerii*, *Z. officinale* and *Z. junceum* (Theilade, 1993). After that, 10 species of plants in 9 genera of the family Zingiberaceae in Phu Phan Naional Park were studied by palynological method. The genus *Alpinia*, i.e. *A. galanga*; the genus *Amomum*, i.e. *A. uliginosum*; the genus *Boesenbergia*, i.e. *B. xiphostachya*; the genus *Curcuma*, i.e. *C. gracillima* and *C. cf. oligantha*; the genus, *Elettariopsis*, i.e. *E. cf. burttiana*; the genus *Globba*, i.e. *G. laeta*; the genus *Kaempferia*, i.e. *K. laotica* and the genus *Stahlianthus*, i.e *S. campanulatus*; the genus *Zingiber*, i.e. *Z. junceum*. The results indicated that the pollen majority has a spherical form except the pollen of *K. laotica* which has a semi-sperical form and all the pollen of all species have no aperture. This study indicated that there were 7 species of plants which had been not studied by palynology, they were *A. uliginosum*, *B. xiphostachya*, *Curcuma gracillima*, *E. cf. burttiana*, *G. laeta*, *K. laotica* and *S. campanulatus* (Saensouk, 2000). In the latter time, 31 species of plants in the genus *Amomum* in Thailand were studied, i.e. *A. aculeatum*, *A. biflorum*, *A. hastilabium* and *A. repoense*. Their pollen can be classified into 2 group as follows: a group of a pollen which has an echinate pattern on its exine and a group of a pollen which has a psilate pattern on its exine and without an aperture (Kaewsri, 2006). Twenty three species of the plants in the genus *Alpinia* in Thailand were studied by palynology. The result indicated that the majority of their pollen is classified as a type of monads with a spherical form, without an aperture and with an echinate pattern on its exine except *A. luteocarpa*, *A. purpurataa*

and A. vittata (Saensouk, 2006). Forty species of plants in the genus Zingiber in Thailand was studied by palynology. The result indicated that the pollen of them divided into two forms are a spherical form and an ellipsoidal form. The spherical form such as *Z. kerrii*, *Z. laoticum* and *Z. officinale*. The ellipsoidal form such as *Z. callianthus*, Z. *larsenii* and *Z. fragile* (Triboun 2006). Moreover, 3 species of the genus *Cornukaempferia* such as *C. aurantiflora C. larsenii* and *C. longipetiolata* were studied. The results founded that *C. longipetiolata and C. aurantiflora* are similar but *C. larsenii* is different from the both ones and *C. larsenii* is reported as a new species (Saensouk, 2008).

2.3 Molecular study

2.3.1 Conserved regions: ITS

The comparison of nucleotide sequences at specific genomic regions between interested taxa has provided the means for analyzing the phylogenetic relationship within such population. Although the analysis in nucleotide sequences is a powerful tool, selection of appropriate regions for comparison demands several criteria especially the rate of mutation over evolutionary time, polymorphism contents, and the conserved regions for universal primers design. Normally, in most organisms, the regions on the genome which exist as genes encoding for functional proteins would undergo relatively slow mutation, thus, suitable for studying distantly related organisms. However, for the more closely related organisms such as phylogenetic relationship level of plant taxa within the same genus, family, or order, the nucleotide regions with high rate of mutation, e.g., the non-coding sequences, are legitimate. Many molecular phylogenetic studies in plant organisms have focused on the comparison of non-coding nucleotide sequences that resident within or between conserved regions on both nuclear and chloroplast genomes, and revealed for their usefulness in classification and systematics of closely related plant taxa. Despite of redundancy in these potent regions, the investigation in phylogenetic relationship of *Kaempferia* taxa in this study would be conducted by using one conserved regions, i.e., Internal Transcribed Spacer (ITS) region on the nuclear genome.

The ITS region has become one of the most popular genomic region used to analyze nucleotide sequences among population based on evolutionary of nuclear genome (Álvarez and Wendel, 2003). The coding and non-coding units within primary transcript 45S ribosomal RNA (pre-rRNA) gene region on the nuclear genome are organized in tandem arrays of up to several thousand copies and widely known to contain the phylogenetic information during the long-time evolutionary of organisms (Rogers and Bendich, 1987). The region contains the coding small subunit (18S), 5.8S and large subunit (26S) rRNA genes separated by two non-coding internal transcribed spacers 'ITS-1' and 'ITS-2' as shown in Figure 1. Because this region is evolutionary conserved, the non-coding units of ITS-1 and ITS-2 show high level of interspecific divergence and have been used frequently in genetic diversity and molecular phylogenetic studies. A pair of universal primers, ITS1 (forward, 5′-TAGGTGAACCTGCGG-3′) and ITS4 (reverse, 5′-TCCTCCGCTTATTGATATGC-3′), were previously designed to complementary to the conserved sequences of 18S rRNA gene and 26S rRNA gene, respectively (White et al., 1990). The primers are universal among many eukaryotic organisms ranging among fungi, plants, and mammals. By using this universal primers pair in amplification from gDNA sample, the nucleotide sequence of partial 18S rRNA gene, complete ITS-1 spacer, complete 5.8S rRNA gene, complete ITS-2 spacer, and partial 26S rRNA gene would be revealed for phylogenetic analysis.

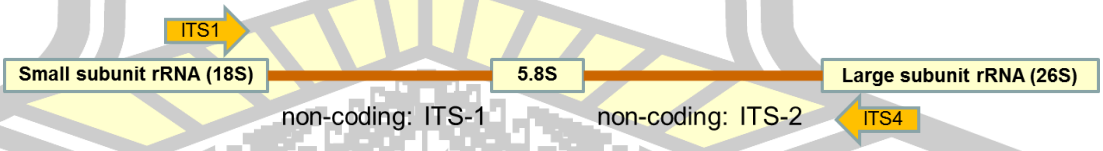


Figure 1 The diagram showing the coding and non-coding units of ITS region on the nuclear genome. The figure is not scaled to the actual nucleotide length proportional to each item. The complementary locations of ITS1 and ITS4 primers are roughly indicated.

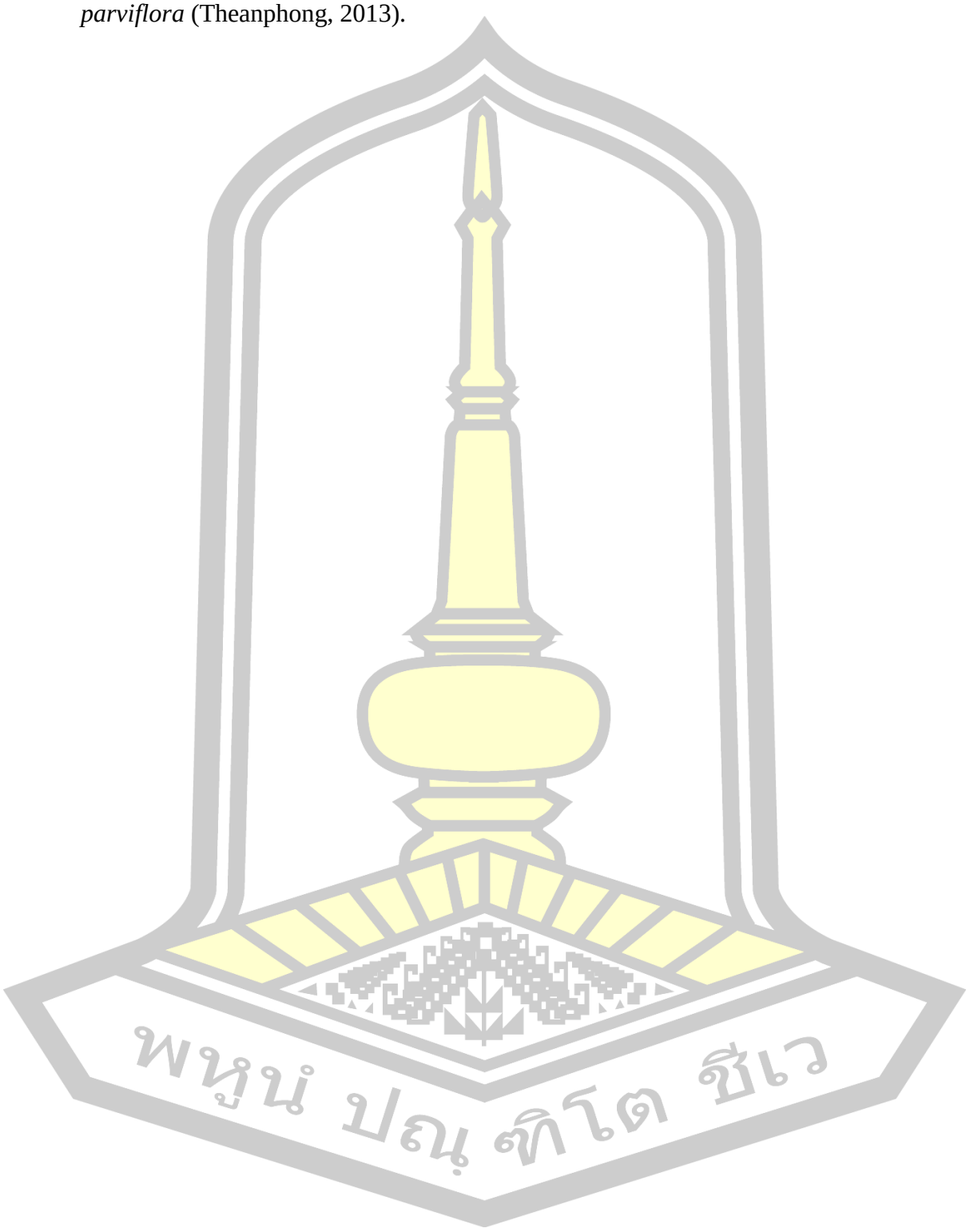
2.3.2 Molecular of the genus *Kaempferia*

A molecular study is the study of taxonomy and evolution of living things by using base sequence in molecules of deoxyribonucleic acid (DNA) selected from a proper part of chromosomes, mitochondria or chloroplasts. The molecular study includes a study of genetic markers by using DNA fingerprints such as RAPD and AFLP, these methods will give more accurate results of taxonomic classification than the method of base sequence of DNA.

As for the plants in the family Zingiberaceae, many articles of research reports in the past and the present have reported the results of taxonomic classification of them and the majority of the articles tend to only present a method of base sequence of DNA for taxonomic classification. The research of Kress et al. (2002) is the research that presents the largest quantity of samples and data of all the research. That research aimed at studying base sequence of DNA of a part called Internal Transcribed spacer (ITS) on a chromosome and a part of a gene called Maturase K (*matK*) on a chloroplast by using a lot of samples of plants. According to the result of the research, the team of researchers suggested a new classification of a family Zingiberaceae that it should be classified into 4 subfamilies as follows: a subfamily siphonochiloideae classified into 1 tribe is siphonochileae, a sub-family Tamijioideae classified into 1 tribe is tamijieae, a sub-family Alpinioideae classified into 2 tribes is Alpinieae and Redelieae, and a subfamily Zingiberoideae classified into 2 tribes in Zingiberae and Globbeae.

Moreover, many projects of research aimed at classifying samples of plants into many classes such as the research of Ngamriabsakul et al (2004) which used a base sequence of DNA of a part of ITS and *trnL-F* on a chloroplast for genus classification within a tribe of Zingibereae, the tribe of Zingibereae classified into 2 genera are *Curcuma* and *Hedychium*. The base sequence of DNA was also used for other parts in order to study some genera of plants; for example, a genus *Alpinia* (Kunthonluxamee, 2008), a genus *Hedychium* (Wongsuwan, 2010), and a genus *Kaempferia* (Techaprasan et al., 2010). As for the research of DNA fingerprints, a RAPD technique was used for a species classification of 5 species of plants in

Thailand which are in the genus *Kaempferia* such as *K. rotunda, K. galanga, and K. parviflora* (Theanphong, 2013).



CHAPTER 3
TAXONOMY

3.1 Taxonomic Methodology

This study was based on field plant collections and herbarium specimens

1) Intensive fieldworks in the type collections of existing taxa were carried on during March-July of 2015-2017.
2) Field notes on plant morphology, distribution and ecology were prepared. Photographs of plant specimens were taken from the collecting location.
3) Specimens were prepared in 95% Ethanol and Glycerin (1:1 ratio).
4) Additional information were retrieved from specimens deposited in Major herbaria, e.g. BK and BKF

3.2 Taxonomic treatment of the genus *Kaempferia* L.

Kaempferia L.

L.,Sp. Pl.: 1. 1753; Roxb., Fl. Ind.1: 15. 1820; Bak. in Hook., Fl. Br. Ind. 6: 218. 1890; Schum. in Pflanzeur.Zingib. 4: 64. 1904; Gagnep. in Lecomle, Fl. Gen. I-C. 6: 45. 1908; Ridl., Fl. Mal. Pen. 4: 245. 1924; Holtt. in Gard. Bul. Sing. 13: 117.1950; Karsen in Bot. Tidsskr. 58: 201. 1962; Chung, Lime. Fl. Mal.2: 709. 1973; Burtt & Smith in Dassanayake, Fl. Cey. 4:508. 1983; Sirirugsa in Nord. J. Bot. 9. 3: 257. 1989 & in Thai For. Bull. (Bot.) 19: 1. 1992; Fl.; Hussin et al. in J. Trop. Subtrop. Bot. 9: 49-54. 2001.

Perennial herb. Rhizome fleshy, usually short**,** with several root**s** in a fascicle**;** root often bearing tubers. Leaves 1 to few**,** rising from the rhizome; blade filiform to very broad; petiole usually short; sheath often keeled, broad and short**;** ligule small, inconspicuous, or none. Inflorescences usually enclosed by the two

innermost leaf-sheaths, or by bladeless sheaths. Flower few to many, spirally arranged, forming head-like inflorescences, each solitary accompanied by 2 small bracteoles in the axil of a bract. Bracts usually lanceolate or linear. Calyx tubular, split along one side, the apex unequally 2- to 3- lobed. Collolla lobe slender and long; subequal, usually linear. Staminode petaloid, often similar to the halves of the labellum, white or purple. Labellum usually deeply bilobed, mostly obovate, usually white or purple, sometime marked with a different colour. Stamen with very short filament or sessile; anther usually 2-5 mm long, longitudinally; anther crest usually large, lobed or entire. Ovary trilocular, placentation axile; stylodial glands mostly filifrom. Fruit often not seen.

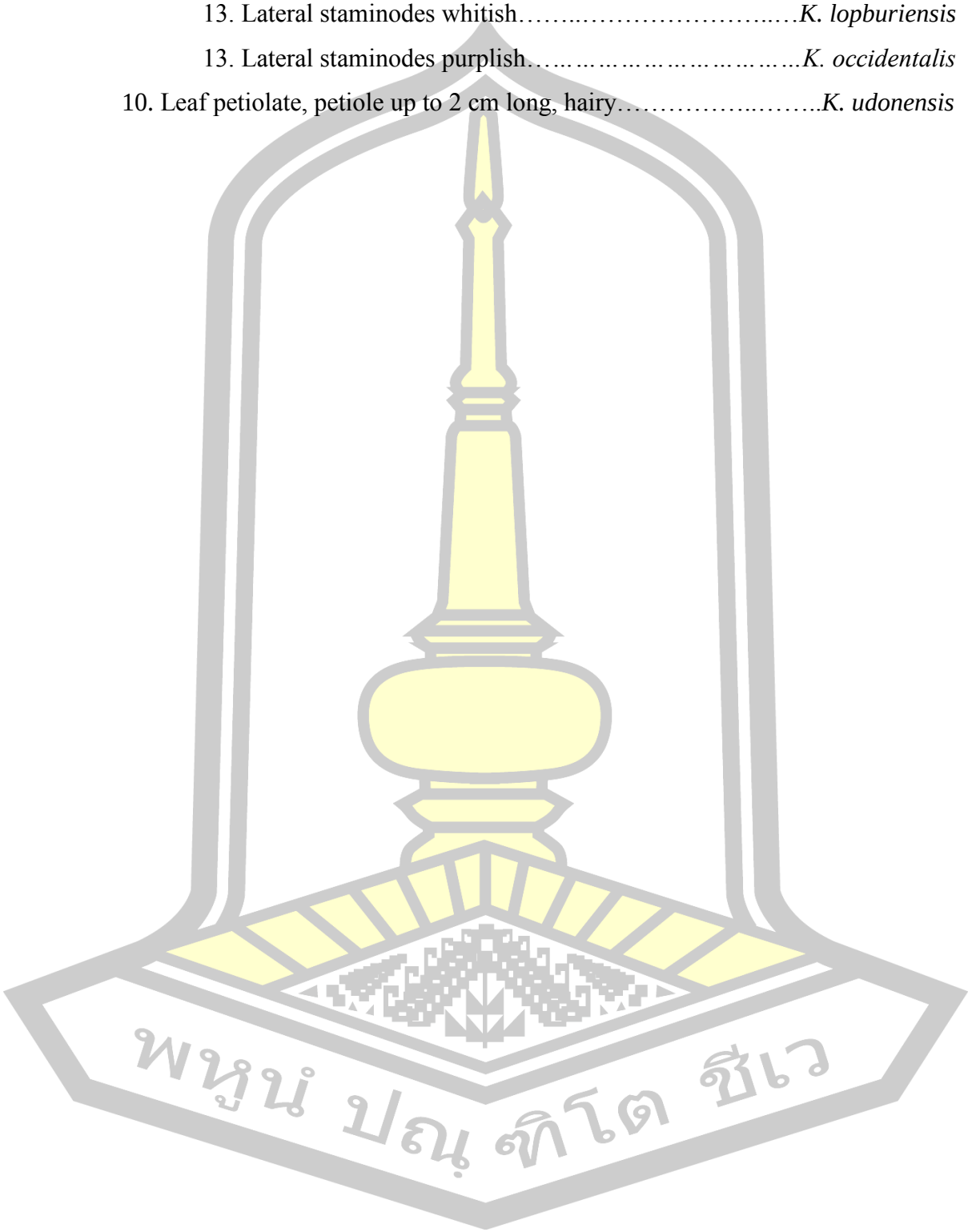
3.3 Key to the examples of the subgenus *Protanthium* (genus *Kaempferia*, family Zingiberaceae) in Thailand and Laos

1. Pseudostem well developed with upright leaves
   2. Leaf sessile
      3. Upper surface glabrous……*K. xiengkhouangensis*
      3. Upper surface hairy or sparsely hairy at the base of midrib
         4. Lateral staminodes erect with deflexed distal half of the labellum……*K. kamolwaniae*
         4. Lateral staminodes and labellum laid on the same plan……*K. takensis*
   2. Leaf petiolate, petiole up to 8.7 cm long, hairy
      5. Leaf blade glabrous on upper surface
         6. Night blooming flower, labellum pure white or white with pale yellow patch at the base……*K. noctiflora*
         6. Day blooming flower, labellum white, pink to purple with deep purple spot at the center……*K. rotunda*
      5. Leaf blade hairy on upper surface or sparsely hairy at the base of midrib
         7. Corolla tube glabrous, lateral staminodes erect with deflexed distal half of the labellum
            8. Day blooming flower, ovary hairy……*K. doisaketensis*
            8. Night blooming flower, ovary glabrous……*K. uttaraditensis*
         7. Corolla tube hairy, lateral staminodes and labellum laid on the same plan
            9. Lateral staminodes obovate, pink, apex acute……*K. grandis*
            9. Lateral staminodes broadly obovate, purplish to violet, apex rounded ……*K. kanchanaburiensis*
1. Pseudostem short with adpressed leaves flat on the ground
   10. Leaf sessile
      11. Leaf blade glabrous on upper surface
         12. Anther crest conspicuously bilobed……*K. grandifolia*
         12. Anther crest trilobed……*K. nakhonsawanensis*
      11. Leaf blade sparsely hairy or hairy on upper surface

13. Lateral staminodes whitish……..……..…*K. lopburiensis*

13. Lateral staminodes purplish…..……*K. occidentalis*

10. Leaf petiolate, petiole up to 2 cm long, hairy……..……..*K. udonensis*



3.4 Desciptions of *Kaempferia* in Thailand and Laos

1. *Kaempferia doisaketensis* Picheans., Meechonk. & Yupparach, sp. nov. Type: Thailand. Changwat Chiang Mai, Amphoe Doi Saket, 4 May 2017, Pichensoonthon & Meechonkit 040517-1 (holotype BK, isotype MSU).

Perennial herb. Pseudostems 3.7-6.4 cm high. Rhizomes short, erect, bearing several roots in a fascicle. Bladeless sheaths 1-3, 1.8-4.2 cm long, hairy. Leaves 1-5; petiole 0.5-3.1 cm long, hairy; blade not prostrate, lanceolate to elliptic, 12.7-21.6 × 4.9-9.5 cm, base cuneate, apex acute to acuminate, margin entire to slightly crenate, upper surfaces green to purplish red, hairy, lower surface reddish, pubescent; ligules, small, trianglular, ca. 1 × 1-2 mm long, reddish, apex acute, hairy. Inflorescence appearing from leafless rhizomes, peduncle 0.7-2.2 cm long, hairy. Flowers 5-13; bracts broadly ovate to ovate, 0.9-3.8 × 0.6-2.4 cm, pale green or pale green with purplish at apex, apex cuspidate to mucronate, hairy; bracteole lanceolate,1.1-1.5 cm × 4-5 mm, apex 2 lobes, acute to acuminate, hairy; calyx tubular, 3.6-5.5 cm long, split on one side, 0.6-1.2 cm long, apex bifid, hairy; corolla tube 3.3 -5.9 cm long, whitish, glabrous; dorsal corolla lobe narrowly lanceolate, 4-5.2 cm × 4-7 mm, apex hooded; lateral corolla lobes narrowly lanceolate, 3.5-4.8 cm × 3-6 mm, apex hooded; lateral staminodes obovate, 3-4.1 × 1.2-1.6 cm, white to white proximally; pale purple distally, apex acute to rounded; labellum broadly obovate, 3.5-4.4 × 2-3.1 cm, pale purple, deep purple at base, apically bilobed for ca. 1/2 its length, each lobe obovate, 1.5-2.8 × 1.2-1.8 cm, apex mucronate to acuminate or emarginate; anther 6-7 × 0.8-0.9 mm, anther crest ovate, 5-9 × 3-5 mm, apex bilobe or tri-dent; stigma funnel-shaped; ovary cylindrical, 4-8 × 2-3 mm, hairy, 3-locular, placentation axile, ovules numerous; stylodes 2, filiform, 6-8 mm long. Fruits obovate or ovate, 0.9-1.7 cm × 5-9 mm, whitish. Seeds numerous, narrowly ellipsoid to obovate, whitish, 3-5 × 1-2 mm; capped with whitish membranous aril.

Phenology: Flowering from April to May; fruiting from May to June

Distribution: This new species is so far only known from the type locations in Changwat Chiang Mai, Thailand.

Ecology: The new species grows on limestone soils, under the shade in dry deciduous forest.

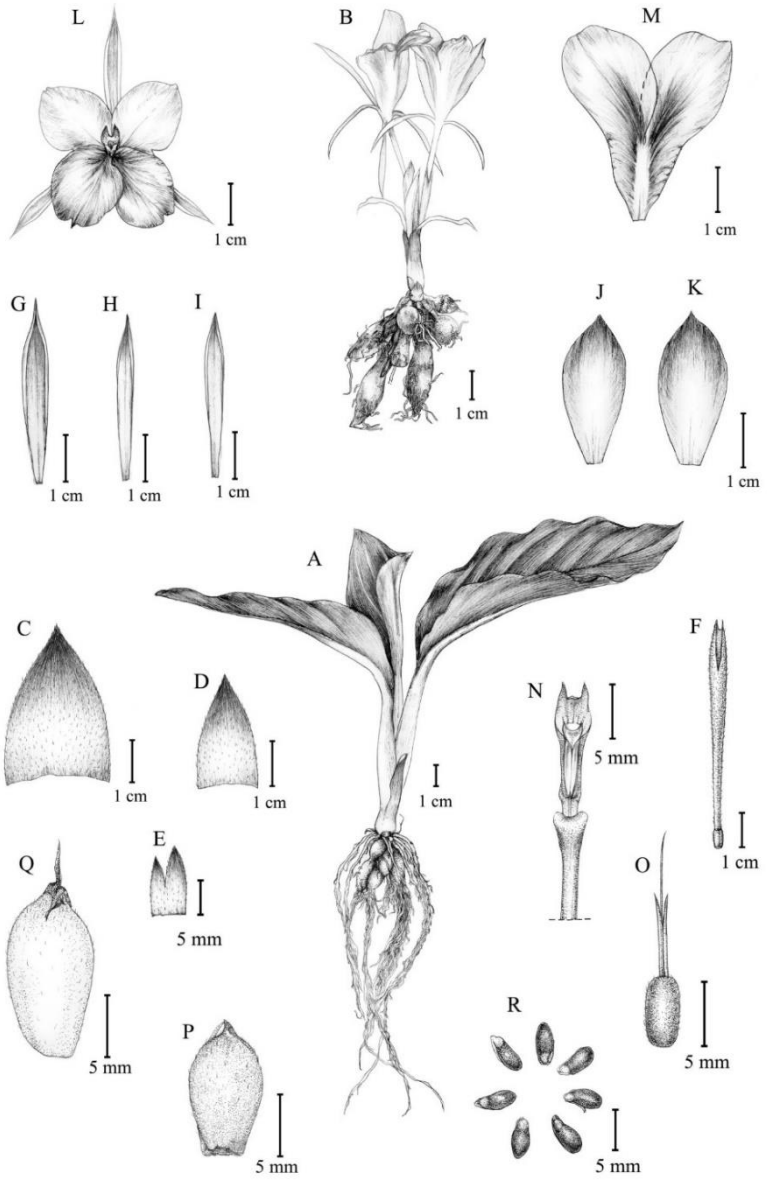


Figure 2 *Kaempferia doisaketensis* Picheans., Meechonk. & Yupparach. A: Habit; B: Roots, rhizome and inflorescence; C and D: Bracts; E: Bracteole; F: calyx tube and ovary; G: Dorsal corolla lobe; H and I: Lateral corolla lobes; J and K: Lateral staminodes; L: A flower showing characteristic staminodes, labellum and anther creast; M: Labellum; N: Anthers, anther crest and stigma; O: Ovary, stylodial glands and lower part of the style; P and Q: Fruit with persistent calyx tube; R: Seeds

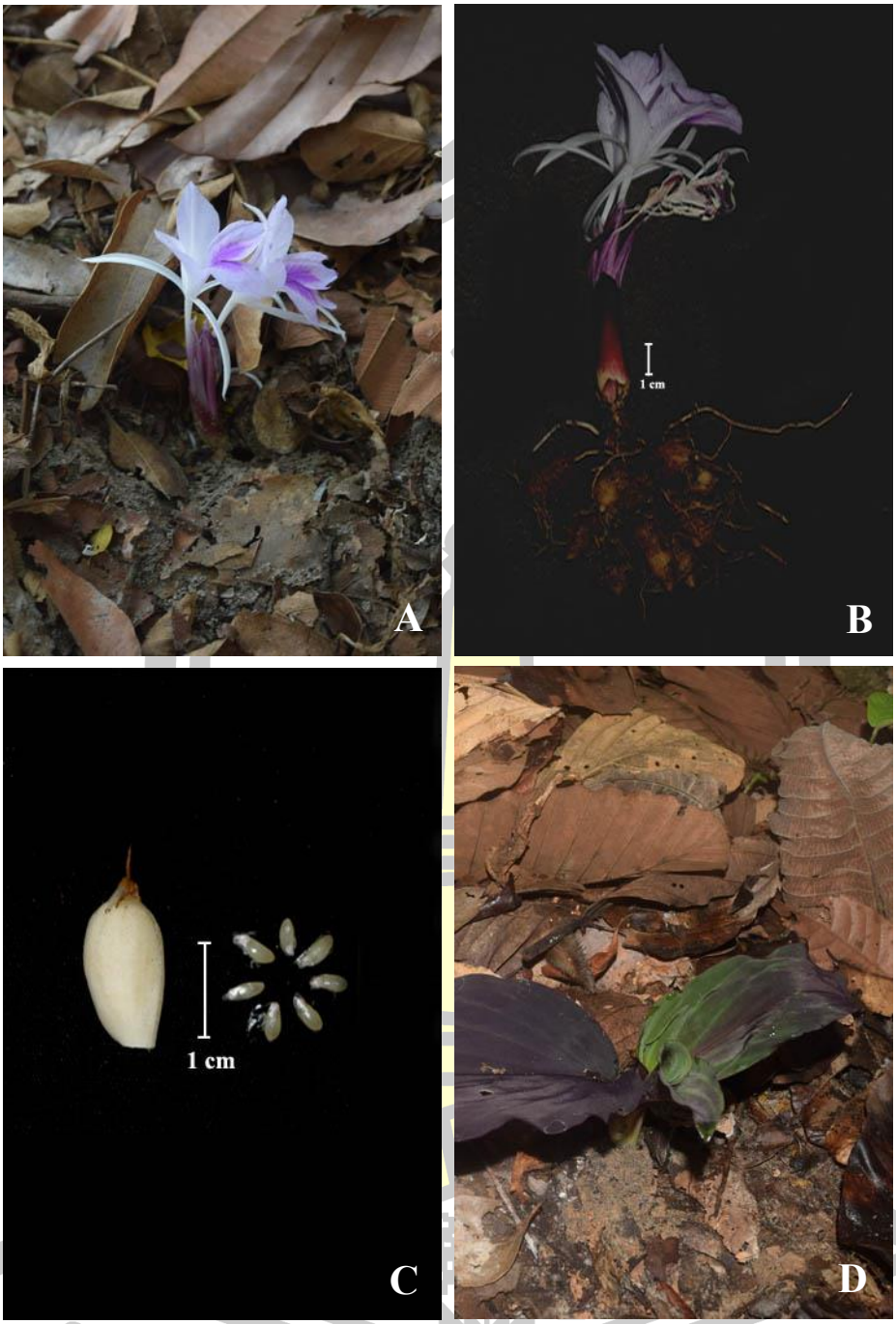


Figure 3 Photographs of *Kaempferia doisaketensis* Picheans., Meechonk. & Yupparach.

A: Inflorescence; B: Roots, rhizome and inflorescence; C: Fruit and seeds; D: The plant in the type location.

2. *Kaempferia grandifolia* Saensouk & Jenjitt., Nord. J. Bot. 2: 2. 2001.
Type: Thailand. Changwat Khon Kaen, Amphoe Phuweing, Kok Phu Ta Kham, 5 March 1998, Saensouk & Jenjittikul, Saensouk 55 (holotype BKF, isotype AAU, BK).

Small, perennial herb. Roots fibrous with globular to fusiform, tuberous storage. Rhizome short, erect. Bladeless sheaths 1-2, 1-3.5 cm long, pubescent. Leaves 3-4; radical, almost horizontal and near the ground; suborbicular, 18-28 × 15.3-18.5 cm, base cuneate, apex acute to acuminate, upper surface green with brown lines along the veins, pale green along the margin, glabrous; lower surface purple with greenish patches, pubescent; ligule broadly triangular, 3-5 mm long, green, apex rounded, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.5-3 cm long. Flowers ca. 12; bracts lanceolate, 1.8-6.1 × 0.7-3.7 cm, apex cuspidate or mucronate, sparsely hairy; bracteoles lanceolate, 1.6-2.7 × 4-6 mm, apex mucronate, sparsely hairy; calyx tubular, 3.5-6.1 cm long, split on one side, 0.6-1.4 cm long, apex 3-lobed, sparsely hairy; corolla tube, 4.6-8.6 cm long, glabrous; dorsal corolla lobe lanceolate oblong, incurved, 3.5-4.5 cm × 5-8 mm, white, apex acute, hooded; lateral corolla lobe lanceolate oblong, incurved, 3.5-4.3 × 4-5 mm, white, apex acute; lateral staminodes oblong to obovate, 2.9-3.8 cm × 4-5 mm, white, apex acute to acuminate, labellum obovate, apically bilobed, 2.4-3.6 × 3.8-4.3 cm,white with pale yellow spot, each lobe apex acute or acuminate; anther 3-4 mm long, anther crest conspicuously bilobed, apex of lobes acute, 4-7 × 2-4 mm, white; ovary ellipsoid, oblique, 5-7 × 0.2 mm, sparsely hairy; stylodes 2, filiform, ca. 5 mm long. Fruits narrowly obovoid to ellipsoid, 3-4.5 × 0.9-1.2 cm, whitish. Seeds numerous, greenish to brown green with white aril.

Phenology: Flowering from March; fruiting from April
Distribution: Northeast Thailand (Khon Kaen).
Ecology: Mostly found in open dipterocarp forest.

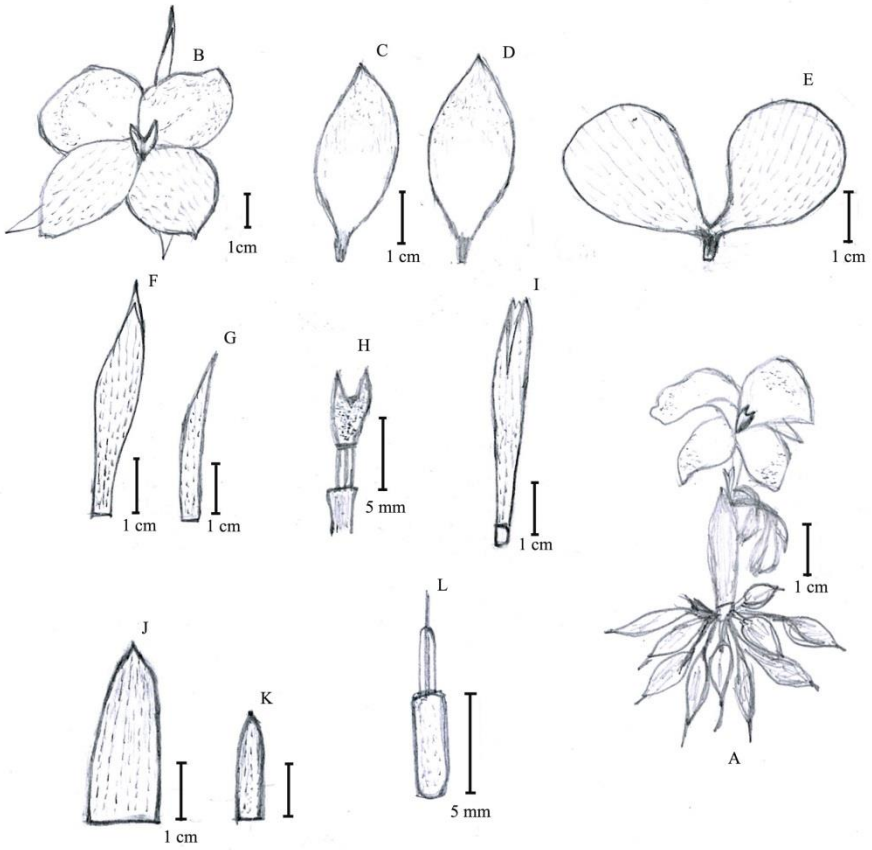


Figure 4 *Kaempferia grandifolia* Saensouk & Jenjitt.

A: Roots, rhizome and inflorescence; B: A flower (top view); C and D: Lateral staminode; E: Labellum; F: Dorsal corolla lobe; G: Lateral corolla lobe; H: Anthers and anther crest; I: calyx tube and ovary; J: Bract; K: Bracteole; L: Ovary with stylodial glands

Figure 5 Photographs of *Kaempferia grandifolia* Saensouk & Jenjitt. A: Inflorescence; B: Roots, rhizome and inflorescence; C: A flower showing characteristic staminodes, labellum and anther creast; D: The plant in the type location.

3. *Kaempferia grandis* Picheans. & Meechonk., sp. nov.

Type: Thailand. Changwat Tak, Amphoe Mae sot, 6 April 2015, Pichensoonthon & Meechonkit 060416-1 (holotype BK, isotype MSU).

Perennial herb. Roots fibrous with globular to fusiform tuberous storage. Rhizome short, erect. Bladeless sheaths1-2, 2.1-2.4 × 1.2-2.5 cm, green, apex acute, sparsely hairy. Leaves 5-6; petiole 0.6-6 cm long, greenish, hairy; blades not prostrate, elliptic to ovate, 13.8-44.1 × 6.2-21 cm, base cuneate, apex acute to acuminate, upper surface green with several white markings, hairy at the base of the midrib, lower surface reddish, hairy; ligule broadly trianglular, 2 lobes, 0.5-1.2 cm long, reddish or greenish, apex rounded to acute, pubescent. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 1.1-3.3 cm long, hairy. Flowers 8-45; bract ovate, 1.6-4.3 × 1-3.3 cm, pale green, apex acute, hairy; bracteole lanceolate, 0.9-2 cm × 3-5 mm, apex 2-lobed, apex of each lobe acute, hairy; calyx tubular, 2.4-5.6 cm long, split on one side, 0.9-1 cm long, whitish, apex bifid, hairy; corolla tube, 5.2-7.7 cm long, whitish, hairy; dorsal corolla lobe oblong to narrowly ovate, 2.1-3.6 cm × 4-6 mm, white, apex acute, hooded; lateral corolla lobe oblong to narrowly ovate, 2.7-3.1 cm × 3-4 mm, white, apex acute; lateral staminodes obovate, 2.1-3.5 × 1.4-1.9 cm, pink, apex acute; labellum obovate, 2.2-3.8 × 3.1-3.9 cm, pink, deep pink with white patch at the base, apex divided to the base, each lobe obovate, 1.5-3.1 × 1.2-2.3 cm, apex rounded to acute; anther 4-5 mm long, anther crest ovate to rectangular, 6-7 × 3-4 mm, pink, apex bifid to trifid; ovary oblong to obovate, 3-6 × ca. 2 mm long, whitish, hairy; stylodes 2, filiform, ca. 5 mm long. Fruits ovate to oblong, 1.4-2 cm × 1-1.4 cm, pink, hairy. Seeds numerous, ovate to oblong, yellowish, ca. 5 × 4 mm; capped with white membranous aril.

Phenology: Flowering from March to April; fruiting from April to May.

Distribution: This new species is so far known from the type location in Changwat Tak, northern Thailand.

Ecology: The new species grows under the shade of dipterocarp forest or bamboo forest.

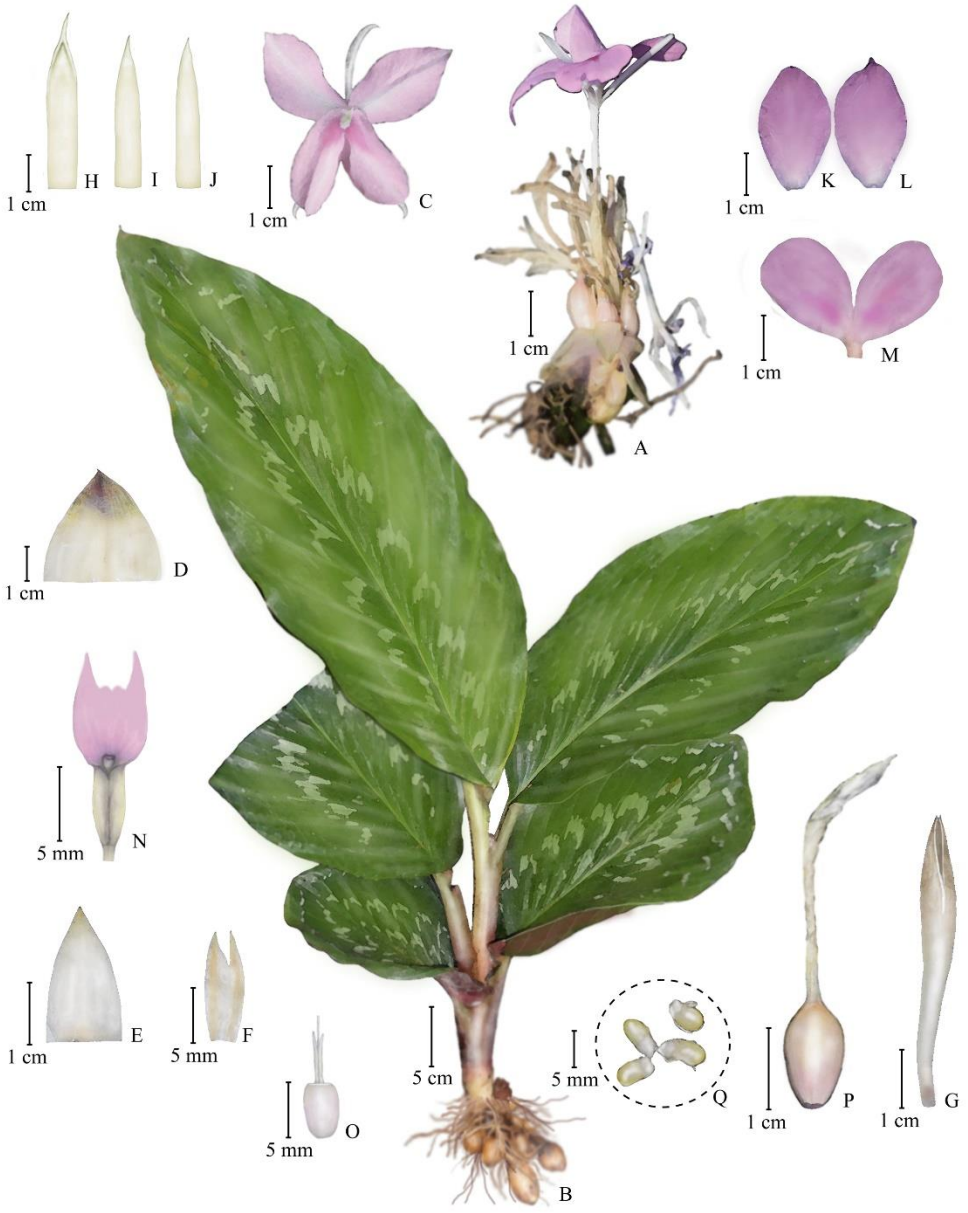


Figure 6 *Kaempferia grandis* Picheans. & Meechonk.

A: Roots, rhizome, fruits and inflorescence; B: Habit; C: A flower showing characteristic staminodes, labellum and anther creast; D and E: Bracts; F: Bracteole; G: calyx tube and ovary; H: Dorsal corolla lobe; I and J: Lateral corolla lobes; K and L: Lateral staminodes; M: Labellum; N: Anthers and anther crests; O: Ovary, stylodial glands and lower part of the style; P: Fruit and with persistent calyx tube; Q: Seeds

Figure 7 Photographs of *Kaempferia grandis* Picheans. & Meechonk. A: Inflorescence; B: Roots, rhizome and inflorescence; C: Lower part of a leaf showing a red ligule; D: The plant in the type location

4. *Kaempferia kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.
Type: Thailand. Changwat Uttaradit, Amphoe Thong Saen Khan, alt 107 m, 4 Jun 2016, Picheansoonthon & Meechonkit 040616-1 (holotype BK, isotype MSU).

Perennial herb. Roots fibrous with globular to fusiform tuberous storage. Rhizome short, erect. Bladeless sheaths, 2.4-10.1 cm long. Leaves 1-2(-3), sessile; blades not prostrate, elliptic to ovate, 18-51.3 × 8.8-17.5 cm, base cuneate, apex acute to acuminate, upper surface green, sparsely hairy at the base of the midrib, lower surface pale green, sparsely hairy; ligule, small, 0.6-0.9 cm long, green, apex acute, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.6-3.7 cm long, glabrous. Flowers 6-11; bracts ovate, 3.3-4.3 × 1.5-4.2 cm, apex acute to mucronate, hairy; bracteole lanceolate, 2-2.5 × 5-8 mm, apex acute, hairy; calyx tubular, 4.0-5.3 cm long, split on one side 0.7-1.6 cm long, apex bifid to trifid, sparsely hairy at apex; corolla tube, 4.1-6.4 cm long, white; dorsal corolla lobe oblong to narrowly ovate, 4.2-6.2 × 0.7-1.3 cm, apex aristate, hooded; lateral corolla lobe oblong to narrowly ovate, 3.8-6.1 × 0.7-1.2 cm, apex acute; lateral staminodes broadly obovate to oblong, 4.8-6.1 × 2.1-2.7 cm, white to purple, apex rounded to acute or cuspidate; labellum obovate, 4.4-6 × 3.3-3.7 cm, purple, deep purple toward the base, apically bilobed for ca. 1/3 its length, 2.3-2.9 cm, each lobe narrowly obovate, apex rounded to slightly emarginate; anther 7-8 mm long, anther crest ovate, 0.8-1.6 cm × 4-7 mm, white to violet, apex 4-lobed to 5-lobed; the outer lobes acute and elongate, the middle shorter; ovary oblong or cylindrical, 4-6 × 2-3 mm, glabrous; stylodes 2, filiform, ca. 5 mm long. Fruits ovate to oblong, 1.2-3.4 × 0.8-1.5 cm, whitish and many red spot at the top. Seeds numerous, ovate, yellow-green, ca. 6 × 3 mm; capped with white membranous aril.

Phenology: Flowering May-June, fruiting June.

Distribution: This new species is so far only known from the type locations in Changwat Uttaradit, Thailand.

Ecology: In lowland dry deciduous forest at an altitude around 107 m. It grows limestone soil under bamboo shade.

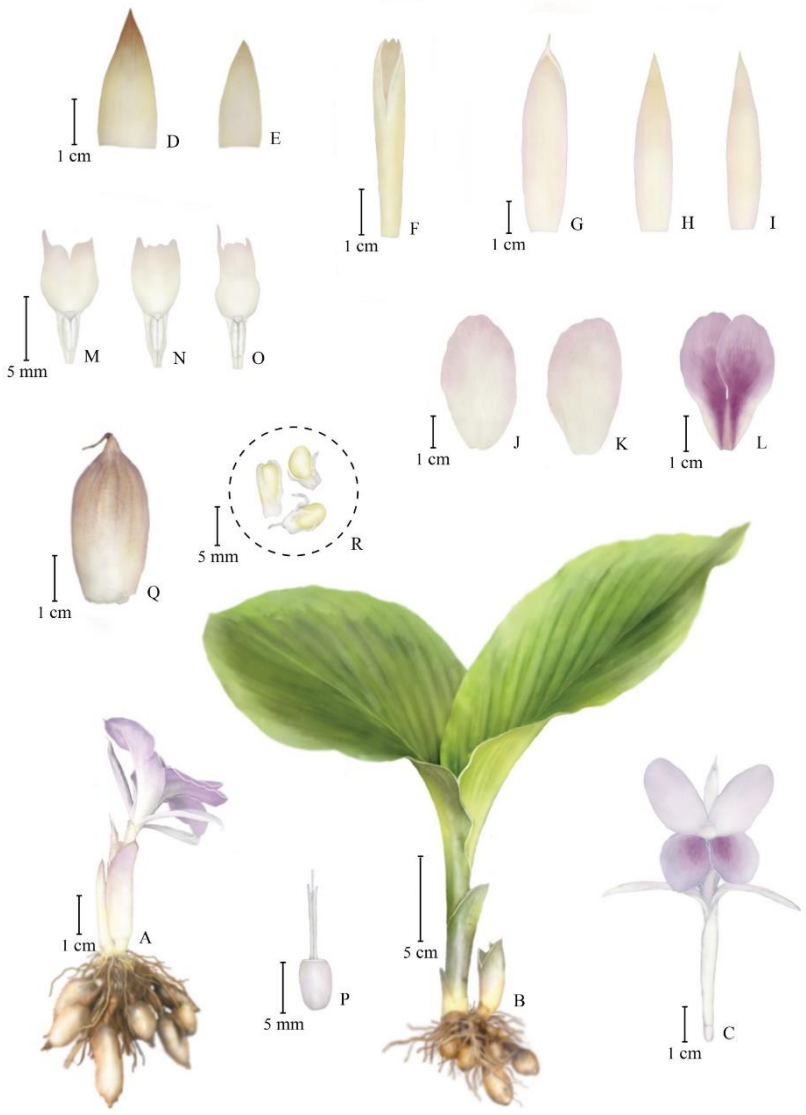


Figure 8 *Kaempferia kamolwaniae* Picheans., Meechonk. & Wongsuwan. A: Roots, rhizome and inflorescence; B: Habit; C: A flower, showing ovary, calyx tube, corolla tube, staminodes and labellum; D: Bract; E: Bracteole; F: calyx tube; G: Dorsal corolla lobe; H and I: Lateral corolla lobes; J and K: Lateral staminodes; L: Labellum; M, N, and O: Anthers and anther crests; P: Ovary, stylodial glands, and lower part of the style; Q: fruit with persistent calyx tube; R: Seeds.

Figure 9 Photographs of *Kaempferia kamolwaniae* Picheans., Meechonk. & Wongsuwan.

A: Inflorescence; B: Lower part of a leaf showing a red ligule; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

5. *Kaempferia kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov. Type: Thailand. Changwat Kanchanaburi, Amphoe Si Sawat, alt. 255m, 12 April 2015, Picheansoonthon & Meechonkit 120415-1 (holotype BK, isotype MSU).

Perennial herb. Roots fibrous with globular to fusiform tuberous storage. Rhizome short, erect. Bladeless sheaths, 2.2-8.6 cm long, sparsely hairy. Leaves 1-4 (-6); petiole 1-3.4 cm long, hairy; blades not prostrate, ovate to elliptic, 12-27.6 × 6.8-16.8 cm, base cuneate to obtuse, apex acute to acuminate, upper surface green with several green markings or white markings, hairy at the base of the midrib, lower surface green, sparsely hairy; ligule, broadly triangular, 0.6-2.4 × 0.4-1.9 cm, reddish, apex obtuse, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.9-3.4 cm long, hairy. Flowers 6-18; bract ovate, 2.3-4 × 0.8-2.4 cm, apex acute, hairy; bracteole lanceolate, 1.2-1.3 cm × 3-4 mm, apex 2-lobed, each lobe acute, hairy; calyx tubular, 3-3.7 cm long, split on one side, 0.5-1.5 cm long, apex bifid, hairy; corolla tube, 5.9-7.5 cm long, whitish, hairy; dorsal corolla lobe oblong to narrowly ovate, 2.5-3.5 cm × 4-6 mm, apex acute, hooded; lateral corolla lobe oblong to narrowly ovate, 1.5-2.8 cm × ca. 4 mm, apex acute; lateral staminodes broadly obovate, 2.1-2.5 × 1.7-1.8 cm, purplish to violet, apex rounded; labellum broadly obovate, purplish to violet, deep purplish to violet toward the base, 1.8-2.9 × 2.7-3.9 cm, apex divided almost to the base, each lobe broadly obovate, 1.5-2.1 × 1.6-2 cm, apex rounded; anther 4-6 mm long, anther crest orbicular to rectangular, 5-8 × 3-7 mm, white to violet; ovary oblong to obovate, 3-5 × ca. 2 mm long, glabrous to sparsely hairy; stylodes 2, filiform, ca. 5 mm long. Fruits ovate to oblong, 2-2.4 cm × 0.7-0.9 cm, purple. Seeds numerous, ovate to oblong, purple, ca. 5 × 4 mm; capped with whitish membranous aril.

Phenology: Flowering March-April, fruiting April-May.

Distribution: This new species is so far only known from the type locations in Changwat Kanchanaburi, Thailand.

Ecology: This new species grows limestone soil or rock under bamboo shade in dry deciduous forest at the altitude 255 m.

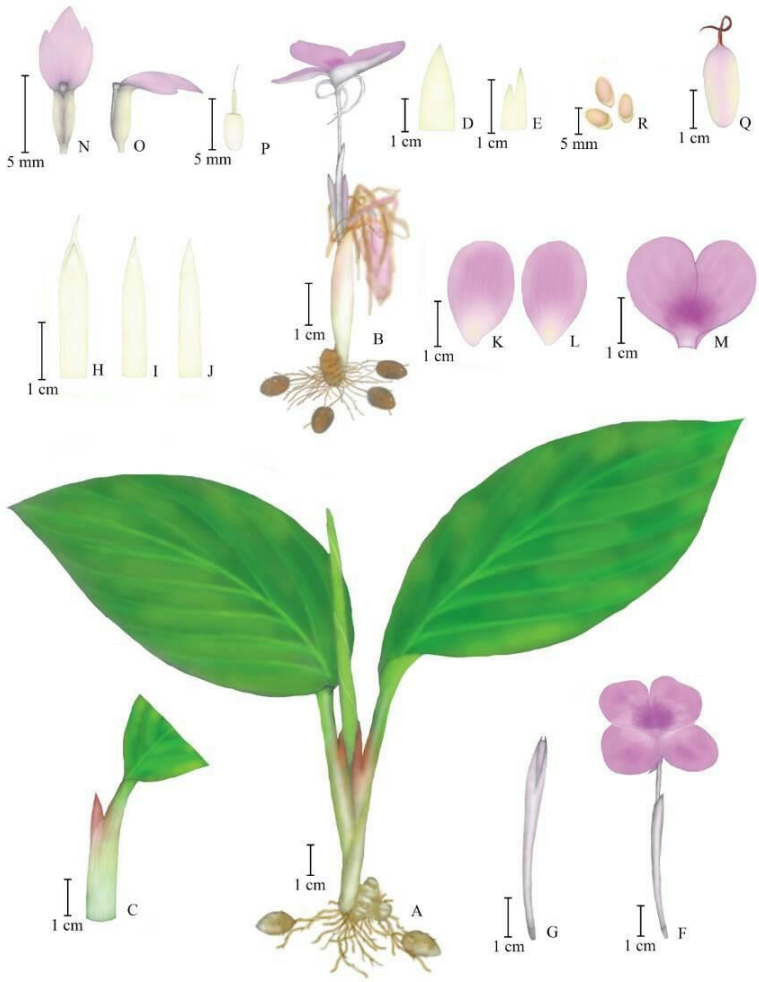


Figure 10 *Kaempferia kanchanaburiensis* Picheans., Meechonk. & Phokham. A: Habit; B: Roots, rhizome and inflorescence; C: Leaf base, showing ligule (side view); D: Bract; E: Bracteole; F: A flower, showing ovary, calyx tube, corolla tube, staminodes and labellum; G: Ovary and calyx tube; H: Dorsal corolla lobe; I and J: Lateral corolla lobes; K and L: Lateral staminodes; M: Labellum; N and O: Anthers and anther crests (N: front view, O: side view); P: Ovary, stylodial glands and lower part of the style; Q: fruit with persistent calyx tube. R. Seeds.

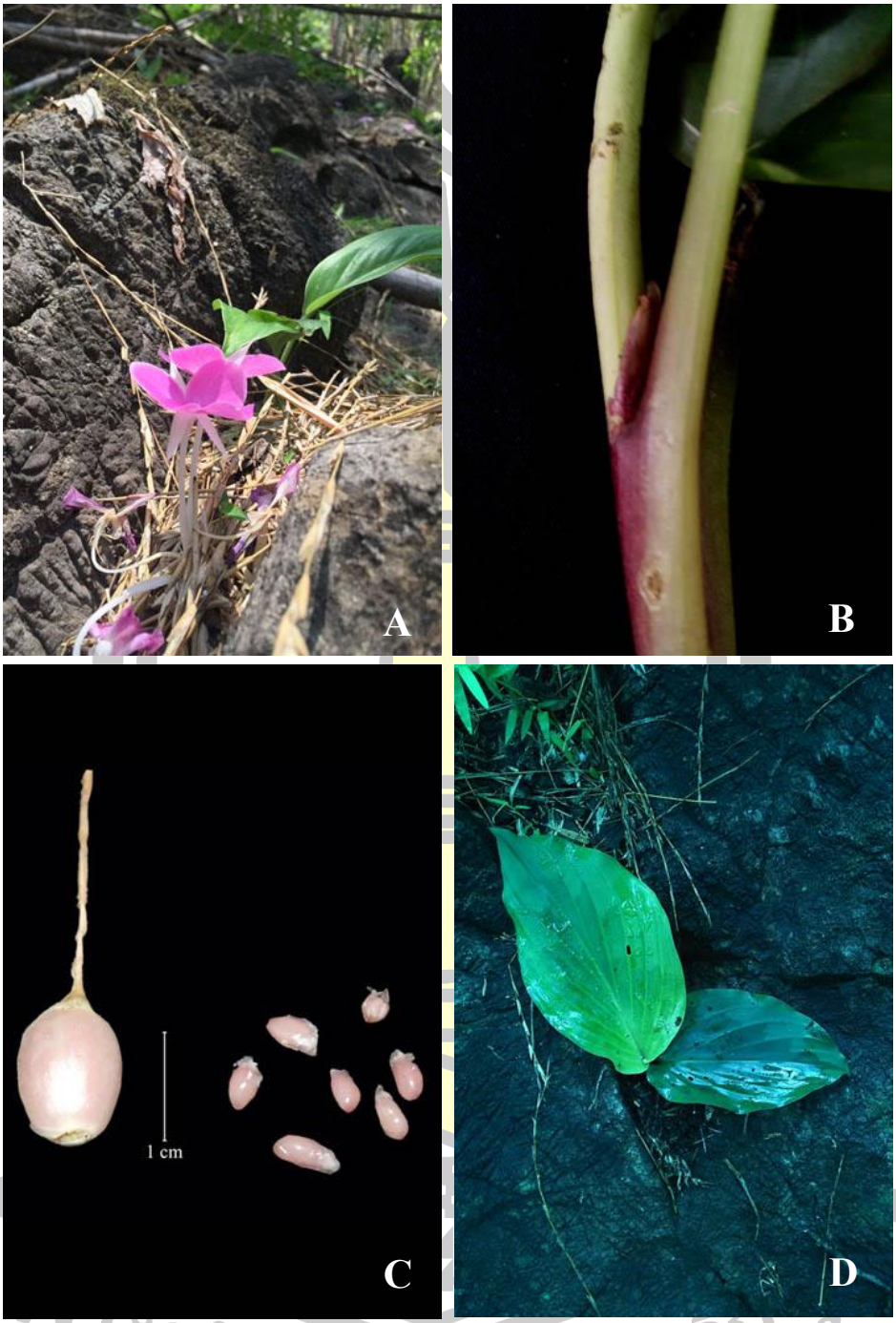


Figure 11 Photographs of *Kaempferia kanchanaburiensis* Picheans., Meechonk. & Phokham.

A: Inflorescence; B: Lower part of a leaf showing a red ligule; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

6. *Kaempferia lopburiensis* Picheans., J. Jpn. Bot. 85: 148-152. 2010.
Type: Thailand. Changwat Lopburi, Amphoe Mueang Khao Sa-ang, 14°49′85.2″N 100°44′87.0″E, alt 200 m, 8 April 2008, Picheansoonthon & Koonterm 154 (holotype BKF, isotype BK, SING).

Perennial herb. Roots fibrous with globular to fusiform, tuberous storage. Rhizome short, erect. Bladeless sheaths 2-3, 0.9-6 cm long, glabrous. Leaves 1-4 radical, almost horizontal and near the ground; blades suborbicular to orbicular, 12.3-24.1 × 11-23.5 cm, base cuneate, apex acute to acuminate, upper surface pale green with light purple band along the margin, sparsely hairy, lower surface pale green, pubescent; ligule broadly triangular, 0.9-1.2 × 1.1-1.5 cm, apex obtuse to rounded, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 4-5 cm long, hairy. Flowers 6-18; bracts lanceolate, 4.1-6 × 1.4-2.2 cm, pale green, apex cuspidate or mucronate, hairy; bracteoles membranous, lanceolate, 2.3-2.7 × 2-4 mm, apex 2-lobed, apex of each lobe acute, hairy; calyx tubular, 4.3-7.7 cm long, split on one side, 0.6-0.9 cm long, apex 3-lobed, sparsely hairy at apex; corolla tube 4.5-10 cm long, white; dorsal corolla lobe lanceolate-oblong, 2.5-3.6 cm × 5-7 mm, apex hooded with a thorn-like point ca. 5 mm long; lateral corolla lobes oblong, incurved, 2.4-3.4 cm × 3-6 mm, white, apex acute; lateral staminodes obovate, 2.6-3.1 × 1.2-1.8 cm, whitish, apex rounded; labellum obovate to suborbicular, 3-3.2 × 2.3-3.3 cm, purple, deep purple toward the base, apex deeply bilobed, each lobe obovate, 1.8-2.6 × 1.3-1.6 cm; anther 4-5 × 1-2 mm long, anther crest rectangular or broadly obovate, 0.4-0.9 cm × 3-6 mm, white to violet; apex trident to crenate; ovary cylindrical, 4-6 × 2-3 mm long, pubescent toward the upper part; placentation axile; stylodes 2, filiform, ca. 5 mm long. Fruits, cylindrical to ellipsoid, 3.3-4.4 cm × 1.1-1.3 cm, whitish. Seeds numerous, ovate, whitish to brownish, 4-6 × 2-3 mm; capped with white aril.

Phenology: Flowering from March to April; fruiting from April to May.

Distribution: Central Thailand (Changwat Lopburi).

Ecology: This species grow on decayed limestone soil under bamboos shade in dry deciduous forest at the altitude 200-220 m.

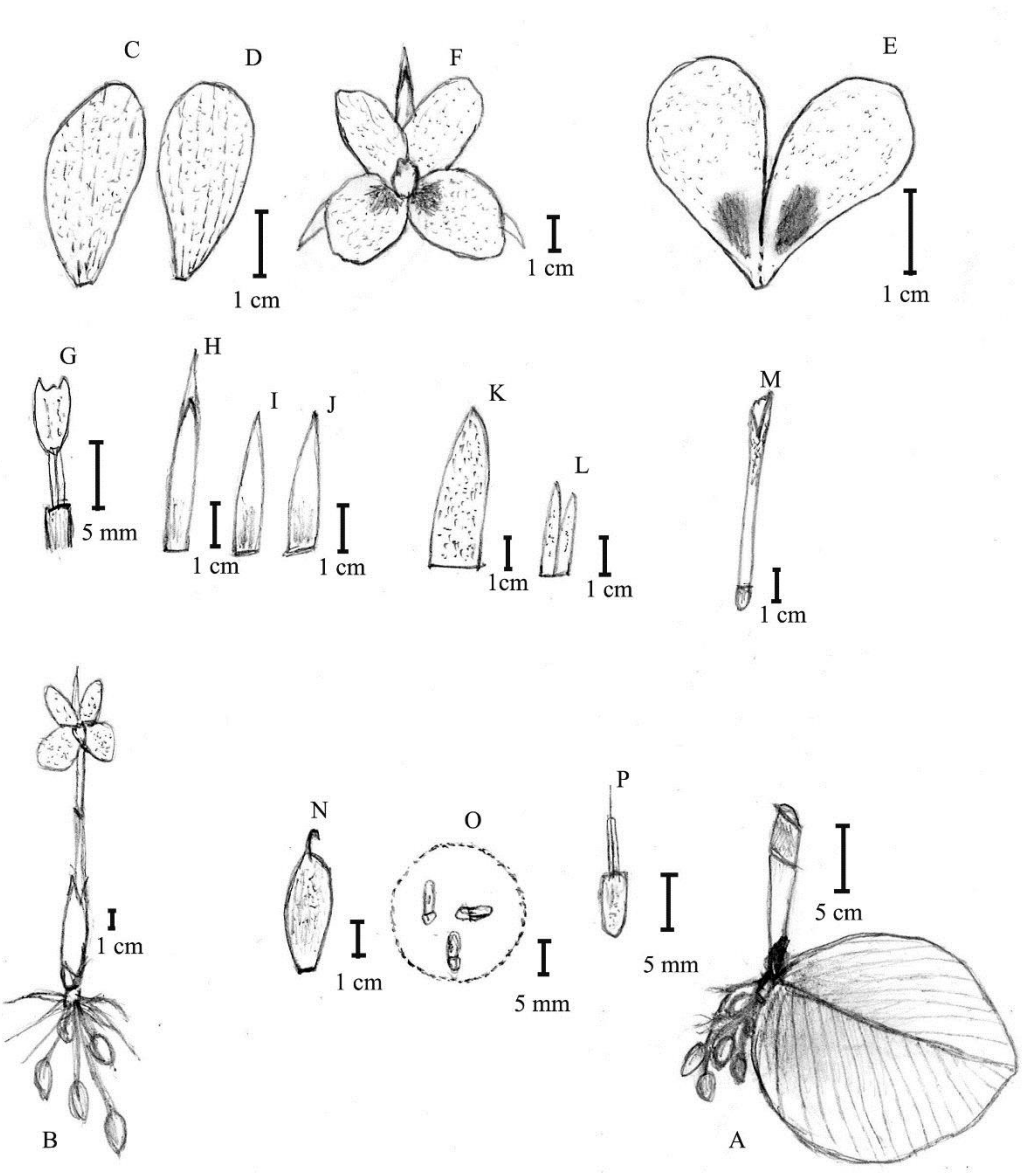


Figure 12 *Kaempferia lopburiensis* Picheans.

A: Habit; B: Roots, rhizome and inflorescence; C and D: Lateral staminodes; E: Labellum; F: Flower (top view), showing part of the three corolla lobes, staminodes and labellum; G: Anthers and anther crests; H: Dorsal corolla lobe; I and J: Lateral corolla lobes; K: Bract; L: Bracteole; M: Ovary and calyx tube; N: Fruit with persistent calyx; O: Seeds

Figure 13 Photographs of *Kaempferia lopburiensis* Picheans. A: Inflorescence; B: Roots, rhizome and inflorescence; C: Lower part of a leaf showing a red ligule; D: The plant in the type location.

7. *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov. Type: THAILAND. Changwat Nakhon Sawan, Amphoe, Phai Sali, alt 131 m, 1 May 2017, Picheansoonthon & Meechonkit 010517-1 (holotype BK).

Perennial herb. Roots fibrous with globular to fusiform, tuberous storage. Rhizome short, erect. Bladeless sheaths, 2-3, 0.8-7 × 0.7- 2.4 cm, green and reddish, sparsely hairy. Leaves 1; sessile; almost horizontal and near the ground, blade suborbicular, 13.6-22.7 × 13.1-22.9 cm, base cordate, apex acute or acuminate, upper surface green, glabrous, lower surface pale green, hairy; ligule broadly trianglular, 0.9-1.2 cm × 4-8 mm, reddish, apex rounded or acute, sparsely hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.5-1.4 cm long. Flowers 7-10; bract ovate, 1.9-3.4 × 0.8-2.5 cm, apex acute, hairy; bracteole lanceolate, 1.4-2.1 cm × 4-5 mm, apex 2-lobed, each lobe acute or apex acute, hairy; calyx tubular, 3.4-5.2 cm long, split on one side, 4-8 mm long, apex bifid or trifid, hairy; corolla tube 3.5-7.9 cm long, whitish, glabrous; dorsal corolla lobe lanceolate-oblong, 2.4-3.1 cm × 5-6 mm, apex acute, hooded; lateral corolla lobe lanceolate-oblong, 2.2-2.9 × 3-4 nm, apex acute; lateral staminodes obovate, 2.3-3.1 × 0.9-1.6 cm, pale purplish, apex rounded; labellum broadly obovate, 1.9-3.1 × 2.3-2.8 cm, pale purplish, deep purple toward the base, apex divided to 2/3 of labellum length or almost to the base, each lobe obovate, 1.4-1.7 × 1-1.2 cm, apex rounded to emarginate or partly overlapping; anther 3-4 mm long, anther crest oblong, 6-7 × 3-5.5 mm, purplish, apex trilobe; ovary cylindrical or ellipsoid, 4-7 × 2-3 mm, pubescence or hairy; stylodes 2, filiform, 4-5 mm long. Fruits oblong, 3.9-4 cm × 8-9 mm, whitish, curved, upper part red-brownish, hairy. Seeds numerous, ovate to elliptic, yellowish, 5-5.5 × 2.5-3 mm; capped with whitish membranous aril.

Phenology: Flowering from March to April, fruiting from May to June.

Distribution: This new species is so far only known from the type locations in Changwat Nakhon Sawan, Thailand.

Ecology: This new species grows in dry deciduous forest.

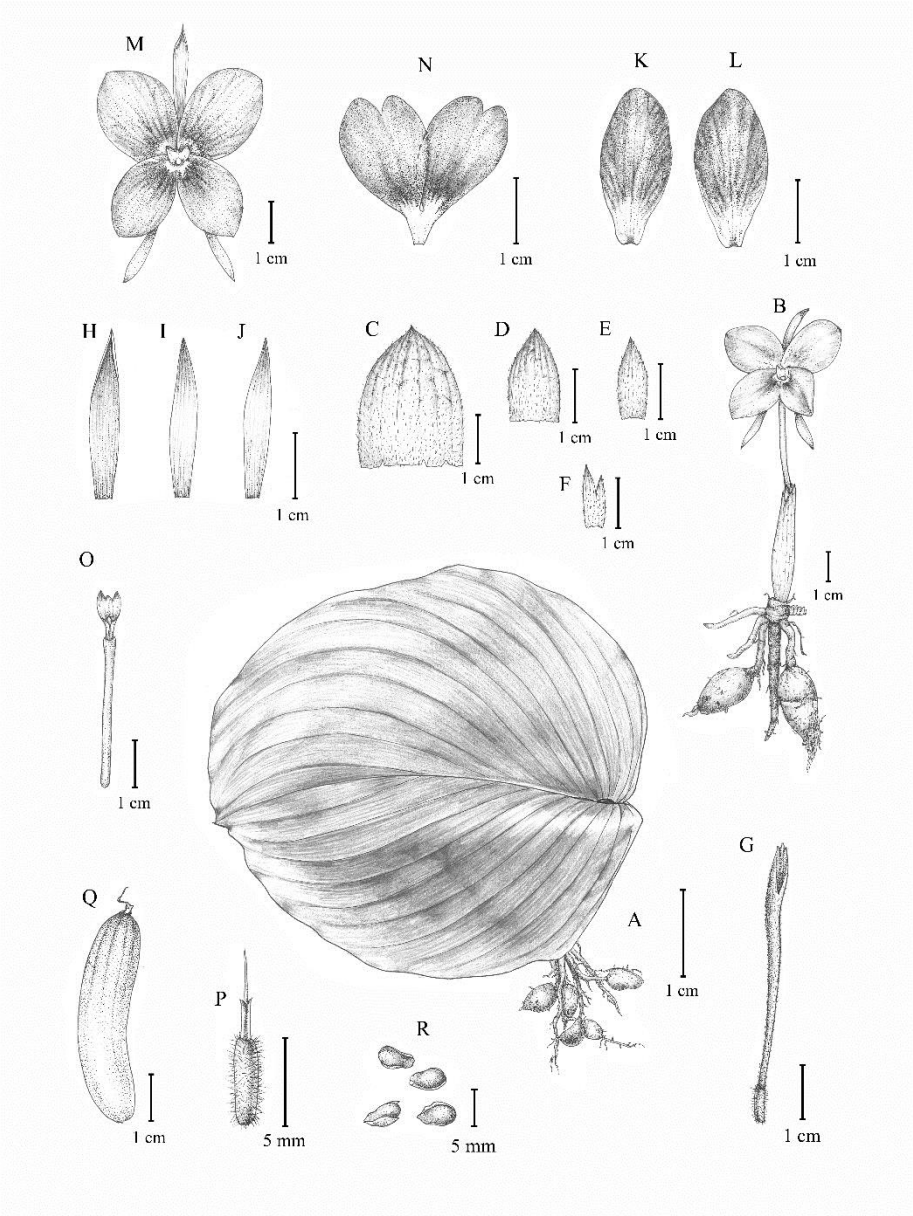


Figure 14 *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach A: Habit; B: Roots, rhizome and inflorescence; C, D, and E: Bract; F: Bracteole; G: Ovary and calyx tube; H: Dorsal corolla lobe; I and J: Lateral corolla lobes; K and L: Lateral staminodes; M: A flower (top view); N: Labellum; O: Anthers and anther crests; P: Ovary, stylodial glands, and lower part of the style; Q: Fruit with persistent calyx tube; R: Seeds.

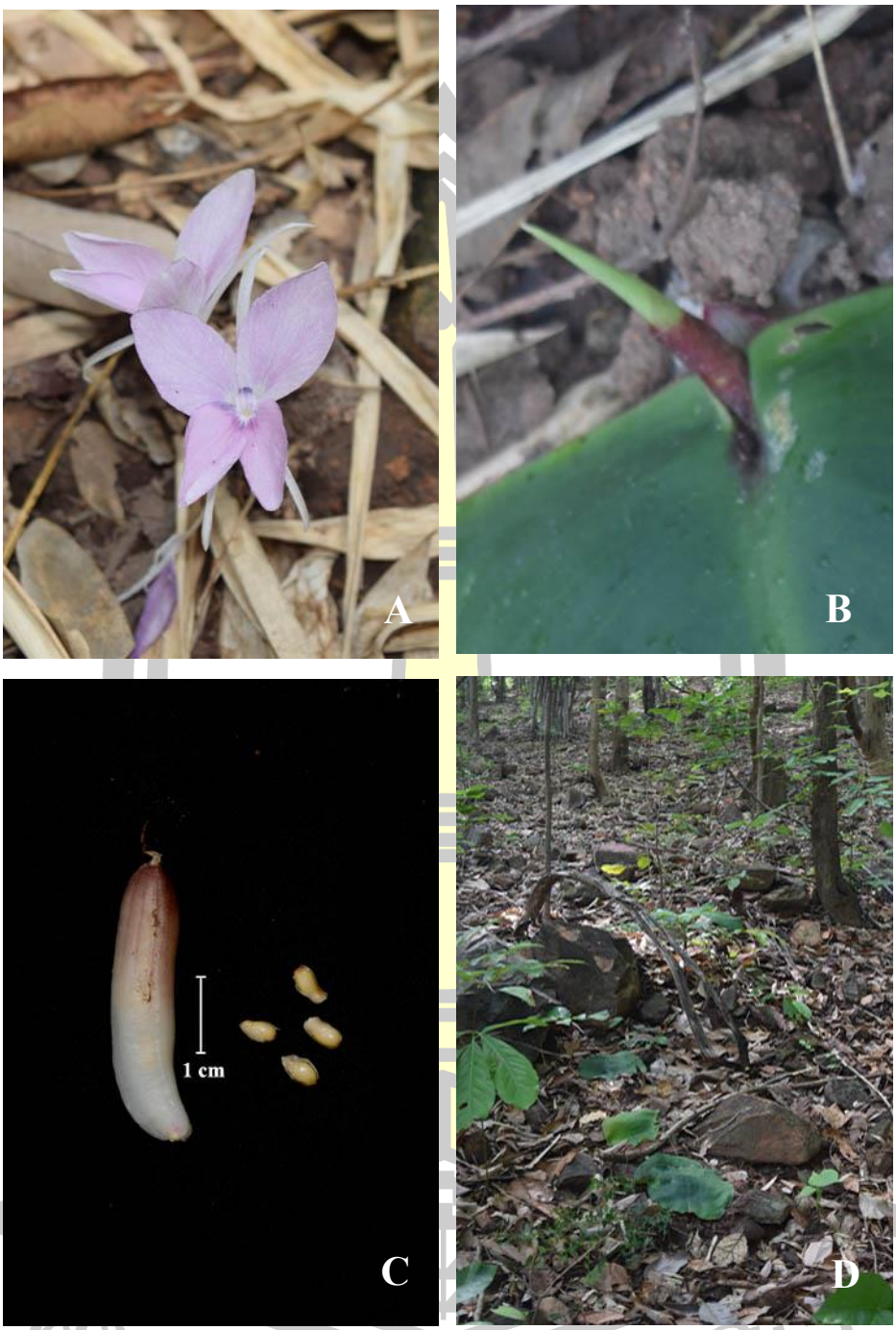


Figure 15 Photographs of *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach.

A: Inflorescence; B: Lower part of a leaf showing a red ligule; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

8. *Kaempferia noctiflora* Nopporn c. & Jenjitt., Phytotaxa. 316 (1): 067-072. 2017. Type: THAILAND. Changwat Chiang Mai, Amphoe, Mae On, alt 600-610 m, 23 May 2015, Nattapon Nopporncharoenkul NNSB-340 (holotype BKF, isotypes E, SING, QBG, Suan Luang Rama IX herbarium (Include spirit)).

Perennial herb. Roots fibrous-fusiform with terminal tubers. Rhizome short, erect. Bladeless sheaths, 1-2, 0.8-7 × 0.7- 2.4 cm, green to purplish red, apex rounded, hairy. Leaves 3-4; petiole short, ca. 1 cm long, pale green to purplish red, sparsely hairy; blades not prostrate, ovate to elliptic, 13.6-22.7 × 13.1-22.9 cm, base acute, apex acuminate to cuspidate, upper surface pale green to tinged purplish red, usually with tinged purplish red patch along the midvein, glabrous, lower surface purplish red, pubescent; ligule broadly trianglular, 1.8-3 mm long, pale green to purplish red, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle subsessile to 1 cm long, glabrous. Flowers 4-7; bract ovate to lanceolate-ovate, 1-3.4 × 2-3 cm, green, apex acute to acuminate, hairy; bracteole lanceolate, ca. 1.7 cm × 5 mm, apex 2-lobed, each lobe acute, glabrous; calyx tubular, 5.1-6 cm long, split on one side, 6-10 mm long, apex bifid, glabrous; corolla tube 6-7 cm long, whitish, glabrous; dorsal corolla lobe lanceolate-oblong, 4-4.8 cm × 4-5 mm, apex aristate, hooded; lateral corolla lanceolate-oblong, 3.8-4 × 3-4 nm, apex aristate to acute; lateral staminodes, oblong- elliptic, 2.8-4 × 1-1.3 cm, white, apex acute; labellum broadly obovate, 3.4-4 × 2.1-3.4 cm, pure white or white with pale yellow patch from the base, bilobed divided to 1/2 -2/3 of labellum, each lobe obovate, 2-2.2 × 1.3-1.6 cm, apex acute, rounded to slightly bilobed, partly overlapping; anther 5-6 mm long, anther crest oblong, 7-9 × 3-5 mm, white, apex biobed; ovary cylindrical, ca. 6 × 2-2.2 mm, creamy yellow, sparsely hairy; stylodes 2, filiform, 4-5 mm long. Fruits ellipsoid, 1.7-2 cm × 8-9 mm, yellowish green, glabrous. Seeds numerous, ovate to ellipsoid, yellowish, 5-7 × 2-3 mm; capped with whitish membranous aril.

Phenology: Flowering from May to June, fruiting from to July

Distribution: This new species is so far only known from the type locations in Changwat Chiang Mai, Thailand.

Ecology: This new species grows on clay loamy soil with decayed rocks in the shade in dry deciduous forest on hills.

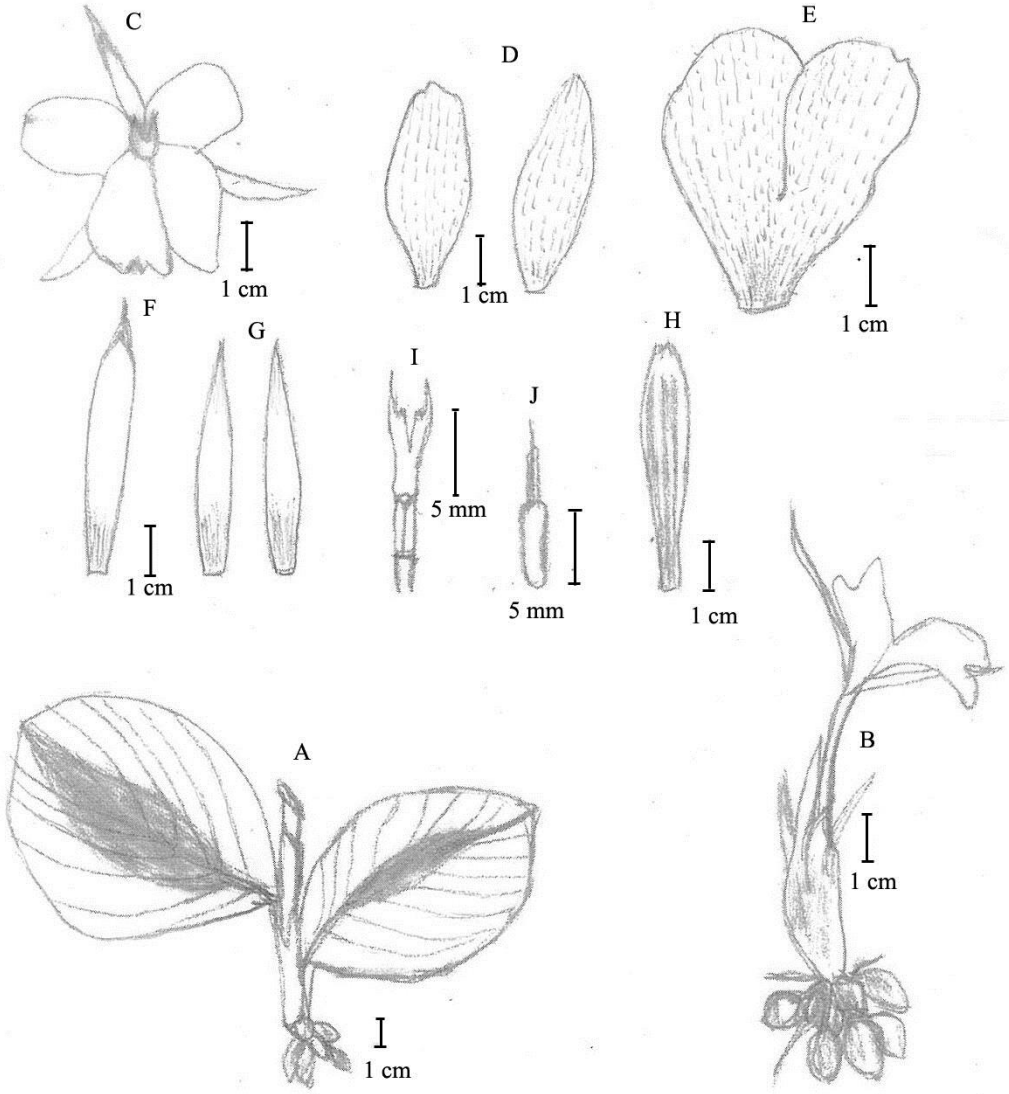


Figure 16 *Kaempferia noctiflora* Nopporn c. & Jenjitt.

A: Habit; B: Roots, rhizome and inflorescence; C: Flower in front view; D: Lateral staminode; E: Labellum; F: Dorsal corolla lobe; G: Lateral corolla lobe; H: Calyx tube; I: Anthers and anther crest; J: Ovary with part of the style and the stylodes.

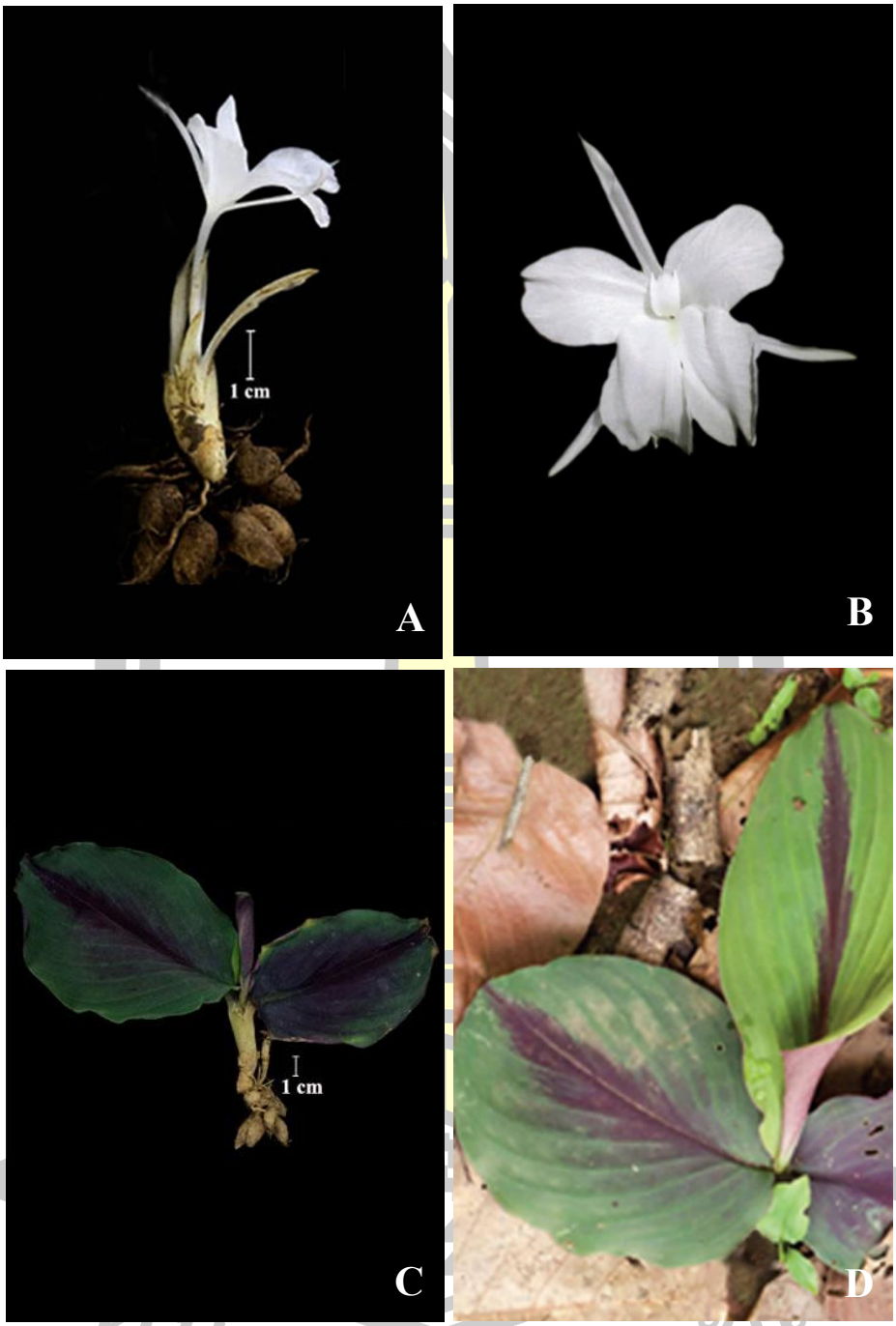


Figure 17 Photographs of *Kaempferia noctiflora* Noppornc. & Jenjitt. A: Inflorescence; B: A flower showing characteristic staminodes, labellum and anther creast; C: Habit; D: The plant in the type location.

9. *Kaempferia occidentalis* Picheans., Meechonk. & Phokham, sp. nov.
Type: Thailand, Changwat Kanchanaburi, Amphoe Sai Yok, alt. 60 m, 11 April 2015, Picheansoonthon & Meechonkit 110415-1 (holotype BK, isotype MSU).

Perennial herb. Roots fibrous with globular to fusiform, tuberous storage. Rhizome short, erect. Bladeless sheaths 1-3, 2-7.9 cm long, hairy. Leaves 1-2(-4), sessile, almost horizontal and near the ground; blades suborbicular to elliptic, 11.2-38 × 10.3-31.2 cm, base cuneate to obtuse, apex mucronate to obtuse, upper surface green, sparsely hairy at the base of the midrib, lower surface pale green with reddish at the top and lateral, sparsely hairy; ligule broadly trianglular, 0.8-1.7 cm long, reddish, apex obtuse to rounded, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.7-3.1 cm long, hairy. Flowers 6-18; bracts ovate, 2.2-4.2 × 1.1-2.7 cm, pale green, apex mucronate, hairy; bracteoles lanceolate, 1.3-1.9 cm × 2-3 mm, apex 2-lobed, each lobe acute, hairy; calyx tubular, 3.4-6.3 cm long, split on one side, 0.8-1.1 cm long, apex bifid, hairy; corolla tube, 4.2-7.9 cm long, whitish, hairy; dorsal corolla lobe oblong to narrowly ovate, 1.8-2.6 cm × 5-6 mm, apex acute, hooded; lateral corolla lobe oblong to narrowly ovate, 1.9-2.5 cm × 3-4 mm, apex acute; lateral staminodes broadly obovate, 2.1-2.8 × 1.3-2 cm, lilac purple, apex rounded to slightly emarginate; labellum broadly obovate, 1.8-2.9 × 2.7-3.9 cm, lilac purple, deep purple with yellow-orange line at base, apex divided almost to the base, each lobe broadly semi-circular, 1.5-2.1 × 1.6-2 cm, apex rounded to slightly emarginate; anther 5-6 mm long, anther crest ovate to rectangular, 5-8 × 4-8 mm, white to violet; ovary oblong to cylindrical, 3-5 × 2 mm long, sparsely hairy; stylodes 2, filiform, ca. 5 mm long. Fruits obovate to elliptic, 3-3.6 × 1.2-1.7 cm, sweet purple. Seeds numerous, ovate, yellowish, ca. 4 ×3 mm; capped with whitish membranous aril.

Phenology: Flowering from March to April; fruiting from April to May.

Distribution: This new species is so far only known from the type locations in Changwat Kanchanaburi, Thailand.

Ecology: In lowland dry deciduous forest at an altitude around 60 m. It grows limestone soil near the bamboos.

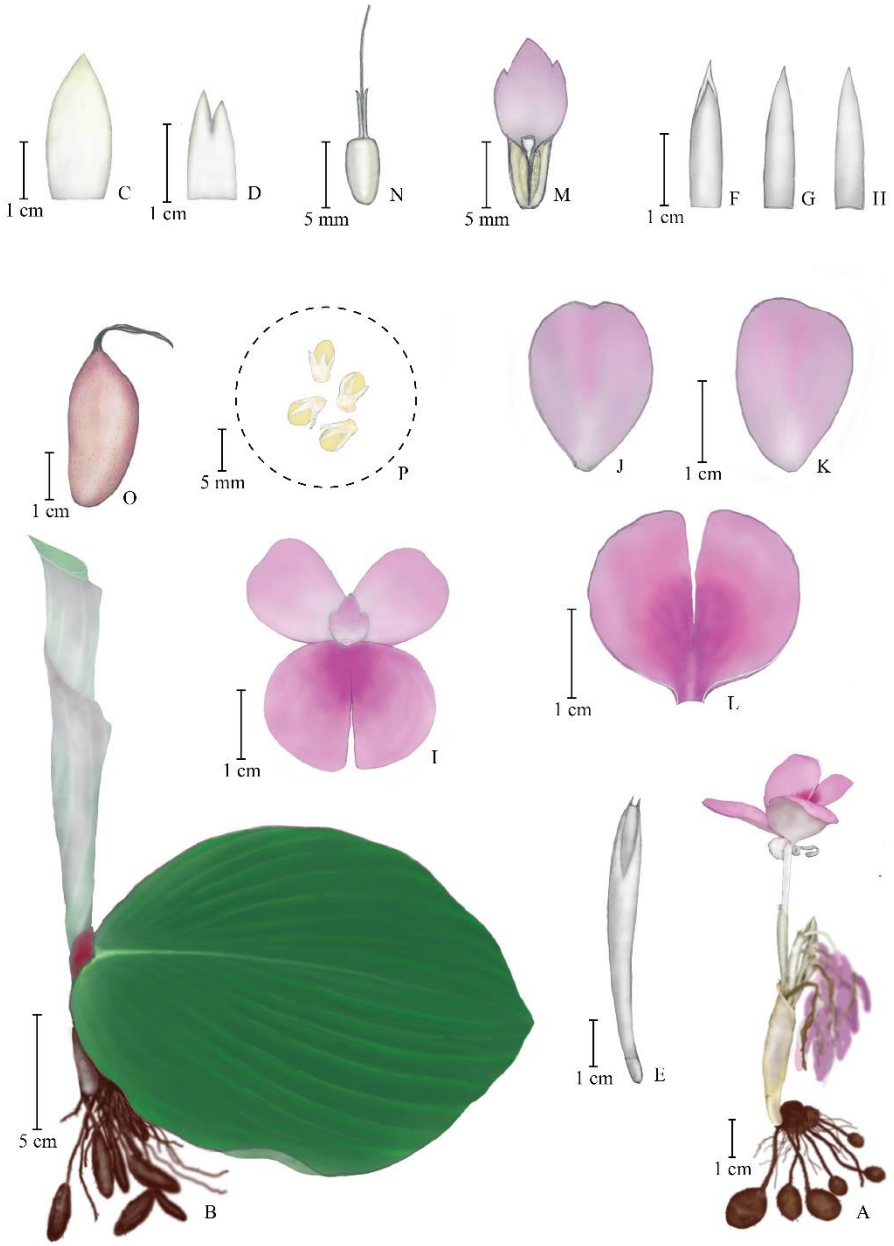


Figure 18 *Kaempferia occidentalis* Picheans., Meechonk. & Phokham. A: Roots, rhizome and inflorescence; B: Habit; C: Bract; D: Bracteole; E: Calyx tube and ovary; F: Dorsal corolla lobe; G and H: Lateral corolla lobe; I: Flower (top view); J and K: Lateral staminodes; L: Labellum;M: Anthers, stigma and anther crest; N: Ovary with part of the style and the stylodes; O: Fruit with persistent calyx tube; P: Seeds.

Figure 19 Photographs of *Kaempferia occidentalis* Picheans., Meechonk. & Phokham.

A: Inflorescence; B: Lower part of a leaf showing a red ligule; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

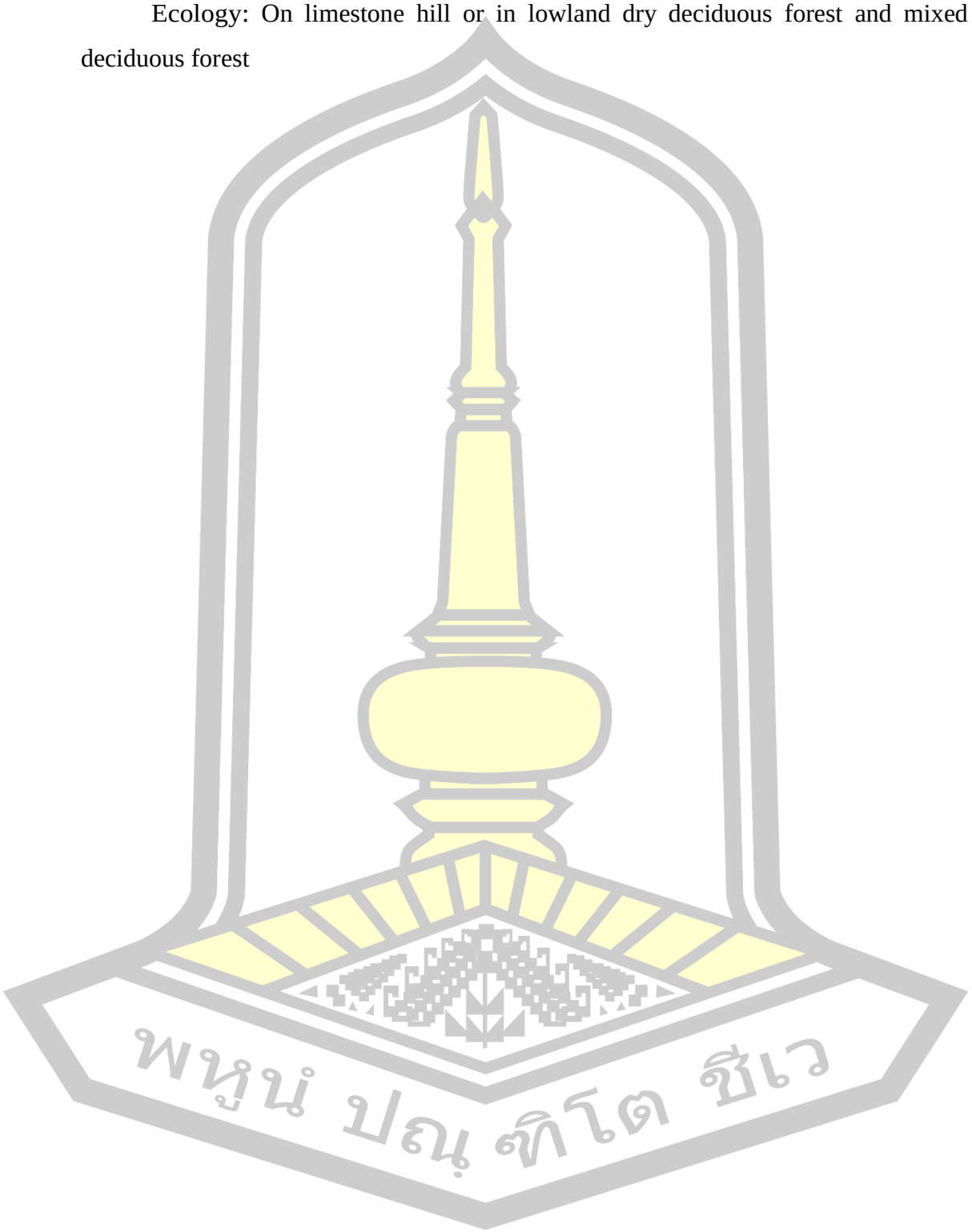
10. *Kaempferia rotunda* L., Sp. P1: 3. 1753; Roscoe, Monand. P1. t. 97.1828; Wight, Icon. T. 2029. 1853; Bak. in Fl. Br. Ind. 6: 22. 1890; Schum. in Pflanzenr. Zingib. 4: 87. 1904; Gagnep. in Fl. Gen. I-C: 47. 1908; Valet., Bull. Jard. Bot. Buitenzorg ser. 2. 27: 109. 1918; Ridl., Fl. Mal. Pen. 4: 246. 1924; Holttum. Gard. Bull. Sing. 13: 120. 1950. Plate 11: 4; Fl. China 24: 368-370. 2000; Kress et al. in Am. J. Bot. 89(11):1682-1696. 2002; Nopporncharoenkul and Jenjittikul in Phytotaxa. 316(1): 067-072. 2017; Theanphong et al. in Songklanakarin J. Sci. Technol. 40(3): 617-622. 2018.

Perennial herb. Roots fibrous with globular to fusiform, tuberous storage. Rhizome short, erect. Bladeless sheaths 1-3, 2.1-19.1 cm long, hairy. Leaves 1-5(-7); petiole 1.4-8.7 cm long, hairy; blades not prostrate, lanceolate-oblong to elliptic, 12-39.5 × 3.8-13 cm, base cuneate, apex acute, upper surface green, glabrous, lower surface pubescence; ligule broadly triangular, 1-3 mm long, green or green-reddish, apex acute to rounded hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.3-8.4 cm long, hairy. Flowers 5-16; bracts lanceolate, 2.5-5.6 × 1.1-3.3 cm, apex mucronate to acuminate, ciliate; bracteoles lanceolate, 1-2.8 cm × 2-5 mm , apex acute or 2-lobed, apex of each lobe acute, hairy; calyx tubular, 3.8-6.5 cm long, split on one side, 1-1.7 cm long, apex 2-lobed, sparsely hairy; corolla tube, 4.7-8 cm long, glabrous; dorsal corolla lobe oblong to narrowly ovate, 3.6-6.1 cm × 6-8 mm, apex aristate, hooded; lateral corolla lobe oblong to narrowly ovate, 3.4-5.5 cm × 3-5 mm, apex aristate; lateral staminodes oblong, 2.8-5.3 × 0.9-2.2 cm, white, purple-tinted apex rounded to acute; labellum obovate, 3.3-4.9 × 2-2.9 cm, purple, deep purple toward the base apically bilobed for ca. 1/2 its length, each lobe elliptic, apex rounded to mucronate; anther 5-8 mm long, anther crest oblong, 7-10 × 2-4 mm, white, the outers acute and elongate, the middle one shorter, entire or emarginate; ovary cylindrical or rectangular or oblong, 4-7 × 2-3 mm, hairy; stylodes 2, filiform, ca. 5 mm long. Fruits ovate to oblong, 1.6-2.5 × 0.7-1.1 cm, whitish. Seeds numerous, ovate, whitish, 4-7 × 2-4 mm; capped with white membranous aril.

Pheology: Flowering from March to April; fruiting from April to May.

Distribution: Central, Northern and North-Eastern Thailand.

Ecology: On limestone hill or in lowland dry deciduous forest and mixed deciduous forest



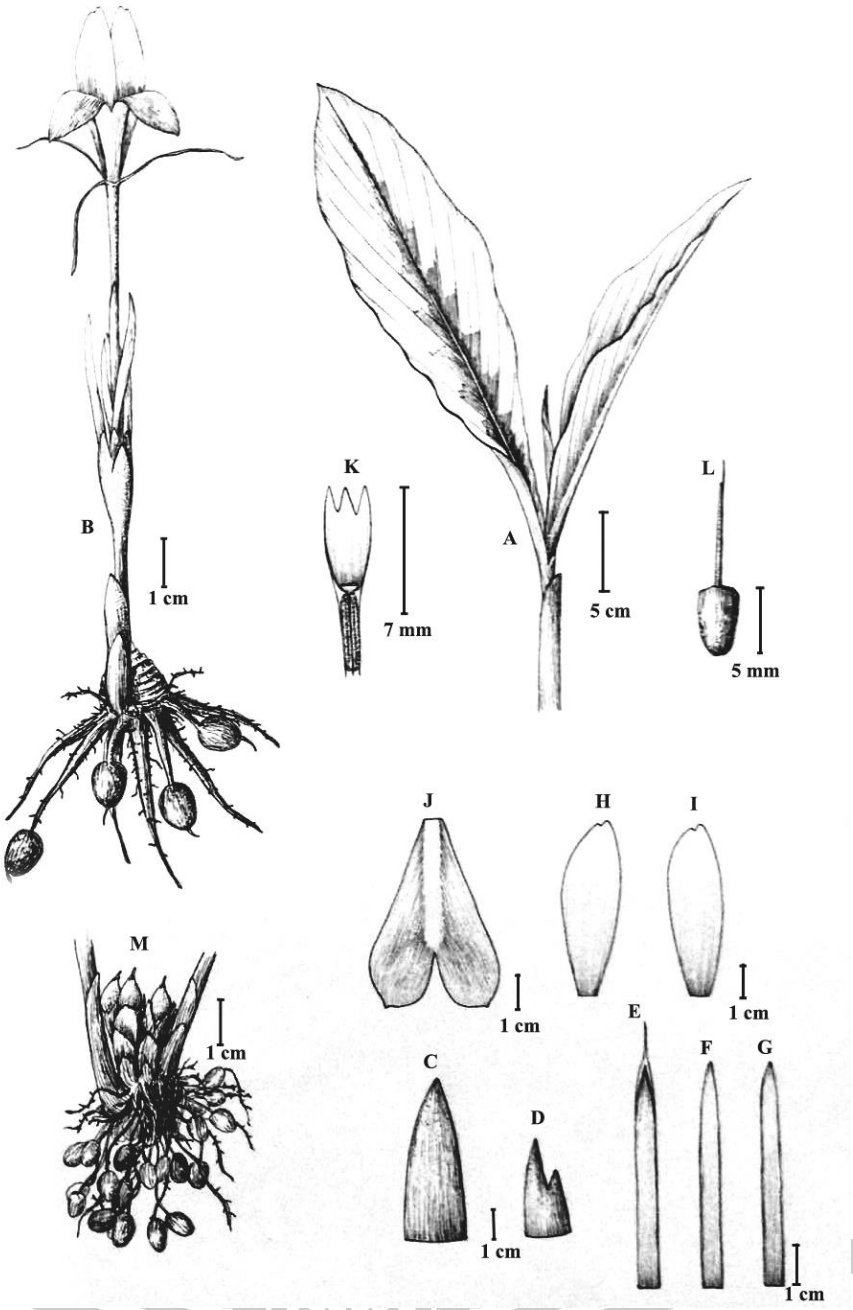


Figure 20 *Kaempferia rotunda* L.

A: Habit; B: Roots, rhizome and inflorescence; C: Bract; D: Bracteole; E: Dorsal corolla lobe; F and G: Lateral corolla lobes; H and I: Lateral staminodes; J: Labellum; K: Anthers and anther crests; L: Ovary, stylodial glands, and lower part of the style; M: Fruit with roots.

Figure 21 Photographs of *Kaempferia rotunda* L.
A: Inflorescence; B: Flower (top view), showing part of the three corolla lobes, staminodes and labellum; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

11. *Kaempferia takensis*. Picheans & Meechonk., sp. nov.

Type: Thailand. Changwat Tak, Amphoe Sam Ngao, alt. 257m, 16 April 2016, Pichensoonthon & Meechonkit 160416-1 (holotype BK, isotype MSU).

Perennial herb. Roots fibrous with globular to fusiform tuberous storage. Rhizome short, erect. Bladeless sheaths 1-2, 2.1-5.2 cm long, hairy. Leaves 2-4(6); sessile; blades not prostrate; ovate to elliptic, 10.1-43.5 × 7.1-20.9 cm, base cuneate, apex acute to acuminate, upper surface green with several green markings, hairy at the base of the midrib, lower surface reddish, hairy; ligule, broadly trianglular, membranous, 1-3.5 × 0.8-2.5 cm, reddish, apex rounded, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, peduncle 0.5-1 cm long, hairy. Flowers 5-19; bract ovate, 2.3-4 × 0.8-2.4 cm, apex acute, hairy; bracteole lanceolate, 1.2-1.3 cm × 3-4 mm, apex 2-lobed, apex of each lobe acute, hairy; calyx tubular, 2.4-2.8 cm long, split on one side, 0.5- 1.5 cm long, apex bifid, hairy; corolla tube, 2.8-7.5 cm long, whitish, hairy; dorsal corolla lobe oblong to narrowly ovate, 2.5-3.5 cm × 4-6 mm, apex acute, hooded; lateral corolla lobe oblong to narrowly ovate, 1.5-2.8 cm × ca. 4 mm, apex acute; lateral staminodes, broadly obovate, 2.1-2.5 × 1.7-1.8 cm, purple, apex rounded; labellum broadly obovate, 2.4-3.2 × 2.7-4.8 cm, purple, deep purple toward the base, apex divided almost to the base, each lobe broadly obovate, 2.1-2.7 × 1.4-2.5 cm, apex rounded; anther 4-6 mm long, anther crest oblong to rectangular, 5-8 × 3-7 mm, white to purple, apex bilobed; ovary oblong to obovate, 3-5 × 2 mm long, glabrous to sparsely hairy ; stylodes 2, filiform, ca. 5 mm long. Fruits, ovate to oblong, 1.1-2.4 cm × 0.7-1 cm, yellow-green. Seeds numerous, ovate to oblong, yellow-green, 5-8 × 3-4 mm; capped with white membranous aril.

Phenology: Flowering from March to April; fruiting from April to May.

Distribution: Northern Thailand (Changwat Tak)

Ecology: On limestone hill and under bamboos shade in dry deciduous forest.

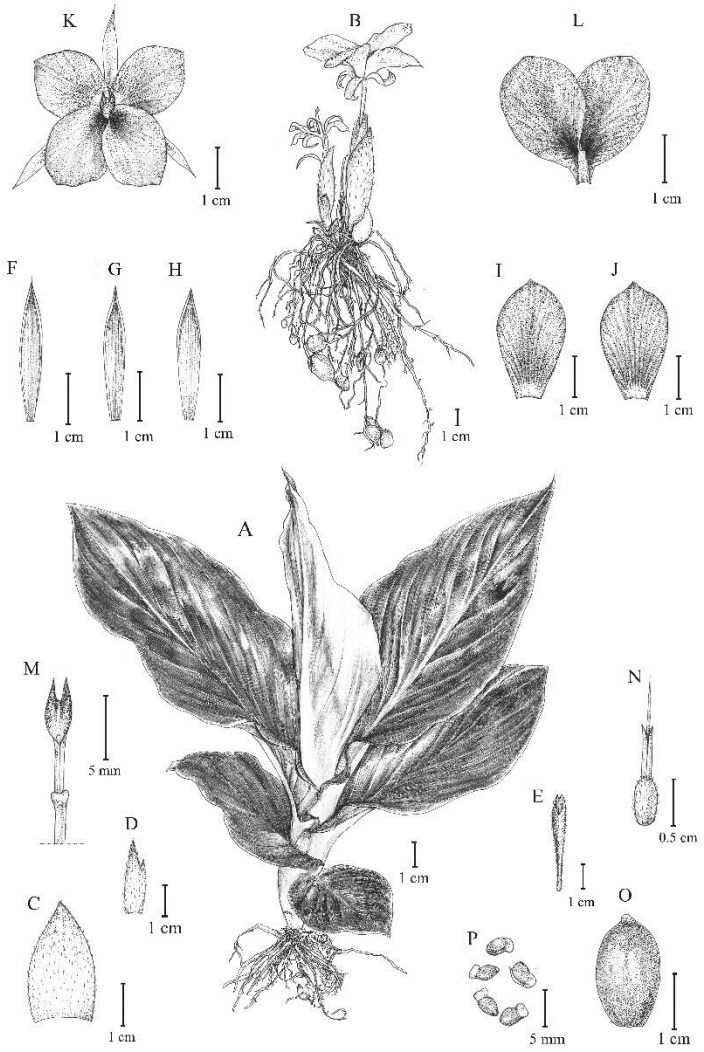


Figure 22 *Kaempferia takensis* Picheans. & Meechonk.

A: Habit; B: Roots, rhizome and inflorescence; C: Bract; D: Bracteole; E: Ovary and calyx tube; F: Dorsal corolla lobe; G and H: Lateral corolla lobes; I and J: Lateral staminodes; K: A flower (top view); L: Labellum; M: Anthers and anther crest; N: Ovary and stylodial glands; O: Fruit; P: Seeds.

Figure 23 Photographs of *Kaempferia takensis* Picheans. & Meechonk. A: Inflorescence; B: Lower part of a leaf showing a red ligule; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

12. *Kaempferia udonensis* Picheans. & Phokhom, J. Jpn. Bot. 88: 297-308. 2013. Type: Thailand. Changwat Udon Thani, Amphoe Nong Wua So, Tambon Mak Ya, Khao Nokyoong Thong, N 17° 12.287' E 102° 38.261', altitude 360 m, 31 March 2011, Picheansoonthon & Phokham 310311-1 (holotype BKF, isotype BK, SING).

Perennial herb. Rhizomes short, erect, with fusiform tuberous roots. Leaves 2-4; petiole 1.5-2 cm long, hairy; blades horizontal near the ground, orbicular to elliptic, 19-27.5 × 14.7-18.8 cm, base cuneate to obtuse, apex cuspidate to acuminate; margin slightly undulate, reddish, upper surface green with several silvery markings, hairy at the base of the midrib, lower surface reddish brown, pubescent; ligules broadly triangular, 1.4-2 × 1.2-1.3 cm, reddish, apex obtuse, hairy. Inflorescences produced toward end of the dry season from leafless rhizomes, peduncle 1.1-3 cm long, hairy. Flowers 5-30; bracts ovate, 2.9-4.8 × 1.2-3.5 cm, apex acute, hairy; bracteoles lanceolate, 1.8-2.3 cm × 3-5 mm, apex 2-lobed, apex of each lobe acute, hairy; calyx tubular, 5.2-7.2 cm long, split on one side, 0.6-1.3 cm long, apex bifid, hairy; corolla tube, 6.2-10.7 cm long, whitish, glabrous; dorsal corolla lobe oblong to narrowly ovate, 2.4-3.5 × 0.5-1 cm, apex acute, hooded; lateral corolla lobes oblong to narrowly ovate, 2-3.3 cm × 4-6 mm, apex acute; lateral staminodes broadly obovate, 2.1-3.2 × 1.8-2.9 cm, light purple, apex rounded; labellum broadly obovate, 1.8-3 × 2.8-3.5 cm, light purple, deep purple at base, apex divided almost to the base, each lobe broadly obovate, 1.2-2.5 × 1.3-1.9 cm, apex rounded; anther 4-6 mm long, anther crest white to violet, rectangular, 5-9 × 6-8 mm, apex acute to trifid ; ovary rectangular, 4-7 mm long, pubescent; stylodes 2, filiform, ca. 5 mm long. Fruits fleshy, ovate, oblong to obovate, 1.2-3.4 × 0.8-1.4 cm. Seeds numerous, ovate, reddish, 3-6 × 2-4 mm; capped with whitish membranous aril.

Phenology: Flowering from March to April; fruiting from April.

Distribution: This new species is so far only known from the type locations in Changwat Udon Thani, Thailand.

Ecology: The new species grows on limestone soils or rocks, under the shade in dry deciduous forest, at the altitude of 600-720 m.

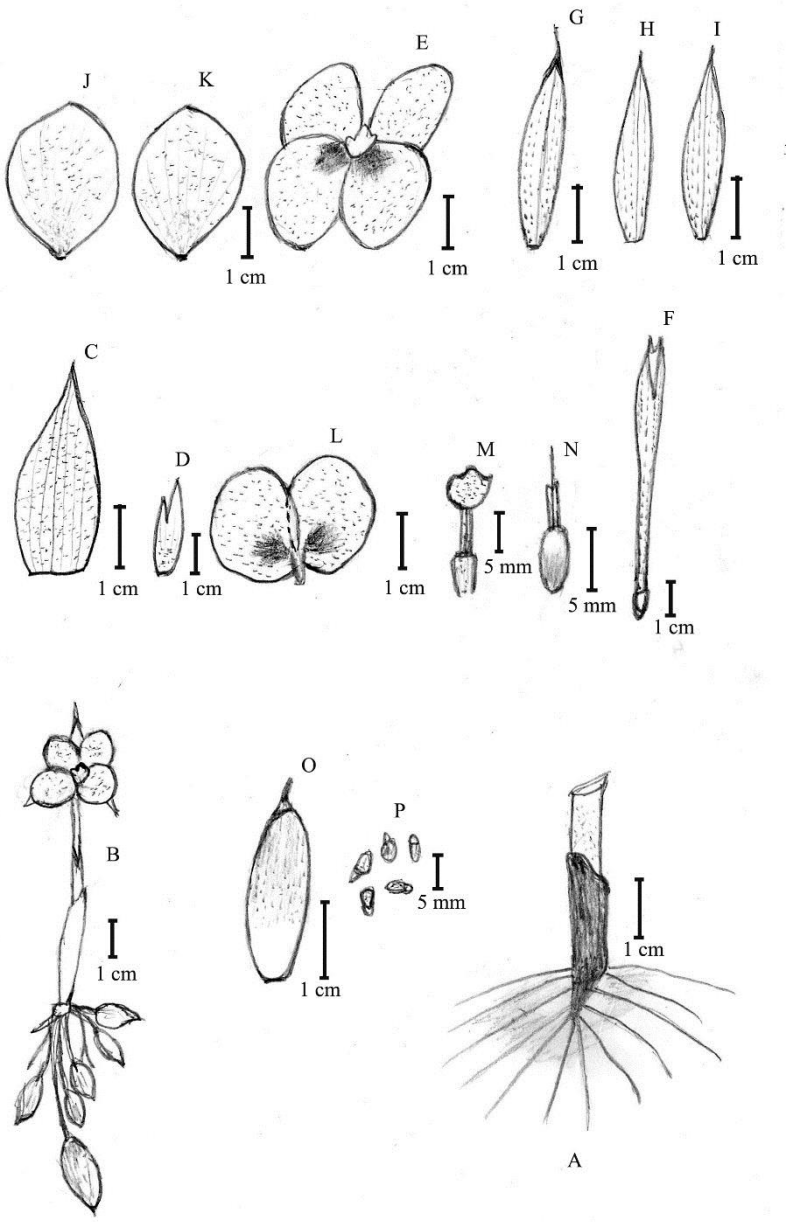


Figure 24 *Kaempferia udonensis* Picheans. & Phokham.

A: Part of leaf showing the ligule; B: Roots, rhizome and an inflorescence; C: Bracts; D: Bracteole; E: A flower (top view); F: Ovary and calyx tube; G: Dorsal corolla lobe; H and I: Lateral corolla lobes; J and K: Lateral staminodes; L: Labellum; M: Anthers and anther crests; N: Ovary, stylodial glands, and lower part of the style; O: A fruit with persistent calyx tube; P: Seeds.

Figure 25 Photographs of *Kaempferia udonensis* Picheans. & Phokham. A: Inflorescence; B: Lower part of a leaf showing a red ligule; C: Fruit with persistent calyx and seeds; D: The plant in the type location.

13. *Kaempferia uttaraditensis* Picheans. & Meechonk., sp. nov.
Type: Thailand. Changwat Uttaradit, Amphoe Phichai, alt. 125 m, 14 Jun 2016, Picheansoonthon & Meechonkit 140616-1(holotype BK, isotype MSU).

Perennial herb. Roots fibrous with globular to fusiform, tuberous storage. Rhizome short, erect. Bladeless sheaths 1-2, 2.3-6.6 cm long, green to purplish red, apex acute, hairy. Leaves 1-3(-4); petiole 1-3.5 cm long, greenish, hairy; blades not prostrate, elliptic to lanceolate, 8-21.3 × 2.4-9.3 cm, base cuneate, apex acuminate, upper surface green, sparsely hairy at the base of the midrib, lower surface pale green, sparsely hairy; ligule, small triangular, 0.5-2 mm long, greenish, apex acute, hairy. Inflorescences produced towards the end of the dry season from the leafless rhizomes, night blooming, peduncle 1.2-3.2 cm long, glabrous. Flowers 5-10; bracts broadly ovate to ovate, 1.1-3.2 × 0.7-2.2 cm, pale green, apex acute to mucronate, hairy; bracteoles lanceolate, 0.7-1.7 cm × 3-5 mm, whitish, apex acute, hairy; calyx tubular, 3.8-5.5 cm long, split on one side, 1.1-1.6 cm long, white to pale greenish, apex bifid, hairy; corolla tube, 3.6-6.6 cm long, white, glabrous; dorsal corolla lobe lanceolate-oblong, 2.9-4.1 cm × 4-7 mm, white, apex acute, hooded; lateral corolla lobe lanceolate-oblong, incurved, 2.8-3.6 cm × 4-7 mm, white, apex acute; lateral staminodes oblong or obovate, 2.5-4.3 × 0.4-1.2 cm, white, apex rounded to acute; labellum broadly obovate, 3.1-4 × 1.9-2.7 cm, base attenuate into 0.8-1 cm × 4-5 mm claw, pure white or white with purplish patch at the base, apex bilobed divided to 1/2-2/3 of labellum length, each lobe obovate to narrow obovate, 1.4-2.2 × 0.8-1.1 cm, apex rounded to acute or emarginate or partly overlapping; anther 3-5 mm long, anther crest oblong, broadly obovate, or rectangular, 4-5 × 3-5 mm, white, apex bilobed to crenate; ovary oblong to cylindrical, 4-6 × 2-3 mm, whitish, glabrous; stylodes 2, filiform, ca. 5 mm long. Fruits elliptic, whitish, ca. 7.5 × ca. 4 mm, seed numerous, ovate, whitish; capped with whitish membranous aril.

Phenology: Flowering from March to April, fruiting from April to May.

Distribution: This new species is so far only known from the type locations in Changwat Uttaradit, Thailand.

Ecology: It grows on limestone soil near the channel under the shade of deciduous forest at the altitude around 125 m.

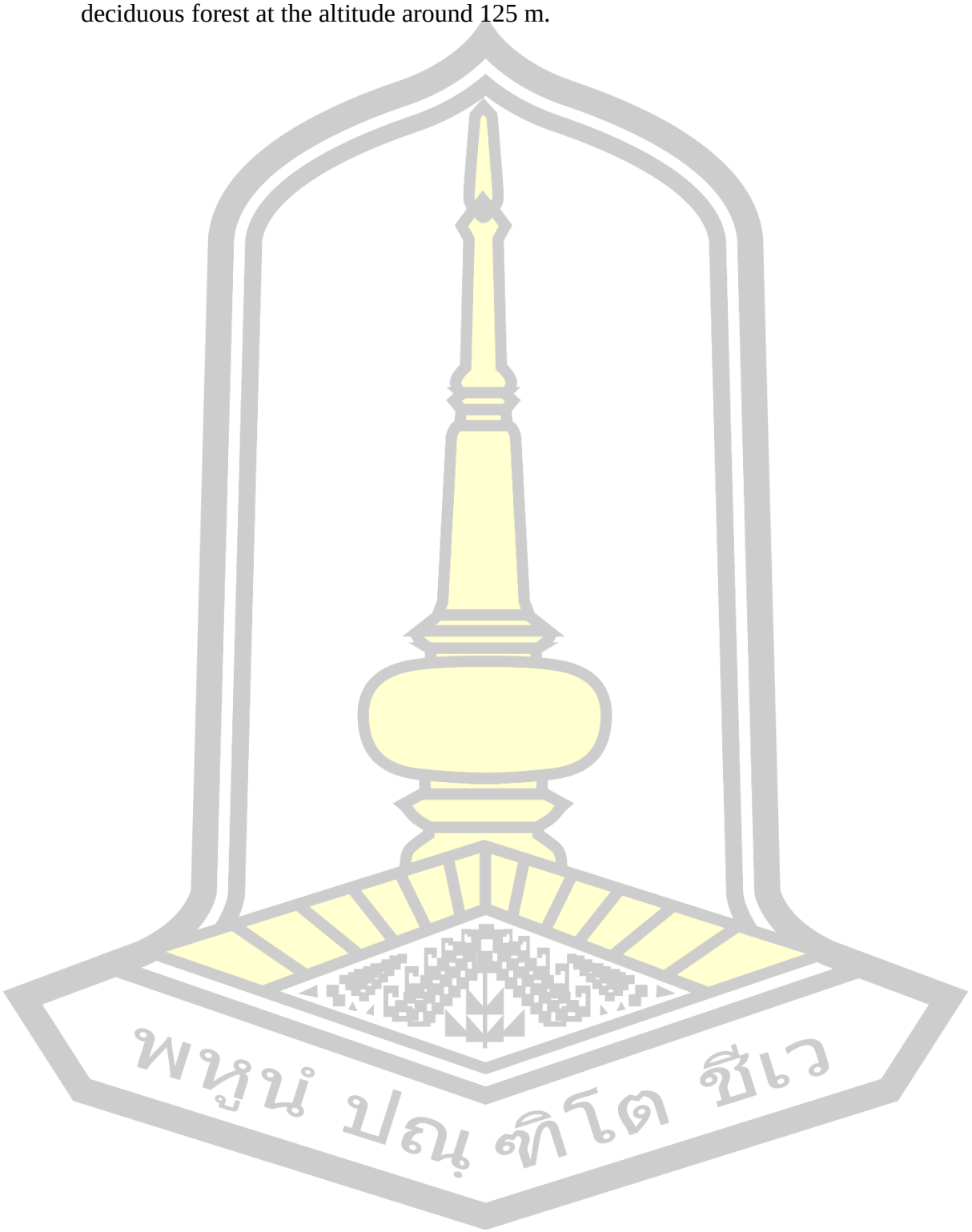


Figure 26 *Kaempferia uttaraditensis* Picheans. & Meechonk.
A: Roots, rhizome and inflorescence; B: Habit; C: A flower, showing ovary, calyx tube, corolla tube, lateral staminodes and labellum; D: Bract; E: Bracteole; F: ovary and calyx tube; G: Dorsal corolla lobe; H, I: Lateral corolla lobes; J, K. Lateral staminodes; L. Labellum; M: Anthers and anther crest; N: Ovary, stylodial glands, and lower part of the style.

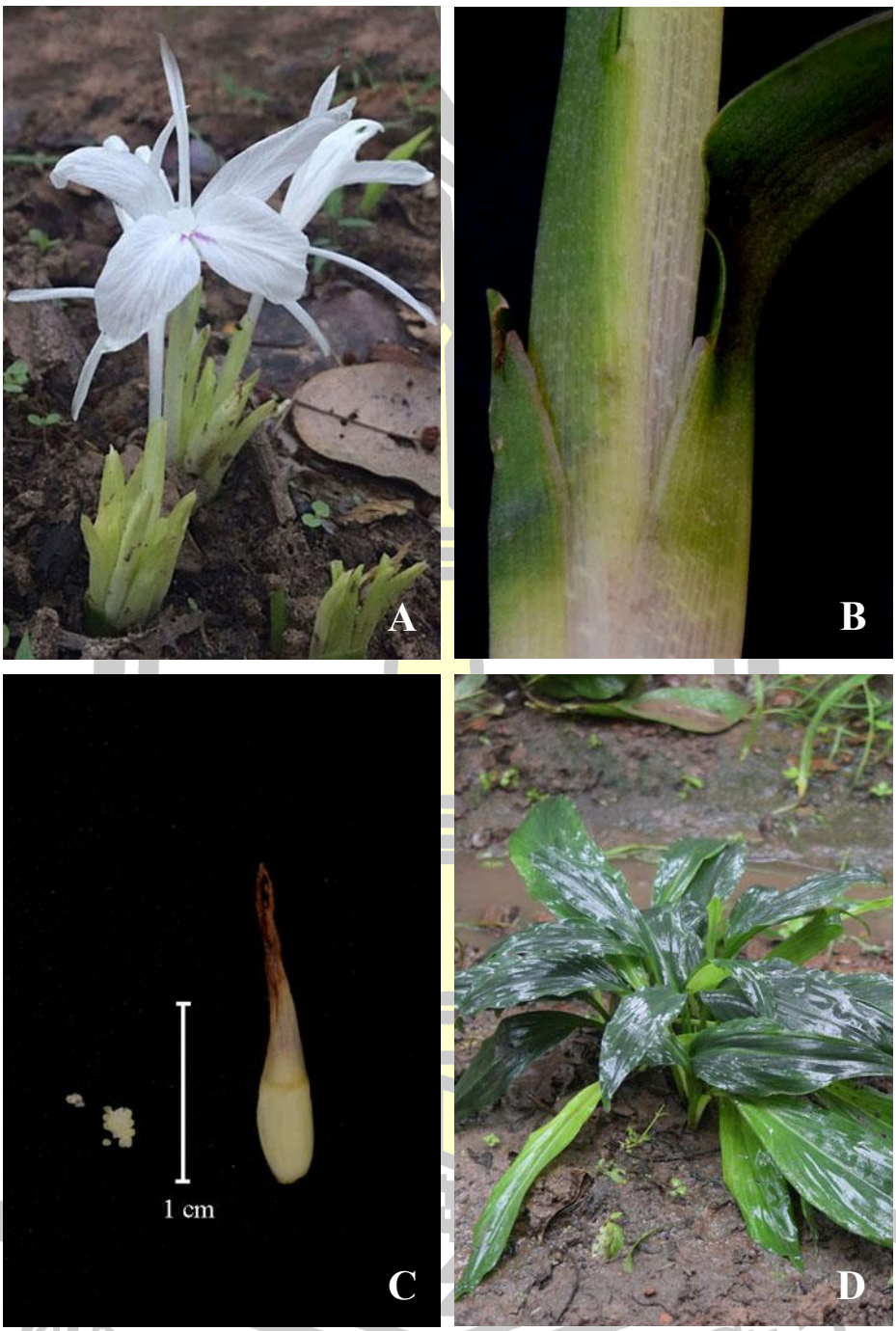


Figure 27 Photographs of *Kaempferia uttaraditensis* Picheans. & Meechonk. A: Inflorescence; B: A flower, showing ovary, calyx tube, corolla tube, corolla lobes, staminodes and labellum; C: Fruit with persistent calyx and seeds; F: The plant in the type location.

14. *Kaempferia xiengkhou*angensis Picheans. & Phokhom, J. Jpn. Bot. 88: 297-308. 2013.

Type: LAO PDR, Xiengkhouang District, Mueang Kham, N 19° 33.139’ E 103° 44.384’, altitude 600-720 m, 25 March 2011, *Picheansoonthon & Phokham* 250311-1, (holotype BKF, isotypes BK, SING)

Perennial herb. Rhizomes short, erect, bearing several roots in a fascicle. Leaves 3-5, sessile; blade distichous, broadly elliptic to lanceolate, 14.8-27.5 × 10.4-13.9 cm, base cuneate, apex acute to acuminate, margin slightly undulate, upper surface green, glabrous, lower surface pale green, pubescent; leaf-sheaths, 8.9-12 cm long, sparsely hairy; ligules membranous, 4-10 mm long, apex obtuse, hairy. Inflorescence appearing from leafless rhizomes, peduncle 0.9-2.9 cm long. Flowers 10-19; bracts broadly ovate to ovate, 2.6-5.4 × 1-3.5 cm, apex acute, hairy; bracteole, ovate, 1-1.4 × 2-6 mm, apex 2 lobes, reddish, acuminate, hairy; calyx tubular, 2.7-5.4 cm long, split on one side, 0.8-1.2 cm long, reddish, apex trifid, hairy; corolla tube 4.6-7.8 cm long, whitish, glabrous; dorsal corolla lobe narrowly lanceolate, 2.7-3.6 cm × 5-6 mm, apex hooded; lateral corolla lobes narrowly lanceolate, 2.1-3.5 cm × 3-5 mm, apex acute; lateral staminodes obovate, 2-3.3 × 1.1-1.9 cm, deep pink, apex rounded to apiculate; labellum broadly obovate, 1.7-3 × 2.5-4.3 cm, deep pink, violet at base, divided to the base, each lobe obovate, 1.3-2.2 × 1.1-2 cm, apex rounded to apiculate; stamen sessile; anther 4-6 mm long, anther crest ovate or rectangular, 6-8 × 2-3 mm, apex bilobe, tri-dent, or variable; stigma funnel-shaped; ovary cylindrical, 4-6 × 2 mm, sparsely hairy, 3-locular, placentation axile, ovules numerous; stylodes 2, filiform, ca. 5 mm long. Fruits obovate-oblong to oblong, 1-1.8 cm × 6-9 mm. Seeds numerous, narrowly ellipsoid to ovate, brownish, ca. 3 × 2-3 mm; capped with whitish aril.

Phenology: Flowering from March to April; fruiting from April to May.

Distribution: This new species is widely distributed in the limestone ridges in Mueang Kham of Xiengkhouang District, Laos. Several large populations were discovered in the areas 50 kilometers around the type locations.

Ecology: The new species grows on limestone soils or rocks, under the shade in dry deciduous forest, at the altitude of 600-720 m.

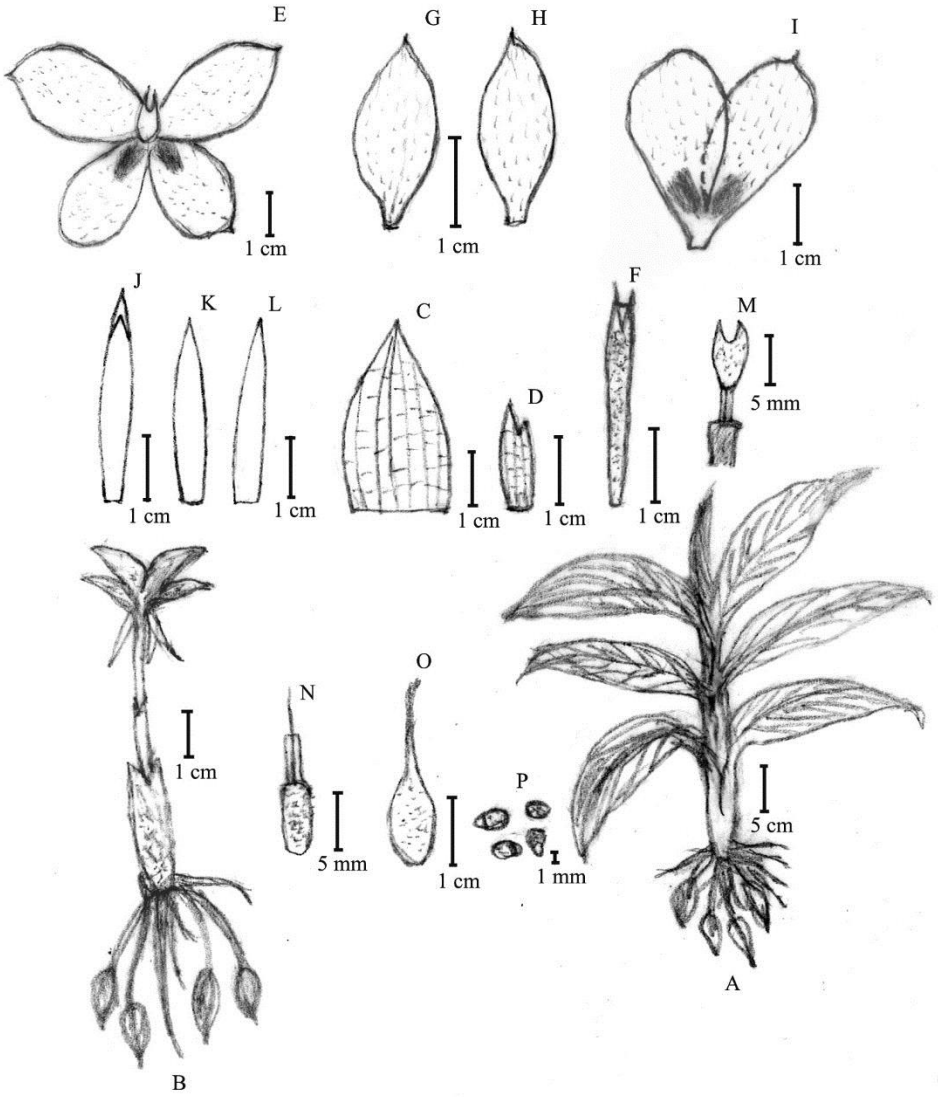


Figure 28 *Kaempferia xiengkhouangensis* Picheans. & Phokham.
A: Habit; B: Roots, rhizome and an inflorescence; C: Bracts; D: Bracteole; E: A flower (top view); F: Calyx tubes; G and H: Lateral staminodes; I: Labellum; J: Dorsal corolla lobe; K and L: Lateral corolla lobes; M: Anthers, and anther crests; N: Ovary with part of the style and the stylodes; Q: Fruit with persistent calyx tube; P: R: Seeds

Figure 29 Photographs of *Kaempferia xiengkhouangensis* Picheans. & Phokham.

A: Inflorescence; B: Roots, rhizome and inflorescence; C: Lower part of a leaf showing the ligule; D: The plant in the type location.

Morphological comparison of existing group and 8 new taxa were reported as follows:

Table 1 Morphological comparison between *Kaempferia rotunda* L. and *K. doisaketensis* Picheans., Meechonk. & Yupparach

Characters	***K. rotunda***	***K. doisaketensis***
1. Leaf		
Shape	lanceolate-oblong to elliptic, 12-39.5 × 3.8-13 cm, base cuneate, apex acute	lanceolate to elliptic, 12.7-21.6 × 4.9-9.5 cm, base cuneate, apex acute to acuminate, margin entire to slightly crenate
Upper surface	green, glabrous	green to purplish red, hairy
Lower surface	green or red	reddish
Petiole	1.4-8.7 cm long	0.5-3.1 cm,long
2. Inflorescence Peduncle	0.3-8.4 cm long, hairy	0.7-2.2 cm long, hairy
3. Flowers Bract	lanceolate, 2.5-5.6 × 1.1-3.3 cm, pale green, apex mucronate to acuminate, ciliate	broadly ovate to ovate, 0.9-3.8 × 0.6-2.4 cm, pale green, or pale green with purplish at apex, apex cuspidate to mucronate, hairy
Dorsal corolla lobe	oblong to narrowly ovate, 3.6-6.1 cm × 6-8 mm, white, apex aristate, hooded	narrowly lanceolate, 4-5.2 cm × 4-7 mm, apex hooded
Lateral corolla lobe	oblong to narrowly ovate, 3.4-5.5 × 3-5 mm, apex aristate	narrowly lanceolate, 3.5-4.8 cm × 3-6 mm, apex hooded
Lateral staminodes	oblong, 2.8-5.3 × 0.9-2.2 cm,white, purple-tinted, apex rounded to acute	lanceolate to obovate, 3-4.1 × 1.2-1.6 cm, white to white proximally; pale purple distally, apex acute to rounded
Labellum	obovate, 3.3-4.9 × 2-2.9 cm, purple, deep purple toward the base, apically bilobed for ca. 1/2 its length, each lobe elliptic, apex rounded to mucronate	broadly obovate, 3.5-4.4 × 2-3.1 cm, pale purple, deep purple at base, apically bilobed for ca. 1/2 its length, each lobe obovate, 1.5-2.8 × 1.2-1.8 cm, apex mucronate to acuminate or emarginate

.

Table 1 Morphological comparison between *Kaempferia rotunda* L. and *K. doisaketensis* Picheans., Meechonk. & Yupparach. (Cont.)

Characters	***K. rotunda***	***K. doisaketensis***
Anther crest	oblong, 7-10 × 2-4 mm, 3 lobed the outers acute and elongate, the middle one shorter, entire or emarginate	ovate, 5-9 × 3-5 mm, apex bilobe or tri-dent
Stylodial glands	ca. 5 mm long	6-8 mm long
4. Fruit	ovate to oblong, 1.6-2.5 × 0.7-1.1 cm, whitish	obovate or ovate, 0.9-1.7 cm × 5-9 mm, whitish,
5. Seeds	ovate, whitish, 4-7 × 2-4 mm; capped with white membranous aril.	narrowly ellipsoid to obovate, whitish, 3-5 × 1-2 mm; capped with whitish membranous aril.

The new species is morphologically similar to *Kaempferia rotunda* L., but differs in the following characters: (1) green to purplish red and hairy upper leaf surface, (2) shorter petiole, (3) pale green or pale green with purplish at apex and broadly ovate to ovate bract, (4) broadly obovate labellum, (5) longer stylodial gland and (6) dorsal and lateral corolla lobe apex hooded.

Table 2 Morphological comparison between *Kaempferia xiengkhouangensis* Picheans. & Phokhom and *K. grandis* Picheans. & Meechonk.

Characters	***K. xiengkhouangensis***	***K. grandis***
Leaves		
Shape and size	broadly elliptic to lanceolate, (14.8-27.5 × 10.4-13.9 cm	elliptic to ovate, 13.8-44.1 × 6.2-21 cm
Upper surface	green, glabrous	green with several white markings, hairy at the base of the midrib
Lower surface	pale green, pubescent	reddish, hairy
Ligule	0.4-1.0 cm long, hairy	0.5-1.2 cm long, pubescent
Petiole	sessile	0.6-6 cm long, hairy
Inflorescence		
Peduncle	0.9-2.9 cm long, sparsely hairy	1.1-3.3 cm long, hairy
Number of flowers	10-19	8-45
Flowers		
Corolla tube	4.6-7.8 cm long, glabrous	5.2-7.7 cm long, hairy
Staminodes	obovate, 2-3.3 × 1.1-1.9 cm, deep pink, apex rounded to apiculate	obovate, 2.1-3.5 × 1.4-1.9 cm, pink, apex acute
Labellum	broadly obovate, 1.7-3 × 2.5-4.3 cm, deep pink, violet at base, apex rounded to apiculate	obovate, 2.2-3.8 × 3.1-3.9 cm, pink, deep pink with whitish patch at the base, apex rounded to acute
Seeds	narrowly ellipsoid to ovate, brownish, ca. 3 × 2−3 mm	ovate to oblong, yellowish ca. 5 × 4 mm

Kaempferia grandis is morphologically similar to *K. xiengkhouangensis* Picheans. & Phokham, but differs in the following characters: (1) hairy petiole leaves (0.6-6 cm long), (2) hairy base midrib upper leaf surfaces with abundant white markings, (3) reddish and hairy lower leaf surface, (4) pubescent ligule, (5) obovate and apex rounded to acute labellum and (6) hairy corolla tube.

Table 3 Morphological comparison between *Kaempferia rotunda* L. and *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan.

Characters	***K. rotunda***	***K. kamolwaniae***
1. Leaf		
Shape	lanceolate-oblong to elliptic, 12–39.5 × 3.8-13 cm, base cuneate, apex acute	elliptic to ovate, 18-51.3 × 8.8-17.5 cm, base cuneate, apex acute to acuminate
Upper surface	green glabrous	green, sparsely hairy at the base of the midrib
Petiole	1.4-8.7 cm long, hairy	sessile
Ligule	1-3 mm long, apex acute to rounded	6-9 mm long, apex acute
2. Inflorescence Peduncle Number of flowers	 0.3-8.4 cm long, hairy 5-16	 0.6-3.7 cm long, glabrous 6-11
3. Flowers Lateral staminodes	 oblong, 2.8-5.3 × 0.9-2.2 cm, white, purple-tinted, apex rounded to acute	 broadly-obovate to oblong, 4.8-6.1 × 2.1-2.7 cm, whitish to purplish, apex rounded to acute or cuspidate

This new species is morphologically similar to *Kaempferia rotunda* L., but differs in the following characters: (1) sessile leaves, (2) green and sparsely hairy upper leaf surface, (3) longer ligule [6-9 vs. 1-3 mm], (4) glabrous peduncle, and (5) broadly-obovate to oblong and whitish to purplish staminodes.

Table 4 Morphological comparison between *Kaempferia udonensis* Picheans. & Phokham and *K. kanchanaburiensis* Picheans., Meechonk. & Phokham.

Characters	***K. udonensis***	***K. kanchanaburiensis***
1. Leaf		
Number	2-4	4-6
Shape	horizontal leaves, orbicular to elliptic, 19-27.5 × 14.7-18.8 cm; base cuneate to obtuse	upright leaves, ovate to elliptic, 12-27.6 × 6.8-16.8 cm, base cuneate to obtuse, apex acute to acuminate
Upper surface	green with several silvery markings, hairy at the base of the midrib	green with several green or white markings, hairy at the base of the midrib
Lower surface	reddish brown, pubescent	green, sparsely hairy
Petiole	1.5-2 cm long	1-3.4 cm long
2. Inflorescence		
Number of flowers	5-30	6-18
3. Flowers		
Calyx tube	5.2-7.2 cm long, split on one side, 0.6-1.3 cm long, apex bifid	3-3.7 cm long, split on one side, 0.5-1.5 cm long, apex bifid
Corolla tube	6.2-10.7 cm long, whitish, glabrous	5.9-7.5 cm long, whitish, hairy
4. Seeds	ovate, reddish, 3-6 × 2-4 mm; capped with whitish membranous aril	ovate to oblong, purple, ca. 5 × 4 mm; capped with whitish membranous aril

This new species is morphologically similar to *Kaempferia udonensis* Picheans. & Phokham, but differs in the following characters: (1) ovate to elliptic, upright leaves blades, (2) several green or white markings on upper leaf surface, (3) green and sparsely hairy lower leaf surface, (4) longer petioles [1-3.4 vs. 1.5-2 cm], (5) shorter calyx tubes [3-3.7 vs. 5.2-7.2 cm], (6) hairy corolla tube, and (7) purple seeds.

Table 5 Morphological comparison between *Kaempferia lopburiensis* Picheans. and *K. nakhonsawanensis* Picheans., Meechonk. & Yupparach

Characters	***K. lopburiensis***	***K. nakhonsawanensis***
1. Leaf Shape	suborbicular to orbicular, 12.3-24.1 × 11-23.5 cm, base cuneate, apex acute to acuminate	suborbicular, 13.6-22.7 × 13.1-22.9 cm, base cordate, apex acute or acuminate
Upper surface	pale green, with light purple band along the margin, sparsely hairy	green, glabrous
2. Inflorescence Peduncle	4-5 cm long	0.5-1.4 cm long
3. Flowers Bract	lanceolate, 4.1-6 × 1.4-2.2 cm, apex cuspidate or mucronate, pale green, hairy	ovate, 1.9-3.4 × 0.8-2.5 cm, apex acute, hairy
Corolla tube	4.5-10 cm long, white, glabrous	3.5-7.9 cm long, whitish, glabrous
Anther crest	rectangular or broadly obovate, white to violet, 0.4-0.9 cm × 3-6 mm, apex tri-dent to crenate	oblong, purplish, 6-7 × 3-5.5 mm, apex trilobe
4. Fruit	cylindrical to ellipsoid , whitish, 3.3-4.4 cm × 1.1-1.3 cm	oblong, whitish, upper part red-brownish, 3.9-4 cm × 8-9 mm, hairy
5. Seeds	whitish to brownish , 4-6 × 2-3 mm; capped with white aril	yellowish, 5-5.5 cm × 2.5-3 mm

This new species is morphologically similar to *K. lopburiensis* Picheans. but differs in the following characters: (1) green and glabrous leaf surface, (2) shorter peduncle [0.5-1.4 vs. 4-5 cm, (3) ovate bract, (4) glabrous corolla tube, (5) oblong anther crest, (6) oblong and incurve fruit, and (7) yellowish seeds.

Table 6 Morphological comparison between *Kaempferia lopburiensis* Picheans. and *K. occidentalis* Picheans., Meechonk. & Phokham.

Characters	***K. lopburiensis***	***K. occidentalis***
1. Leaf Shape	suborbicular to orbicular, 12.3-24.1 × 11-23.5 cm, base cuneate, apex acute to acuminate	suborbicular to elliptic, 11.2-38 × 10.3-31.2 cm, base cuneate to obtuse, apex mucronate to obtuse
Lower surface	pale green, pubescent	pale green and reddish, sparsely hairy
2. Inflorescence Peduncle	4-5 cm long, hairy	0.7-3.1 cm long, hairy
3. Flowers Calyx tube	4.3-7.7 cm long, split on one side, 0.6-0.9 cm long, apex 3–lobed, sparsely hairy at apex	3.4-6.3 cm long, split on one side, 0.8-1.1 cm long, apex bifid, hairy
Lateral staminodes	obovate, whitish, 2.6-3.1 × 1.2-1.8 cm, apex rounded	broadly obovate, purplish, 2.1-2.8 × 1.3-2 cm, apex rounded to slightly emarginate
Labellum	obovate to suborbicular, purple, deep purple toward the base, 3-3.2 × 2.3-3.3 cm, apex deeply bilobed, each lobe obovate, 1.8-2.6 × 1.3-1.6 cm	broadly obovate, purplish, deep purple with yellow-orange line at base, 1.8-2.9 × 2.7-3.9 cm, apex divided almost to the base, each lobe broadly semi-circular, 1.5-2.1 × 1.6-2 cm, apex rounded to slightly emarginate
4. Seeds	whitish to brownish , 4-6 × 2–3 mm; capped with white aril	yellowish, ca. 4 ×3 mm; capped with whitish membranous aril

This new species is morphologically similar to *Kaempferia lopburiensis* Picheans., but differs in the following characters: (1) pale green and reddish lower leaf surfaces, (2) peduncle shorter [0.7-3.1 vs. 4-5 cm], (3) calyx tube with bifid apex, (4) broadly obovate and purplish-colored staminodes with rounded to slightly emarginate apex, (5) broadly obovate labellum with divided (almost to the base) apex, and (6) yellowish seeds.

Table 7 Morphological comparison between *Kaempferia udonensis* Picheans. & Phokham and *K. takensis.* Picheans. & Meechonk.

Characters	***K. udonensis***	***K. takensis***
1. Leaf		
Shape	horizontal, orbicular to elliptic, 19- 27.5 × 14.7-18.8 cm, base cuneate to obtuse, apex cuspidate to acuminate; margin slightly undulate, reddish	blades not prostrate, blades ovate to elliptic, 10.1-43.5 × 7.1-20.9 cm, base cuneate, apex acute to acuminate
Upper surface	green with several silvery markings, at the base of the midrib	green with several green markings, hairy at the base of the midrib
Lower surface	reddish brown, pubescent	reddish, hairy
Petiole	1.5-2 cm long, hairy	sessile
Ligule	broadly triangular, 1.4-2 cm long, reddish, apex obtuse, hairy	broadly trianglular membranous, 2-lobed, 1-3.5 cm long, reddish, apex rounded, hairy
2. Inflorescence		
Peduncle	1.1-3 cm long, hairy	0.5-1 cm long, hairy
3. Flowers		
Calyx tube	5.2-7.2 cm long, split on one side, 0.6-1.3 cm long, apex bifid, hairy	2.4-2.8 cm long, split on one side, 0.5- 1.5 cm long, apex bifid, hairy
Corolla tube	6.2-10.7 cm long, whitish, glabrous	2.8-7.5 cm long, whitish, hairy
Anther crest	rectangular, 5-9 × 6-8 mm, white to violet, apex acute to trifid	oblong to rectangular, 5-8 × 3-7 mm, white to purple, apex bilobe
Seeds	ovate, reddish, 3-6 × 2-4 mm; capped with whitish membranous aril	ovate to oblong, 5-8 × 3-4 mm, yellow-green; capped with white membranous aril

This new species is morphologically similar to *Kaempferia udonensis* Picheans. & Phokham, but differs in the following characters: (1) upright leaves, (2)

sessile petiolate, (3) shorter calyx tube [2.4-2.8 vs. 5.2-7.2 cm], (4) hairy corolla tube, (5) bilobed anther crest and (6) yellow-green seeds.

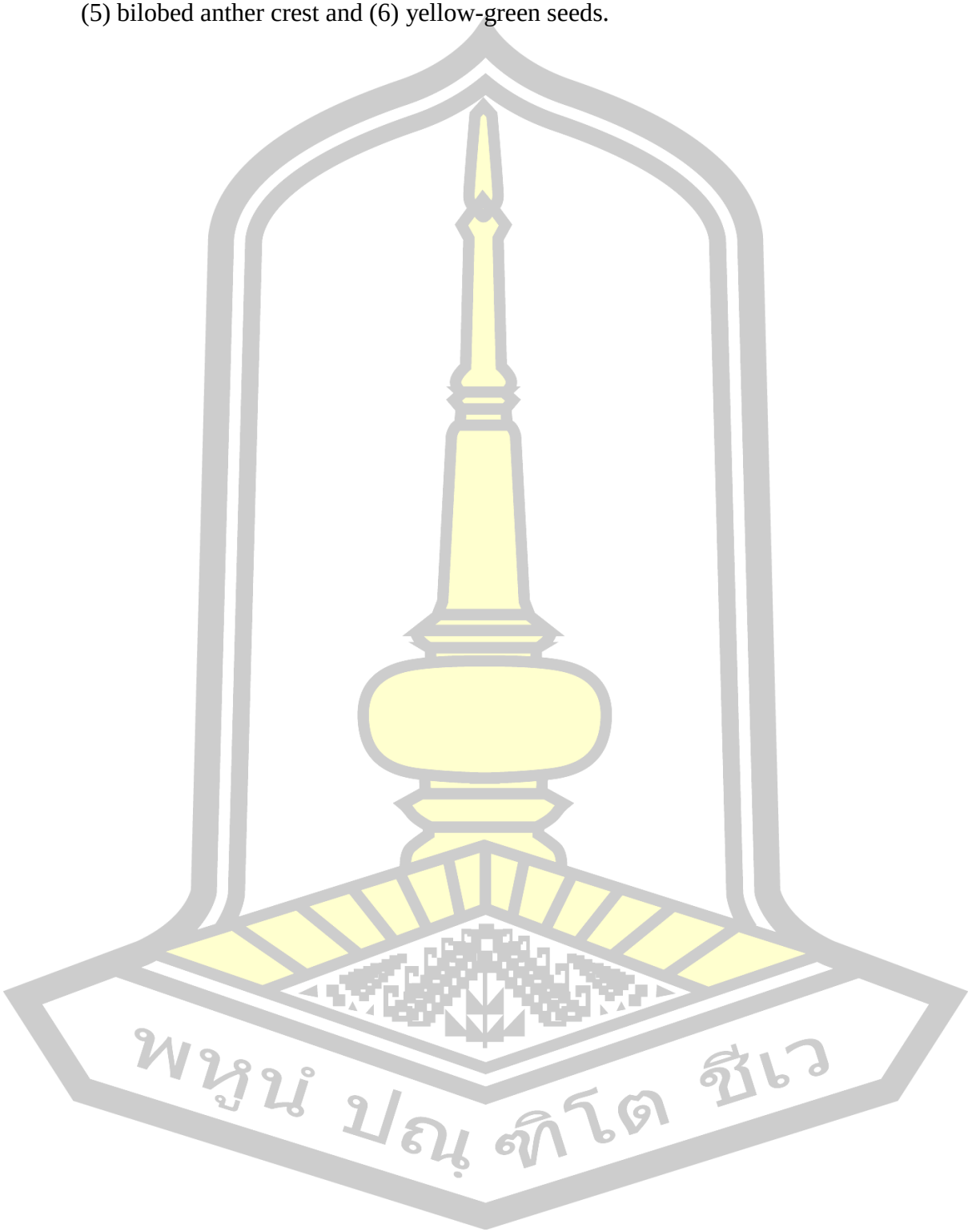


Table 8 Morphological comparison between *Kaempferia noctiflora* Nopporn c. & Jenjitt. and *K. uttaraditensis* Picheans. & Meechonk.

Characters	***K. noctiflora***	***K. uttaraditensis***
1. Leaf		
Shape and size	ovate to elliptic, 13.6-22.7 × 13.1-22.9 cm	elliptic to lanceolate, 8-21.3 × 2.4-9.3 cm
Upper surface	pale green to tinged purplish red, usually with tinged purplish red patch along the midvein, glabrous	green, sparsely hairy at the base of the midrib
Petiole	short, ca. 1 cm long, pale green to purplish red, sparsely hairy	1-3.5 cm long, greenish, hairy
2. Inflorescence		
Peduncle	subsessile to 1 cm long	1.2-3.2 cm long
3. Flowers		
Bracteole	lanceolate, ca. 1.7 cm × 5 mm, apex bilobed, apex of each lobe acute, glabrous	lanceolate, 0.7-1.7 cm × 3-5 mm, apex acute, hairy
Calyx	5.1-6 cm long, split on one side, 0.6-1 cm long, pale yellow, apex bifid, glabrous	3.8-5.5 cm long, split on one side, 1.1-1.6 cm long, white to pale greenish, apex bifid, hairy
Labellum	broadly obovate, 3.4-4 × 2.1-3.4 cm, pure white or white with pale yellow patch from the base, each lobe obovate, 2-2.2 × 1.3-1.6 cm, apex acute, round to slightly bilobed, partly overlapping	broadly obovate, 3.1-4 × 1.9-2.7 cm, base attenuate into 0.8-1 cm × 4-5 mm claw, pure white or white with purplish patch at the base, each lobe obovate to narrow obovate, 1.4-2.2 × 0.8-1.1 cm, apex rounded to acute or emarginate or partly overlapping
Anther crest	oblong, 7-9 × 3-5 mm, white, apex bilobed, acute to acuminate	oblong, broadly obovate, or rectangular, 4-5 × 3-5 mm, white, apex bilobed to crenate
Ovary	cylindrical, ca. 6 × 2-2.2 mm, creamy yellow, sparsely hairy	oblong to cylindrical, 4-6 × 2-3 mm, whitish, glabrous

This new species is morphologically similar to *Kaempferia noctiflora* Nopporncharoenkul & Jenjitt., but differs in the following characters: (1) elliptic to lanceolate blade with sparsely hairy at the base of the midrib, (2) longer petiole [1-3.5 vs. ca. 1 cm], (3) longer peduncle [1.2-3.2 cm long vs. subsessile to 1 cm], (4) hairy

bracteole, (5) hairy calyx, (6) claw labellum, white with purplish patch at the base and (7) glabrous ovary.

As mentioned before, the results showed that there are 8 new taxa i.e. *K. doisaketensis* Picheans., Meechonk. & Yupparach, *K. grandis* Picheans. & Meechonk., *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, *K. nakhonsawanensis*, Picheans., Meechonk., & Yupparach., *K. occidentalis* Picheans., Meechonk. & Phokham, *K. takensis* Picheans. & Meechonk. *and K. uttaraditensis* Picheans. & Meechonk..

CHAPTER 4
PALYNOLOGY

4.1 Method and material

Pollen grains of the subgenus *Protanthium*, genus *Kaempferia* were taken in the field. For scanning electron microscope (SEM; JEOL JSM-6610 LV) prepared specimen and mounted on the stubs, which were covered with glue after that sputter-coated with gold. Pollen grains were observed by SEM.

4.2 Scanning electron microscope (SEM)

Results

1. *Kaempferia doisaketensis*

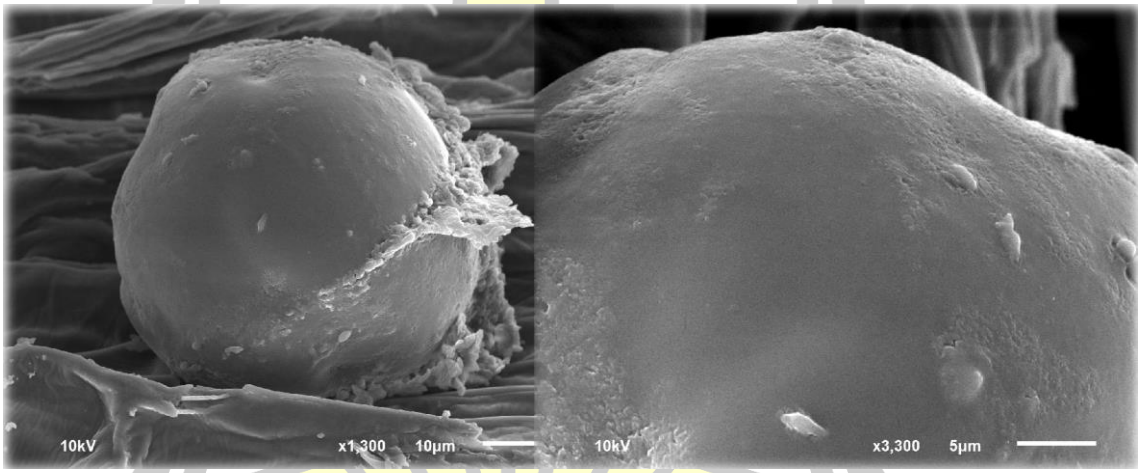


Figure 30 Magnification X 1,300 and X 3,000

2. *Kaempferia grandifolia*

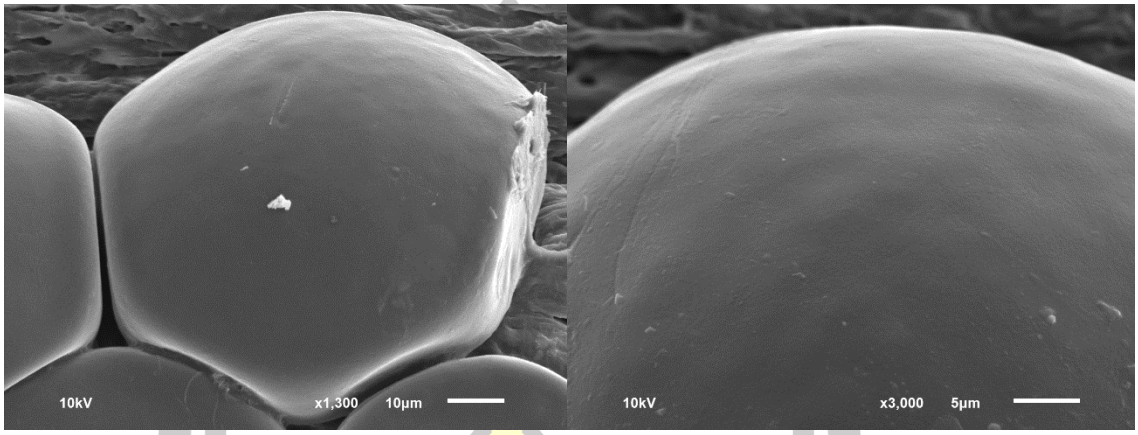


Figure 31 Magnification X 1,300 and X 3,000

3. *Kaempferia grandis*

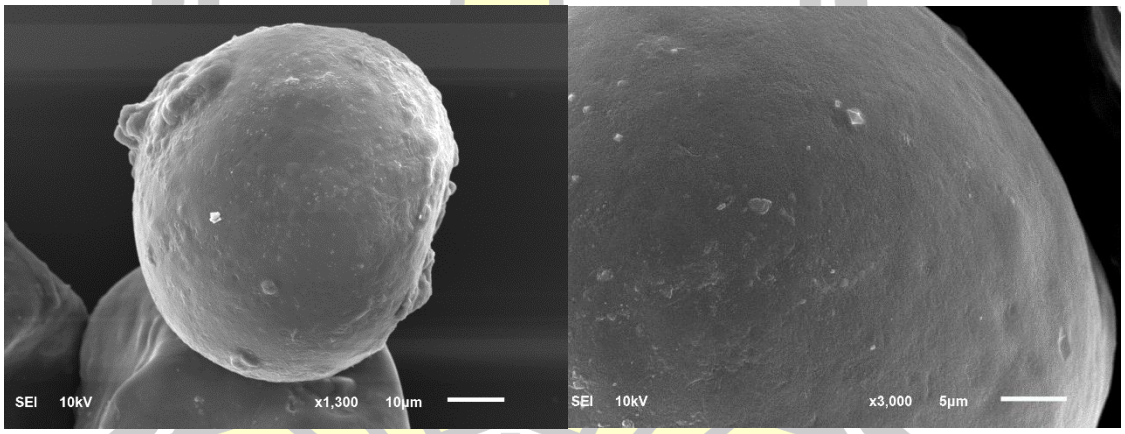


Figure 32 Magnification X 1,300 and X 3,000

4. .*Kaempferia kamolwaniae*

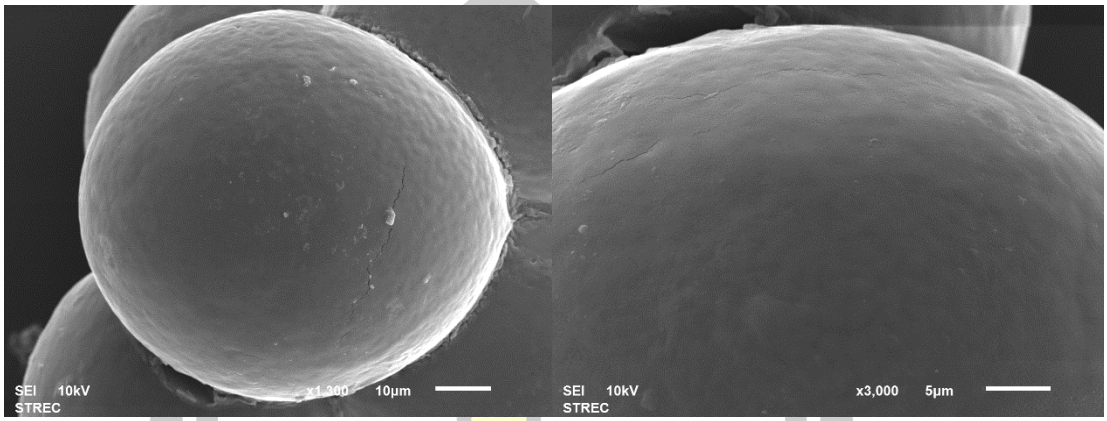


Figure 33 Magnification X 1,300 and X 3,000

5. *Kaempferia kanchanaburiensis*

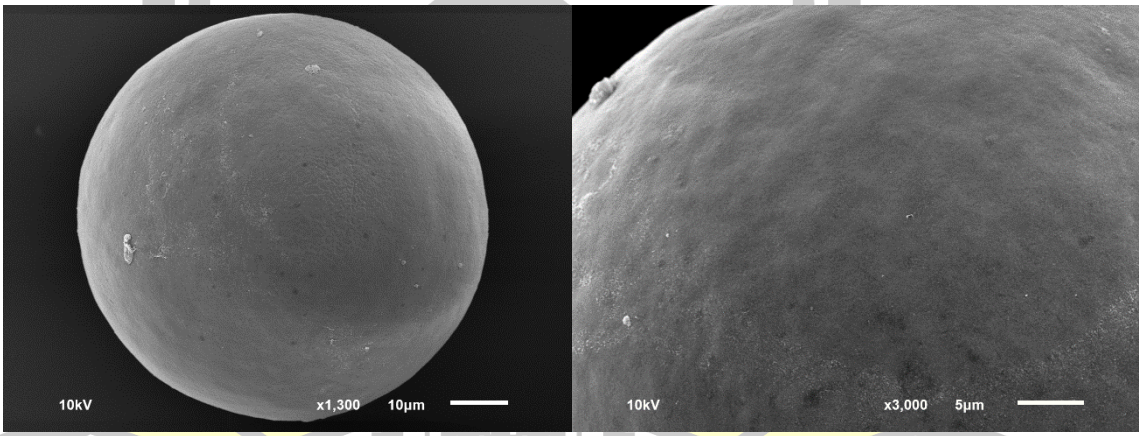


Figure 34 Magnification X1,300 and X 3,000

6. *Kaempferia lopburiensis*

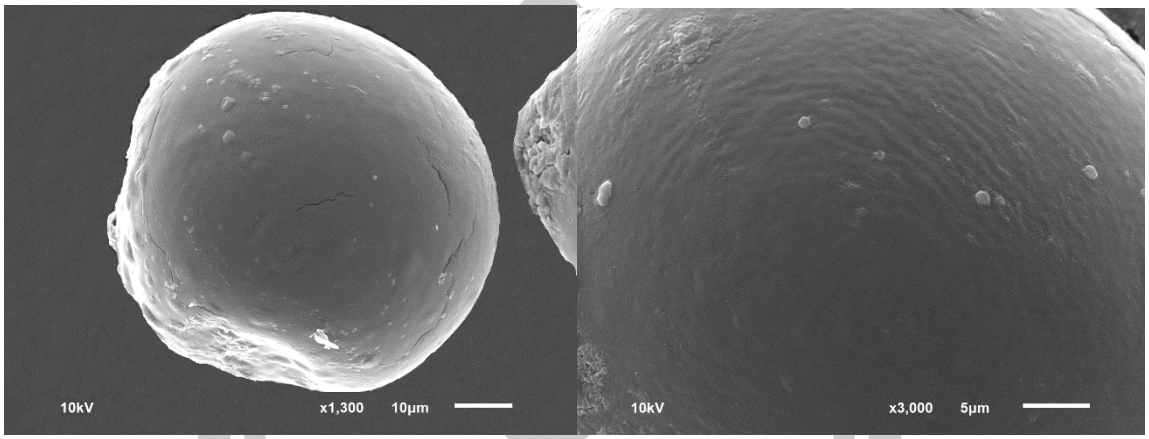


Figure 35 Magnification X 1,300 and X 3,000

7. *Kaempferia nakhonsawanensis*

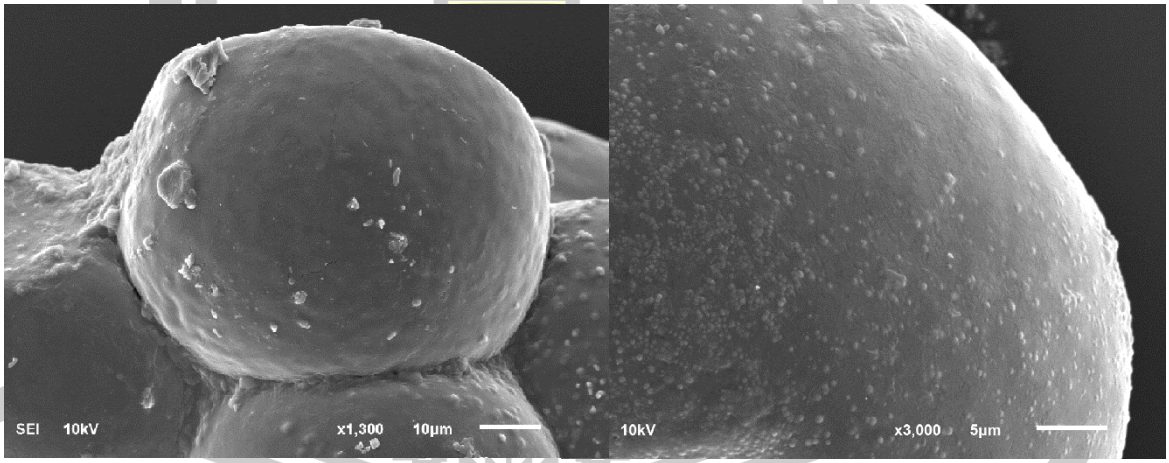


Figure 36 Magnification X 1,300 and X 3,000

8. *Kaempferia noctiflora*

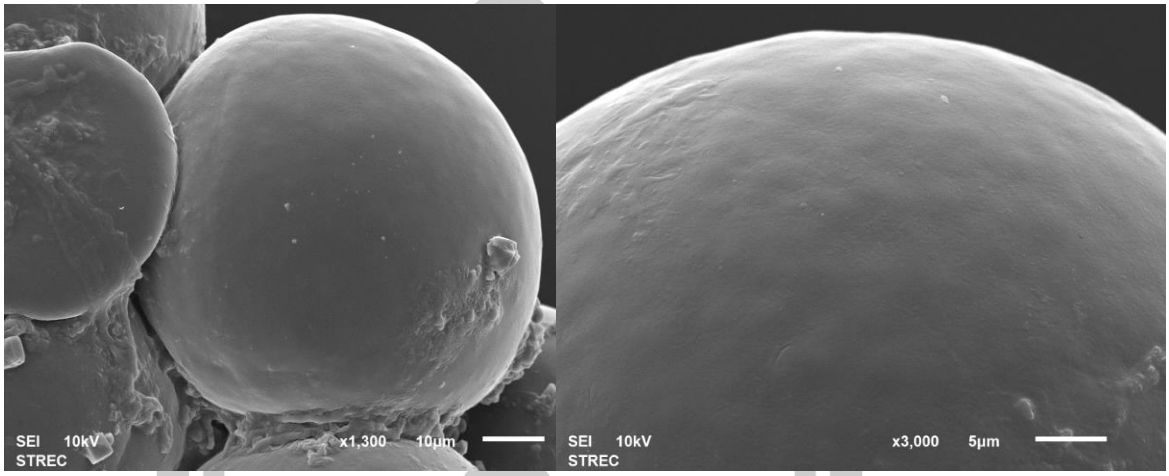


Figure 37 Magnification X 1,300 and X 3,000

9. *Kaempferia occidentalis*

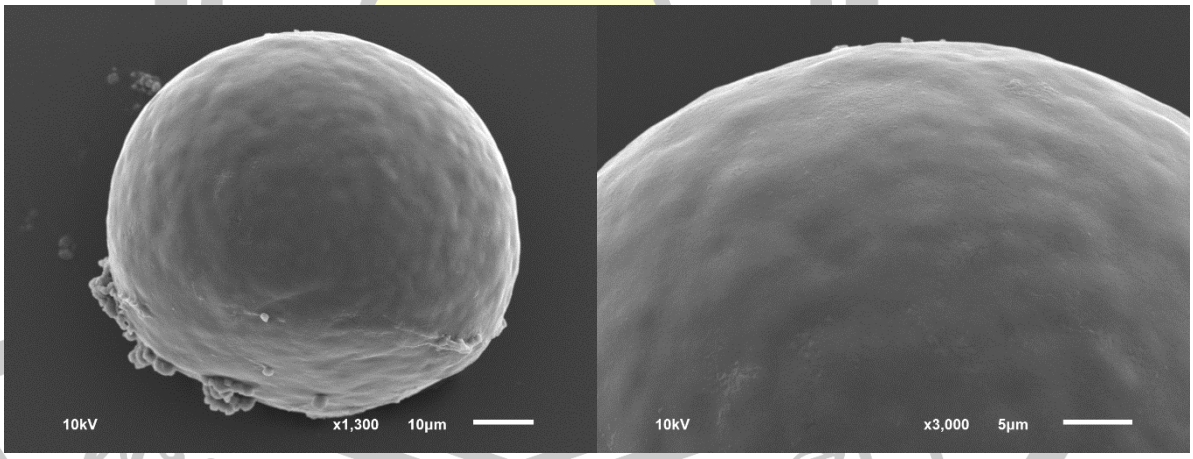


Figure 38 Magnification X 1,300 and X 3,000

10. *Kaempferia rotunda*

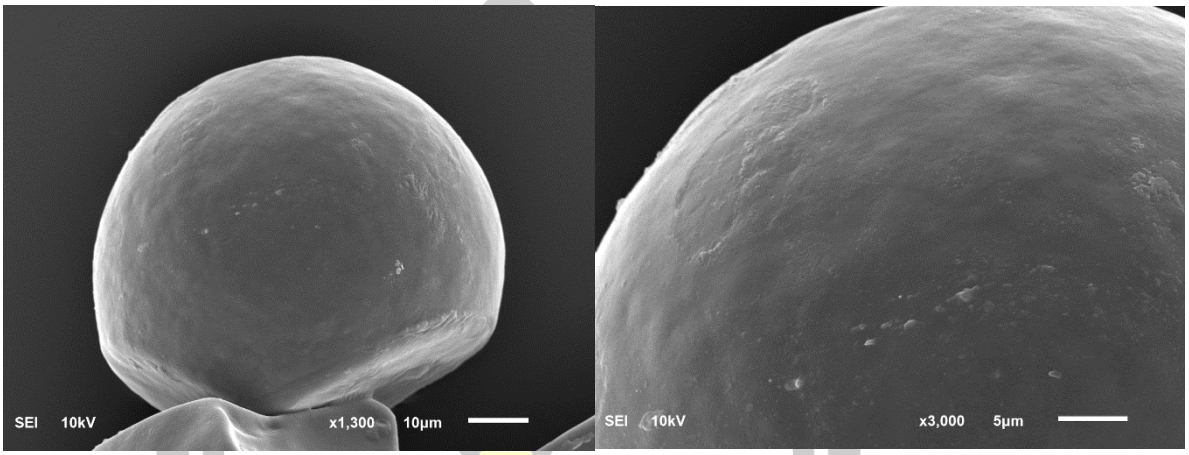


Figure 39 Magnification X 1,300 and X 3,000

11. *Kaempferia takensis*

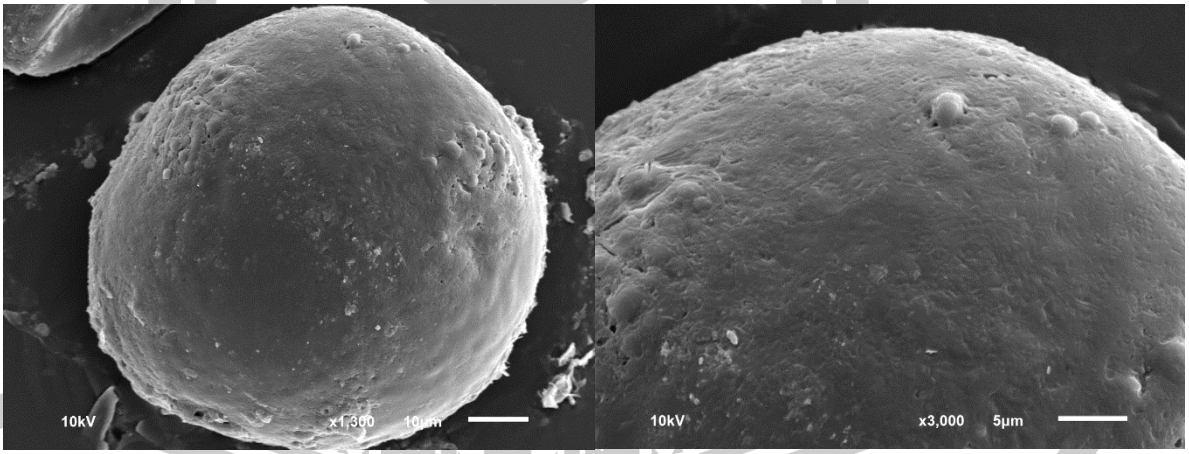


Figure 40 Magnification X 1,300 and X 3,000

12. *Kaempferia udonensis*

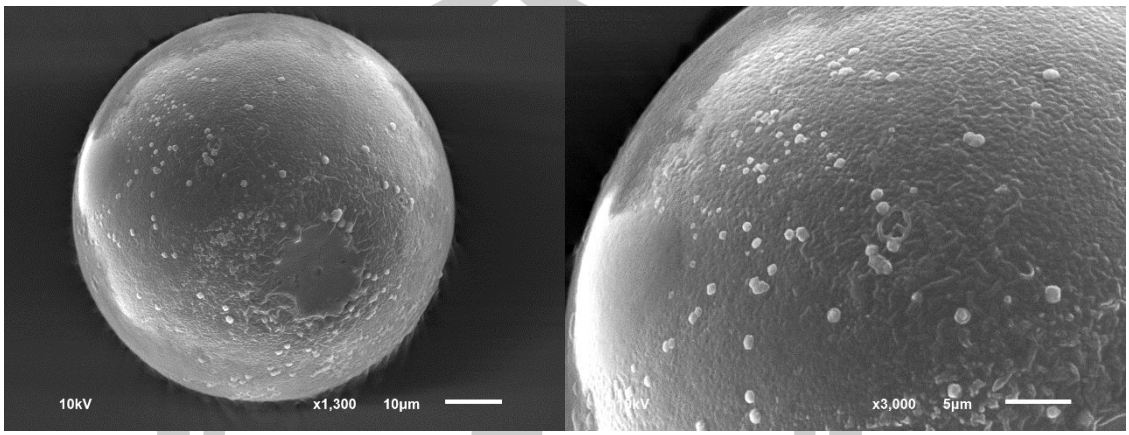


Figure 41 Magnification X 1,300 and X 3,000

13. *Kaempferia uttaraditensis*

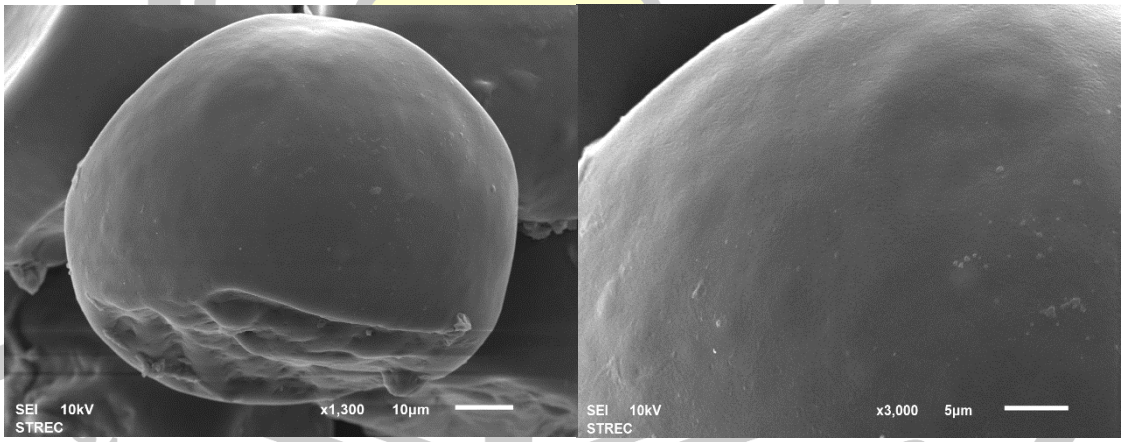


Figure 42 Magnification X 1,300 and X 3,000

14. *Kaempferia xiengkhou*angensis

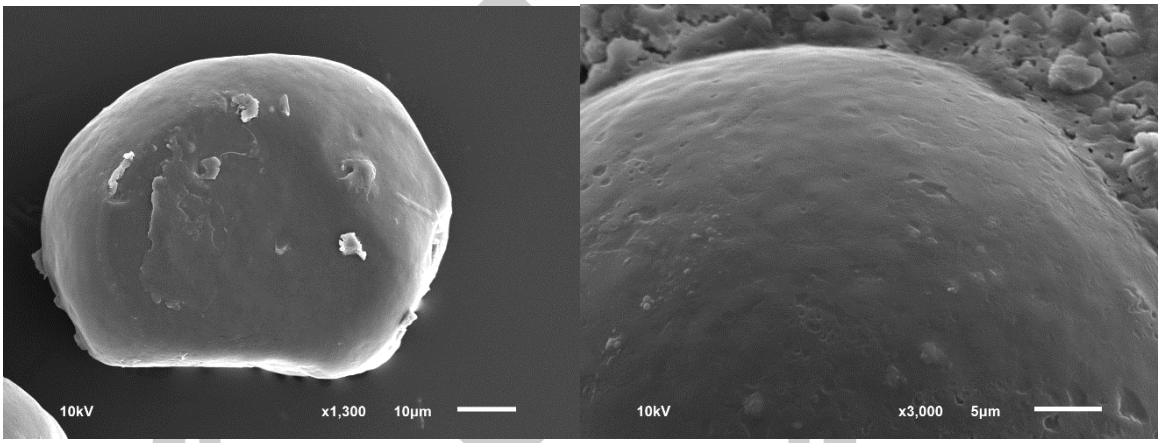


Figure 43 Magnification X 1,300 and X 3,000

As mentioned above, The results showed that all pollen grains of the medicinal plants in subgenus *Protanthium*, genus *Kaempferia* are subspheroidal shapes and smooth exine. The largest pollen grains were belonged to the *K. rotunda* while the smallest one found in the *K. grandis*.

CHAPTER 5
MOLECULAR STUDIES

5.1 Methodology and Materials

To study the relationship of plants in the subgenus *Protanthium*, genus *Kaempferia* in the molecular level, pieces of young leaves of all accessions were collected in the field and dried in silica gel for further DNA extraction in the laboratory. The total gDNA sample of each accession was isolated using the modified CTAB method. The PCR reaction was then performed to amplify the DNA fragment of nuclear ITS1-5.8S-ITS2 region, and then the PCR product was sent for DNA sequencing. Finally, the DNA sequences of all collected accessions including outgroup taxa were multiple-aligned and used to construct the phylogenetic tree.

5.1.1 Plant materials

Totally 9 plant accesessions of *Kaempferia* species were discovered and collected from the field works. Each accession was identified as isolate 'PJMT' following by the ascending number. Additionally, the sequences were retrieved from the GenBank database to be used as cladistics and outgroup in the phylogenetic clustering, respectively.

5.1.2 Isolation of the total gDNA samples

The total gDNA sample of each accession was isolated using the modified CTAB method (Rotchanapreeda et al., 2016). Briefly describe, 500 µl of CTAB buffer (2% CTAB, 1.4 M NaCl, 100 mM Tris-HCl pH 8.0, 20 mM EDTA pH 8.0) was loaded to the mortar. Approximately 25 mg of dried and fresh leaves blades excluding midrib and petiole was cut into the small pieces by sterile scissors into the mortar. One spatula spoon of silica gel 60 (70 – 230 mesh ASTM, Merck) was put into the mortar and the tissue was grinded until became slurry. Then the mixture was transferred to a 1.5-ml microcentrifuge tube. Then another 500 µl of CTAB buffer was added to wash the mortar and transferred into the same tube. The tube was incubated at 65°C for 15 minutes with the 5-minutes interval vortex. The tube was

then cooled down on ice prior to adding of 100 µl of 5 M potassium acetate to obtain the final concentration at 1 M. For salting out effect, the tube was mixed by vortex and then incubated on ice for 15 minutes (or up to 60 minutes for the highest efficiency). For phase separation, one volume of chloroform : isoamyl alcohol (24 : 1, v/v) was added to the tube, mixed by vigorous shaking until forming the emulsion and then centrifuged at 16,000 × g for 15 minutes at room temperature. The upper aqueous phase was transferred to the new 1.5-ml microcentrifuge tube without interrupting the organic phase, and then added with 2 volumes of absolute ethanol at room temperature to precipitate the DNA. The mixture was mixed by gently inversion then the DNA pellet was harvested by centrifugation at 16,000 × g for 15 minutes at room temperature. After centrifugation, the supernatant was carefully discarded and the DNA pellet was washed with 500 µl of 80% ethanol. After the ethanol was discarded, the tube was briefly centrifuged then the residual ethanol was removed by pipetting without interrupting the pellet. The tube was marooned with the opened cap at room temperature until the pellet was dry. Then the pellet was dissolved with 50 µl of TE buffer (10 mM Tris-HCl pH 8.0, 1 mM EDTA pH 8.0). To eliminate RNA contamination, 1 µl of 1 mg/ml RNase A (Sigma-Aldrich) was added to the mixture (final concentration 20 µg/ml) and the tube was then incubated at 37°C for 30 minutes. Finally, the sample was kept at -20°C for long term storage until further uses. Prior to PCR amplification, all isolated gDNA samples were determined for the quantity by spectrophotometry and the quality by gel electrophoresis.

5.1.3 PCR amplification of ITS region

To obtain the DNA sequence of ITS region for each sample, the previously designed forward and reverse primers that specific to this nuclear region were used in this study (White et al., 1990). Additionally, for the DNA sequencing process, the universal primers sequences, pBluescript KS and pBluescript SK, were 5′-end flanked to the original forward and reverse primers sequences, respectively. The sequences of both primers are shown in Table 3.4. The primers were oligo-synthesized by the 1st BASE Company (Malaysia).

Table 9 Information of the newly designed ITS primers

Primers name	**Primers sequences (5′ to 3′)**	**Length**	**Expected product size**
KS_ITS1	CTCGAGGTCGACGGTATCCGTAGGTGAACCTGCGG	35 bp	~700 bp
SK_ITS4	CGCTCTAGAACTAGTGGATCCTCCGCTTATTGATATGC	38 bp	

Note: Sequences with single- and double-underlined represented for pBluescript KS and pBluescript SK, respectively.

Prior to amplification, each gDNA sample was diluted with TE buffer to the concentration of 100 ng/µl and then used as template. The PCR reaction was performed in total volume of 100 µl. In the reaction, the final concentration of each component was as following; 1X Standard *Taq* Reaction Buffer (containing 1.5 mM $MgCl_2$) (NEB), 0.2 mM dNTPs Mix (0.2 mM each dATP, dCTP, dTTP, dGTP) (Promega), 0.5 µM each forward (KS_ITS1) and reverse (SK_ITS4) primers, 3 units of *Taq* DNA Polymerase (NEB), and 100 ng of gDNA sample. After that, the reaction mixture was mixed by vortex, briefly spun down, and then put into a programmable DNA thermal cycler (Amplitronyx ATC401, Nyx Technik).

The PCR program consisted of pre-denaturation step in one cycle at 94°C for 5 minute to completely melt the double-stranded DNA, then two stages of amplification. The first stage contained 15 cycles of denaturation at 94°C for 1 minute, annealing at 55°C for 1 minute, and extension at 72°C for 1 minute, to allowing original primers sequences anneal to gDNA template. Then the second stage contained 25 cycles of denaturation at 94°C for 1 minute, annealing at 65°C for 1 minute, and extension at 72°C for 1 minute, in which, the amplification would occur by using the amplified fragments from the first stage as template. Finally, final-extension step at 72°C for 10 minutes to fulfill polymerization. At the end of the reaction, the PCR products were stored at 4°C.

After the PCR reaction was completed, 5 µl of each PCR product was determined by gel electrophoresis. The PCR samples were then sent for DNA sequencing service at 1st BASE company (Malaysia) with additional PCR clean-up step to purify DNA sample prior to sequencing. In automated dideoxynucleotide sequencing reaction, the pBluescript KS and pBluescript SK universal primers

(offered by the company) served as the sequencing primers for 5′- and 3′-end reaction, respectively.

5.1.4 Quantification of DNA with spectrophotometry

In order to measure for the quantity of isolated gDNA samples, 2 µl of each sample was applied on the pedestal of NanoDrop™ 2000c UV-Vis Spectrophotometer (Thermo Scientific) using TE buffer as a blank. The O.D. at 260 nm would be used to calculate for nucleic acids concentration of the sample, and the ratios of between O.D. 260 nm and 280 nm (260/280 nm) and between O.D. 260 nm and 230 nm (260/230 nm) would be used to indicate for the RNA/proteins and other impurities contamination, respectively.

5.1.5 Qualification of DNA with gel electrophoresis

In order to determine for the quality of isolated gDNA samples and amplified PCR products, the DNA samples were analyzed with gel electrophoresis approach. For gDNA samples, after the concentration was determined, the total mass of 200 ng of each sample was mixed with appropriate volume of TE buffer prior to be loaded. And for PCR products, 5 µl from each reaction would be used. To analyze the DNA, the gDNA or PCR product sample was mixed with 1 µl of 6X Gel Loading Dye, Blue (NEB, catalogue no. B7021S) and then loaded into 1% (w/v) agarose gel, along with 0.25 ng total mass of 2-Log DNA Ladder (NEB, catalogue no. N3200S) as molecular weight standard. The gel was run in 0.5X TAE buffer at 100 V for 25 minutes. After that, the gel was stained in 0.5 µg/ml of ethidium bromide solution for 5 minutes then destained in distilled water for 5 minutes. Finally, DNA fragments on the gel were visualized and photographed using gel documentation system G:BOX Chemi EF2 (Syngene).

5.1.6 Phylogenetic analysis

After the DNA sequencing results of each sample were received, the DNA sequence obtained from 3′-end sequencing was reverse-complemented, and then pairwise aligned with 5′-end sequencing result of the same sample using the Clustal

Omega program (The European Bioinformatics Institute, n.d. b) to generate the full-length DNA sequence. The correction of nucleotide bases was revised manually by verifying from the raw chromatogram. After that, the sequences of universal primers pBluescript KS and pBluescript SK were trimmed. For phylogenetic clustering, the DNA sequences of ITS region of all selected taxa were multiple aligned by the Multiple Alignment using Fast Fourier Transform program (The European Bioinformatics Institute, n.d. a) with "localpair" FFTS setting. After that, the multiple sequence alignment was manually edited and revised by using the program BioEdit version 7.2.5 (Hall, 1999). The alignment was then tested to find out for a best nucleotide substitution model of Maximum Likelihood method using the MEGA program version 7.0.21 (Kumar et al., 2016). The best model would be indicated, in which, model with the lowest Bayesian Information Criterion (BIC) score is the model that displays the maximum posterior probability and considered to describe the substitution pattern the best (Posada and Buckley, 2004). After the best model was indicated, the phylogeny construction was conducted based on Maximum Likelihood statistical method with the following parameters; substitution model of Tamura 3-parameter (Kumar et al., 2016), rates among sites of gamma distribution with 5 rates of discrete gamma categories, gaps/missing data treatment by using all sites, and testing for reliability by bootstrapping with 1,000 replicates. After the phylogeny clustering was constructed, the phylogram was finalized featured using the MS Powerpoint program.

5.2 Results from molecular study

5.2.1 Quantity and quality of isolated gDNA samples

After the plant leaves samples were isolated for total gDNA using modified CTAB-based DNA isolation method, all gDNA samples were verified for their quantity and quality by spectrophotometry and gel electrophoresis, respectively. For quantity, the spectrophotometry approach was used to measure the absorption at the wavelength of 260 nm to determine the concentration of DNA in each isolated sample. For the quality, the physical properties of isolated gDNA sample and the presence of contaminants were verified by gel electrophoresis. To analyze the

samples, the total mass of approximately 500 ng gDNA was prestained with Novel Juice (GeneDireX) and loaded on the agarose gel, separated by electrical field. The gDNA fragments were visualized and photographed by gel document system. Some isolated gDNA samples is shown in Figure 44.

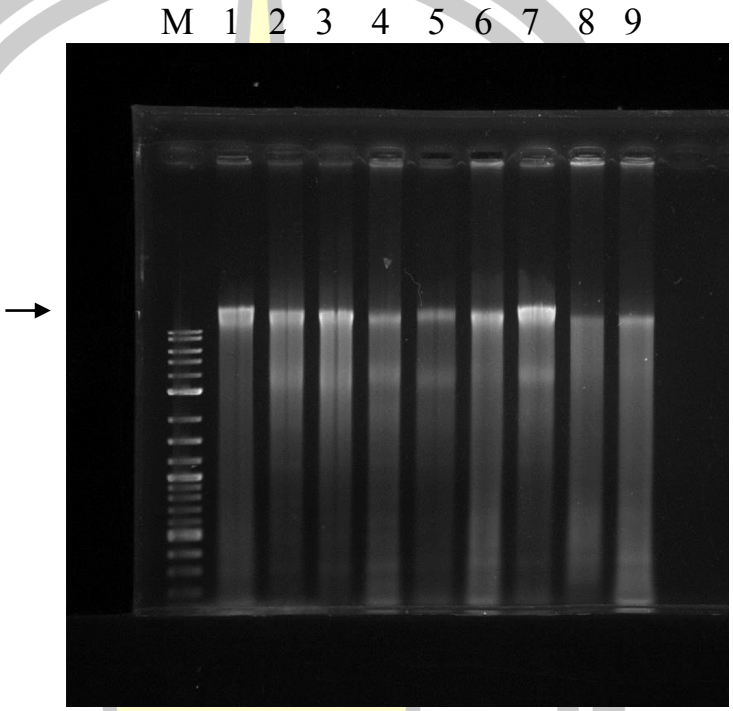


Figure 44 The example isolated gDNA samples analyzed by gel electrophoresis. M, 2-Log DNA Ladder (NEB) (total mass of 0.25 µg loaded). Lane 1 to 9 represent for accessions KR01, UN04, UN03, UN02, UN01, KAR04, KAR03, KAR02, KR02, respectively. The arrow indicates the high molecular weight gDNA fragments.

5.2.2 Amplification of ITS region

The universal primers pair, KS_ITS1 and SK_ITS4, was selected to amplify the conserved ITS region on the chromosome. After PCR product for each plant accession was conducted, all PCR reactions were verified for amplified fragments by gel electrophoresis. The result from PCR amplification generated from ITS region of some accessions is shown in Figure 44. The expected amplified fragment size of ITS

region is at approximately 700 bp for plants in the genus *Kaempferia*. All successful PCR products were then sent for DNA sequencing.

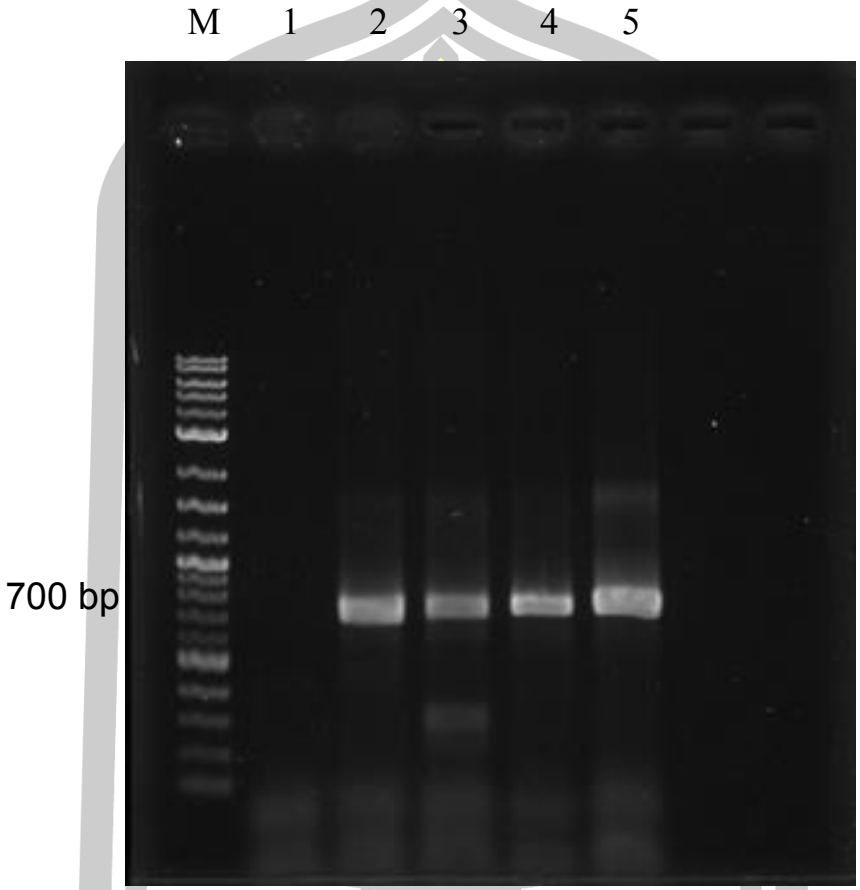


Figure 45 The example PCR products from ITS region analyzed *by gel* electrophoresis. M, 2-Log DNA Ladder (NEB) (total mass of 0.25µg loaded). Lane 1 to 5 represent for accessions banana 20, KAR 03, KAR04, KR06 KX01, respectively. The expected size of PCR products around 700 bp is indicated.

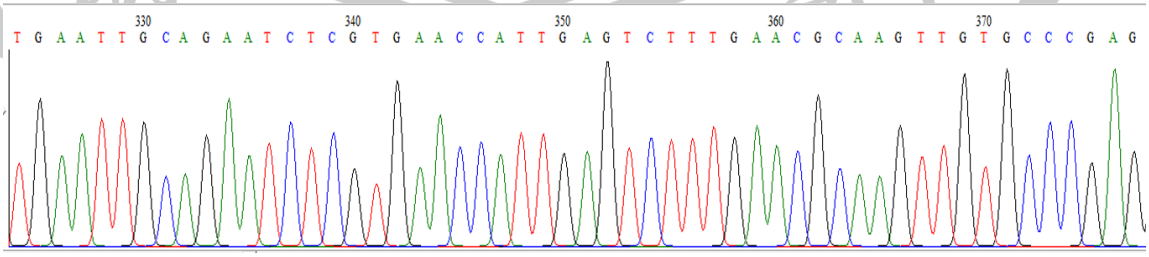


Figure 46 An example of DNA sequencing result from ITS region.

5.2.3 Phylogenetic analysis of *Kaempferia* taxa

After the results from the DNA sequencing were retrieved, the results from both pBluescript KS and pBluescript SK reactions were concatenated to finally obtain the full-length of DNA sequence of ITS region for each accession. Then the multiple-alignment was tested to find out for a best substitution model to maximize the accuracy in hierarchical clustering of the data. The total of 24 nucleotide substitution models was tested using the MEGA program, and the result is shown in Table 2.

Table 10 Testing result for 24 different nucleotide substitution models

Model	BIC value	Model	BIC value	Model	BIC value
T92+G	10854.98	HKY+G+I	10895.25	JC+G+I	11134.33
K2+G	10857.28	GTR+G+I	10901.65	TN93	11206.27
T92+G+I	10865.23	T92+I	10994.12	T92	11208.31
TN93+G	10865.87	K2+I	10997.47	K2	11212.31
K2+G+I	10867.54	TN93+I	11001.15	GTR	11233.33
TN93+G+I	10876.13	GTR+I	11027.83	HKY	11245.36
HKY+G	10884.99	HKY+I	11029.16	JC+I	11257.57
GTR+G	10891.40	JC+G	11124.08	JC	11464.73

For abbreviations. GTR: General Time Reversible; HKY: Hasegawa-Kishino-Yano; TN93: Tamura-Nei; T92: Tamura 3-parameter; K2: Kimura 2-parameter; JC: Jukes-Cantor; G: gamma distribution; I: invariable evolutionary; BIC: Bayesian Information Criterion.

From the result, the model with the lowest BIC value (10854.98) was Tamura 3-parameter with considering of gamma distribution, which used to explain evolutionary rates among sites (T92+G). The model takes into account for the differences in transitional and transversional rates and G+C-content bias. Therefore, this nucleotide substitution model was used to construct the phylogenetic tree with the Maximum Likelihood method.

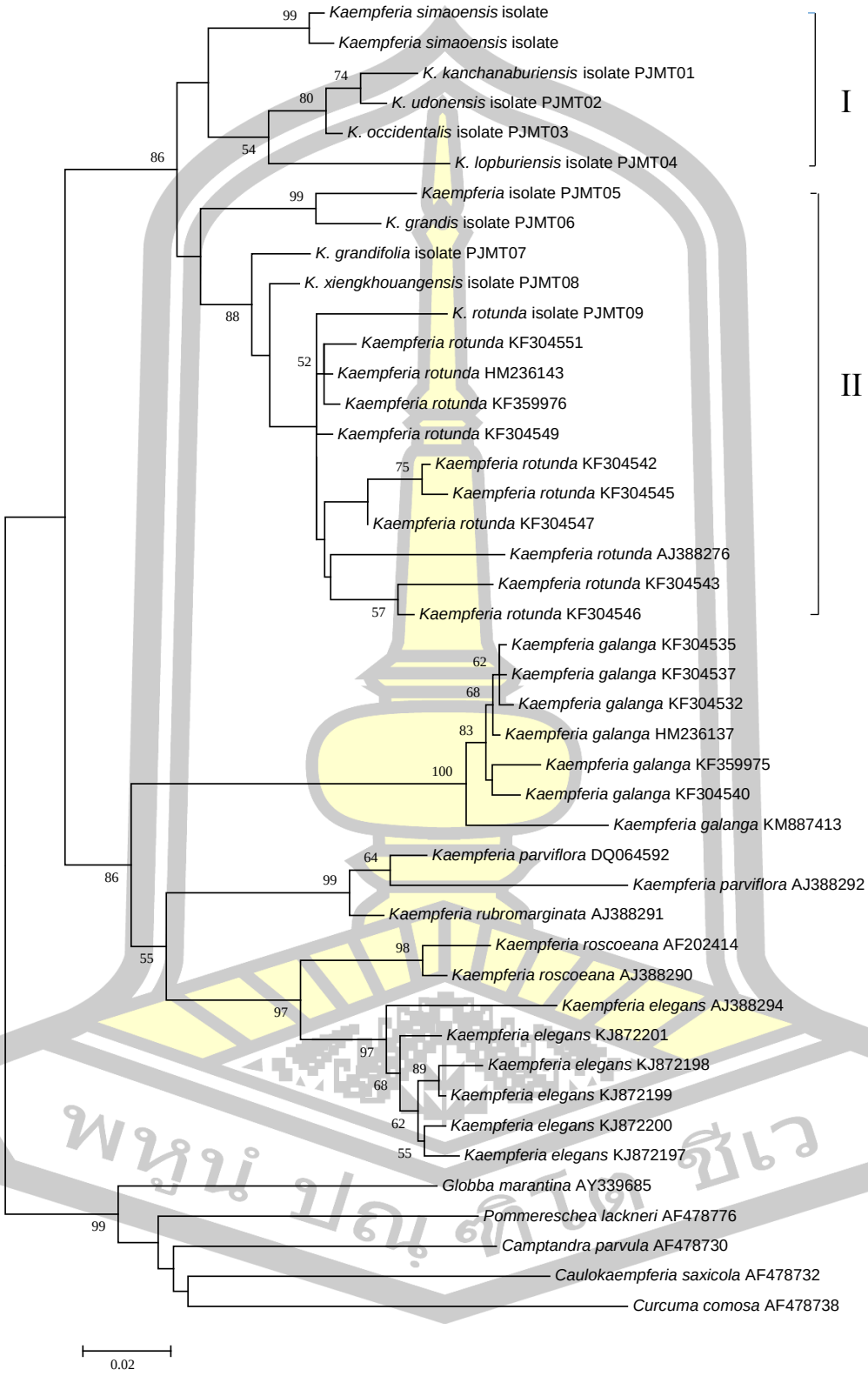


Figure 47 Phylogenetic clustering based on Maximum Likelihood.

Only bootstrap values which >50 are indicated on each branch node. The scale bar beneath the tree is proportional to the branch length. Roman numbers represent for sub-clustered clades.

To describe in more details, 5 species outside the genus in the family Zingiberaceae, *Globba marantina*, *Pommereschea lackneri*, *Camptandra parvula*, *Caulokaempferia saxicola* and *Curcuma comosa*, are clearly clustered as the outgroup. This provides the inferring root to the tree which is virtually located between outgroup and the rest of the interested taxa. Within the clade of family Zingiberaceae, 5 species, are clustered separately apart from all *Kaempferia rotunda* group as cladistics, in which, *K. elegans* has the least relationship to *Kaempferia rotunda* group clade. And the remaining 4 taxa, *K. galanga*, *K. parviflora*, *K. rubromarginata*, and *K. roscoeana* have higher in such relationship.

All 9 accessions of *Kaempferia* taxa were clustered together as the major clade. Moreover, the *Kaempferia* clade could be sub-clustered into 2 clades based on the remoteness between operational taxonomic units (OTUs) measured by branch length. Very high bootstrap values sustained the species novum identity of all 3 proposed new species in this study, in which, the molecular level evidences supported the morphological description by the taxonomy study. Three new species are *K. kanchanaburiensis*, *K. occidentalis*, and *K. grandis*.

CHAPTER 6
CONCLUSION AND DISCUSSION

6.1 Taxonomy

The subgenus *Protanthium*, genus *Kaempferia* were discovered in Thailand for numbers of 13 species and in Laos for 1 species:

The subgenus *Protanthium* in Thailand were shown below.

1. *Kaempferia doisaketensis* Picheans., Meechonk. & Yupparach
2. *K. grandifolia* Saensouk & Jenjittikul
3. *K. grandis* Picheans. & Meechonk.
4. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan
5. *K. kanchanaburiensis* Picheans., Meechonk. & Phokham
6. *K. lopburiensis* Picheans.
7. *K. nakhonsawanensis* Picheans., Meechonk. & Yupparach
8. *K. noctiflora* Nopporn c. & Jenjitt.
9. *K. occidentalis* Picheans., Meechonk. & Phokham
10. *K. rotunda* L.
11. *K. takensis*. Picheans & Meechonk.
12. *K. udonensis* Picheans. & Phokhom
13. *K. uttaraditensis* Picheans. & Meechonk.

One *Kaempferia* taxa reported in Laos was the *K. xiengkhou*angensis Picheans. & Phokhom.

Morphological comparisons of subgenus *Protanthium* revealed the 8 new species, i.e. *K. doisaketensis* Picheans., Meechonk. & Yupparach, *K. grandis* Picheans. & Meechonk., *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, *K. nakhonsawanensis* Picheans., Meechonk. & Yupparach., *K. occidentalis* Picheans., Meechonk. & Phokham, *K. takensis* Picheans. & Meechonk. *and K. uttaraditensis* Picheans. & Meechonk.

This study suggested the flower and leaf blooming of these plants that they were depended on season. The flower annually bloomed in summer while the leaf bloomed in rainy season and they entered hibernation in winter. In defining the new

species, the species concept based on characteristics of the floral plane, flower blooming and pseudostem and leaf were used for comparison between the existing group and new species. In details, the plane of staminode and labellum of flower was perpendicular in *Kaempferia rotunda* while that of the *K. kanchanaburiensis* was nearly parallel. Moreover, the time of flower bloom was also considered. For example, the flower of *K. lopburiensis* bloomed throughout the day while that of the *K. uttaraditensis* bloomed at night. The characteristics of pseudostem in which the well-developed one with upright leaves of the *K. grandis* and the short one with adpressed leaves flat on the ground of the *K. occidentalis* and *K. nakhonsawanensis* were also mentioned. Lastly, the large reddish ligule of the *K. occidentalis* and the small reddish one of the *K. kamolwaniae* were also noted. All mentioned parameters were concerned as species concepts in this study.

Moreover, it was worth noting that the flower of *K. uttaraditensis* bloomed at night with outstanding fragrance. This plant might contain some active ingredients that it could potentially be developed into the medicinal plant. However, further research and investigation were still needed.

6.2 Palynology

All pollen grains of plants in subgenus *Protanthium*, genus *Kaempferia* are subspheroidal shapes and smooth exine. The largest pollen grains were belonged to the *K. rotunda* while the smallest one found in the *K. grandis*. By SEM methods, there was no significant difference of pollen morphology among species in Subgenus *Protanthium*, genus *Kaempferia* found in this study. The palynology results of this study could relatively be compared with those of the *K. galangal* group, e.g. the *K. laotica* that its pollen grain was also subspheroidal shapes and smooth exine (Saensouk, 2000). Previous study on the palynology of genus *Zingiber* revealed two types of pollen that their shapes were ellipsoidal and olive e.g., in the *Zingiber corallinum*, *Z. mioga* and *Z. officinale* (Liang, 1988) which was different from those of the subgenus *Protanthium*, genus *Kaempferia*. In this study, it could be concluded that the characteristics of pollen grains of plants in subgenus *Protanthium* and the *K. galanga* group were subspheroidal shapes and smooth exine**.**

6.3 Molecular studies

The phylogenetic tree of plants in subgenus *Protanthium*, genus *Kaempferia* was successfully constructed. The subgenus *Protanthium* could be sub-clustered into 2 clades. Clade I contained all species with leaf blade was not prostrate and horizontal and near the ground. Clade II contained all species with leaf blade was not prostrate except the *K. grandifolia*. By molecular studies, there were 3 new species found in this study. In comparing the results obtained from the phylogenetic analysis to the morphological characters, the relationship among all *kaempferia* species found in Thailand and Laos was still needed for further investigation. The flower morphology of plants in clade I displayed nearly paralleled staminode and labellum with leaf blade hairy on upper surface and large reddish ligule present near the upper surface of leaves. The plants in clade II mostly had flowers that the staminode and labellum were nearly perpendicular. The labellum was down-bending with well-developed pseudostem and upright leaves containing small reddish ligule. The exception was referred to the *K. grandifolia* which possessed large reddish ligule and short pseudostem. The upper surface of leaf was hairless except that of the *K. grandis.* It was noted that 5 species outside the genus *Kaempferia* but belonged to the family Zingiberaceae (the *Globba marantina*, *Pommereschea lackneri*, *Camptandra parvula*, *Caulokaempferia saxicola* and *Curcuma comosa*) are clearly clustered as the outgroup. This data provided the inferring root to the tree which is virtually located between outgroup and the rest of the interested taxa. Within the clade of family Zingiberaceae, 5 species, are clustered separately apart from all *Kaempferia rotunda* as cladistics, in which, *K. elegans* has the least relationship to *Kaempferia rotunda* clade. And the remaining 4 taxa, *K. galanga*, *K. parviflora*, *K. rubromarginata*, and *K. roscoeana* had higher in such relationship.

The limitation of this phylogenetic tree was referred to the lack of ITS data from some subgenus *Protanthium.* However, this tree could provide tentative information on the relationship among the *Kaempferia* species.

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APPENDIX

***Kaempferia rotunda* L. group**	Bladeless sheaths	Petiole	Leaf blade		Plane of Flower	
			Not prostrate	Prostrate	Vertical	Horizontal
1. *Kaempferia rotunda* L.	2.1-19.1 cm long, hairy	1.4-8.7 cm long, hairy	/		/	
2. *K. grandifolia* Saensouk & Jenjitt.	1-3.5 cm long, pubescent	sessile		/		/
3. *K. lopburiensis* Picheans.	0.9-6 cm long, glabrous	sessile		/		/
4. *K. udonensis* Picheans. & Phokham.	1.5-6.1 cm long	1.5-2 cm long, hairy		/		/
5. *K. xiengkhouangensis* Picheans. & Phokham	2-5.5 cm long	sessile	/			/
6. *K. noctiflora* Nopporne. & Jenjitt.	0.8-7 cm long, hairy	ca. 1 cm long, sparsely hairy	/		/	
7. *K. doisaketensis Picheans., Meechonk & Yupparach, sp. nov.*	1.8-4.2 cm. long, hairy	0.5-3.1 cm long, hairy	/		/	
8. *K. grandis Picheans. & Meechonk., sp. nov.*	2.1-2.4 cm , sparsely hairy	0.6-6 cm long, hairy	/			/
9. *K. kamolwaniae Picheans., Meechonk. & Wongsuwan, sp. nov.*	2.4-10.1 cm long, hairy	sessile	/		/	
10. *K. kanchanaburiensis Picheans., Meechonk. & Phokham, sp. nov.*	2.2-8.6 cm long, sparsely hairy	1-3.4 cm long, hairy	/			/
11. *Kaempferia nakhonsawanensis Picheans., Meechonk. & Yupparach, sp. nov.*	0.8-7 cm long, sparsely hairy	sessile		/		/
12. *K. occidentalis Picheans., Meechonk. & Phokham, sp. nov*	2-7.9 cm long, hairy	sessile		/		/
13. *Kaempferia takensis Picheans & Meechonk., sp. nov*	2.1-5.2 cm long, hairy	sessile	/			/
14. *Kaempferia uttaraditensis Picheans. & Meechonk, sp. nov.*	2.3-6.6 cm long, hairy	1-3.5 cm long, hairy	/		/	

***Kaempferia rotunda* L. group**	Upper surface	Lower surface	Laminar (Shape & size)
1. *Kaempferia rotunda* L.	green, glabrous	green or red, pubescence	1-5(-7), lanceolate-oblong to elliptic, 12-39.5 x 3.8-13 cm, base cuneate, apex acute
2. *K. grandifolia* Saensouk & Jenjitt.	green with brown lines along the veins, pale green along the margin, glabrous	purple with greenish patches, pubescent	3-4, suborbicular, 18-28 x 15.3-18.5 cm, base cuneate, apex acute to acuminate
3. *K. lopburiensis* Picheans.	pale green with light purple band along the margin, sparsely hairy	pale green, pubescence	1-4, suborbicular to orbicular, 12.3-24.1 x 11-23.5 cm, base cuneate, apex acute to acuminate
4. *K. udonensis* Picheans. & Phokham.	green with several silvery markings, hairy at the base of the midrib	reddish brown, pubescent	2-4, orbicular to elliptic, 19-27.5 x 14.7-18.8 cm, base cuneate to obtuse, apex cuspidate to acuminate; margin slightly undulate, reddish
5. *K. xiengkhouangensis* Picheans. & Phokham	green, glabrous	pale green, pubescent	3-5, broadly elliptic to lanceolate, 14.8-27.5 x 10.4-13.9 cm, base cuneate, apex acute to acuminate, margin slightly undulate
6. *K. noctiflora* Nopporne. & Jenjitt.	pale green to tinged purplish red, usually with tinged purplish red patch along the midvein, glabrous	purplish red, pubescent	3-4, ovate to elliptic, 13.6-22.7 x 13.1-22.9 cm, base cuneate, apex acuminate to cuspidate
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	green to purplish red, hairy	reddish, pubescent	1-5, lanceolate to elliptic, 12.7-21.6 x 4.9-9.5 cm, base cuneate, apex acute to acuminate, margin entire to slightly crenate
8. *K. grandis* Picheans. & Meechonk., sp. nov.	green with several white markings, hairy at the base of the midrib	reddish, hairy	5-6, elliptic to ovate, 13.8-44.1 x 6.2-21 cm, base cuneate, apex acute to acuminate
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	green, sparsely hairy at the base of the midrib	pale green, sparsely hairy	1-2(-3), elliptic to ovate, 18-51.3 x 8.8-17.5 cm, base cuneate, apex acute to acuminate

***Kaempferia rotunda* L. group**	Upper surface	Lower surface	Laminar (Shape & size)
10. *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	green with several green markings or white markings, hairy at the base of the midrib	green, sparsely hairy	1-4(-6), ovate to elliptic, 12-27.6 x 6.8-16.8 cm, base cuneate to obtuse, apex acute to acuminate
11. *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	green, glabrous	pale green, hairy	1, suborbicular, 13.6-22.7 x 13.1-22.9 cm, base cordate, apex acute to acuminate
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	green, sparsely hairy at the base of the midrib	pale green with reddish at the top and lateral, sparsely hairy	1-2(-4), suborbicular to elliptic, 11.2-38 x 10.3-31.2 cm, base cuneate to obtuse, apex mucronate to obtuse
13. *Kaempferia takensis* Picheans & Meechonk., sp. nov	green with several green markings, hairy at the base of the midrib	reddish, hairy	2-4(-6), ovate to elliptic, 10.1-43.5 x 7.1-20.9 cm, base cuneate, apex acute to acuminate
14. *Kaempferia uttaraditensis* Picheans. & Meechonk, sp. nov.	green, sparsely hairy at the base of the midrib	pale green, sparsely hairy	1-3(-4), elliptic to lanceolate, 8-21.3 x 2.4-9.3 cm, base cuneate, apex acuminate

***Kaempferia rotunda* L. group**	Ligule	Inflorescences		Number of Flower
		Day blooming (D)	Night blooming(N)	
1. *Kaempferia rotunda* L.	broadly triangular, 1-3 mm long,green or green-reddish, apex acute to rounded, hairy	D		5-16
2. *K. grandifolia* Saensouk & Jenjitt.	broadly triangular, 3-5 mm long, green, apex rounded, hairy	D		ca. 12
3. *K. lopburiensis* Picheans.	broadly triangular, 0.9-1.2 cm long, reddish, apex obtuse to rounded, hairy	D		6-18
4. *K. udonensis* Picheans. & Phokham.	broadly triangular, 1.4-2 cm long, reddish, apex obtuse, hairy	D		5-30
5. *K. xiengkhouangensis* Picheans. & Phokham	membranous, 4-10 mm long , green, apex obtuse, hairy	D		10-19
6. *K. noctiflora* Nopporne. & Jenjitt.	triangular, 1.8-3 mm long,pale green to purplish red, apex obtuse, hairy	N		4-7
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	trianglular, ca. 1 x 1-2 mm long, reddish, apex acute, hairy	D		5-13
8. *K. grandis* Picheans. & Meechonk., sp. nov.	broadly triangular,0.5-1.2 cm long, reddish or greenish, apex rounded to acute, pubescent	D		8-45
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	small, 0.6-0.9 cm long, green, apex acute, hairy	D		6-11

***Kaempferia rotunda* L. group**	Ligule	Inflorescences		Number of Flower
		Day blooming (D)	Night blooming(N)	
10. *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	broadly triangular, 0.6-2.4 cm long, reddish, apex obtuse, hairy	D		6-18
11. *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	broadly trianglular, 0.9-1.2 cm long, reddish, apex rounded or acute, sparsely hairy	D		7-10
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	broadly trianglular, 0.8-1.7 cm long, reddish, apex obtuse to rounded, hairy	D		6-18
13. *Kaempferia takensis* Picheans & Meechonk., sp. nov	broadly trianglular, membranous, 1-3.5 cm long, reddish, apex rounded, hairy	D		5-19
14. *Kaempferia uttaraditensis* Picheans. & Meechonk, sp. nov.	small triangular, 0.5-2 mm long, greenish, apex acute, hairy	N		5-10

***Kaempferia rotunda* L. group**	Peduncle	Bract	Bracteole
1. *Kaempferia rotunda* L.	0.3-8.4 cm long, hairy	lanceolate, 2.5-5.6 × 1.1-3.3 cm, pale green, apex mucronate to acuminate, ciliate	lanceolate, 1-2.8 cm × 2-5 mm , apex acute or 2-lobed, apex of each lobe acute, hairy
2. *K. grandifolia* Saensouk & Jenjitt.	0.5-3 cm long, glabrous	lanceolate, 1.8-6.1 × 0.7-3.7 cm, pale green, apex cuspidate or mucronate, sparsely hairy	lanceolate, 1.6-2.7 × 4-6 mm, apex mucronate, sparsely hairy
3. *K. lopburiensis* Picheans.	4-5 cm long, hairy	lanceolate, 4.1-6 × 1.4-2.2 cm, pale green, apex cuspidate or mucronate, hairy	membranous, lanceolate, 2.3-2.7 × 2-4 mm, apex 2-lobed, apex of each lobe acute, hairy
4. *K. udonensis* Picheans. & Phokham.	1.1-3 cm long, hairy	ovate, 2.9-4.8 × 1.2-3.5 cm, pale green apex acute, hairy	lanceolate, 1.8-2.3 cm × 3-5 mm, apex 2-lobed, apex of each lobe acute, hairy
5. *K. xiengkhouangensis* Picheans. & Phokham	0.9-2.9 cm long, sparsely hairy	bracts broadly ovate to ovate, 2.6-5.4 × 1-3.5 cm, pale green, apex acute, hairy	ovate, 1-1.4 × 2-6 mm, apex 2 lobes, reddish, acuminate, hairy
6. *K. noctiflora* Nopporne. & Jenjitt.	subsessile to 1 cm long, glabrous	ovate to lanceolate-ovate, 1-3.4 × 2-3 cm, green, apex acute to acuminate, hairy	lanceolate, ca. 1.7 cm × 5 mm, apex 2-lobed, each lobe acute, glabrous
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	0.7-2.2 cm long, hairy	broadly ovate to ovate, 0.9-3.8 × 0.6-2.4 cm, pale green or pale green with purplish at apex, apex cuspidate to mucronate, hairy	lanceolate, 1.1-1.5 cm × 4-5 mm, apex 2 lobes, acute to acuminate, hairy
8. *K. grandis* Picheans. & Meechonk., sp. nov.	1.1-3.3 cm long, hairy	bract ovate, 1.6-4.3 × 1-3.3 cm, pale green, apex acute, hairy	lanceolate, 0.9-2 cm × 3-5 mm, apex 2-lobed, apex of each lobe acute, hairy
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	0.6-3.7 cm long, glabrous	ovate, 3.3-4.3 × 1.5-4.2 cm, pale green, apex acute to mucronate, hairy	lanceolate, 2-2.5 × 5-8 mm, apex acute, hairy

***Kaempferia rotunda* L. group**	Peduncle	Bract	Bracteole
10. K. *kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	0.9-3.4 cm long, hairy	ovate, 2.3-4 × 0.8-2.4 cm, pale green, apex acute, hairy	lanceolate, 1.2-1.3 cm × 3-4 mm, apex 2-lobed, each lobe acute, hairy
11. *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	0.5-1.4 cm long, hairy	ovate, 1.9-3.4 × 0.8-2.5 cm, whitish with pale green at apex, apex acute, hairy	lanceolate, 1.4-2.1 cm × 4-5 mm, apex 2-lobed, each lobe acute or apex acute, hairy
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	0.7-3.1 cm, long, hairy	ovate, 2.2-4.2 × 1.1-2.7 cm, pale green, apex mucronate, hairy	lanceolate, 1.3-1.9 cm × 2-3 mm, apex 2-lobed, each lobe acute, hairy
13. *Kaempferia takensis* Picheans & Meechonk., sp. nov	0.5-1 cm long, hairy	ovate, 2.3-4 × 0.8-2.4 cm, apex acute, hairy	lanceolate, 1.2-1.3 cm × 3-4 mm, apex 2-lobed, apex of each lobe acute, hairy
14. *Kaempferia uttaraditensis* Picheans. & Meechonk, sp. nov.	1.2-3.2 cm long, glabrous	broadly ovate to ovate, 1.1-3.2 × 0.7-2.2 cm, pale green, apex acute to mucronate, hairy	lanceolate, 0.7-1.7 cm × 3-5 mm, apex acute, hairy

***Kaempferia rotunda* L. group**	Calyx tube	Corolla tube	Dorsal corolla lobe
1. *Kaempferia rotunda* L.	3.8-6.5 cm long, split on one side, 1-1.7 cm long, apex 2-lobed, sparsely hairy	4.7-8 cm long, white, glabrous	oblong to narrowly ovate, 3.6-6.1 cm × 6-8 mm, white, apex aristate, hooded
2. *K. grandifolia* Saensouk & Jenjitt.	3.5-6.1 cm long, split on one side, 0.6-1.4 cm long, apex 3-lobed, sparsely hairy	4.6-8.6 cm long, white, glabrous	lanceolate oblong, incurved, 3.5-4.5 cm × 5-8 mm, white, apex acute, hooded
3. *K. lopburiensis* Picheans.	4.3-7.7 cm long, split on one side, 0.6-0.9 cm long, apex 3-lobed, sparsely hairy at apex	4.5-10 cm long, white, glabrous	lanceolate-oblong, 2.5-3.6 cm × 5-7 mm, apex hooded with a thorn-like point ca. 5 mm long
4. *K. udonensis* Picheans. & Phokham.	5.2-7.2 cm long, split on one side, 0.6-1.3 cm long, apex bifid, hairy,	6.2-10.7 cm long, whitish, glabrous	oblong to narrowly ovate, 2.4-3.5 × 0.5-1 cm, apex acute, hooded
5. *K. xiengkhouangensis* Picheans. & Phokham	2.7-5.4 cm long, split on one side, 0.8-1.2 cm long, reddish, apex trifid, hairy	4.6-7.8 cm long, whitish, glabrous	narrowly lanceolate, 2.7-3.6 cm × 5-6 mm, apex hooded
6. *K. noctiflora* Nopporne. & Jenjitt.	5.1-6 cm long, split on one side, 6-10 mm long, apex bifid, glabrous	6-7 cm long, whitish, glabrous	lanceolate-oblong, 4-4.8 cm × 4-5 mm, apex aristate, hooded
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	3.6-5.5 cm long, split on one side, 0.6-1.2 cm long, apex bifid, hairy	3.3 -5.9 cm long, whitish, glabrous	narrowly lanceolate, 4-5.2 cm × 4-7 mm, apex hooded
8. *K. grandis* Picheans. & Meechonk., sp. nov.	2.4-5.6 cm long, split on one side, 0.9-1 cm long, apex bifid, hairy	5.2-7.7 cm long, whitish, hairy	oblong to narrowly ovate, 2.1-3.6 cm × 4-6 mm, white, apex acute, hooded
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	4.0-5.3 cm long, split on one side 0.7-1.6 cm long, apex bifid to trifid, sparsely hairy at apex	4.1-6.4 cm long, white, glabrous	oblong to narrowly ovate, 4.2-6.2 × 0.7-1.3 cm, apex aristate, hooded

***Kaempferia rotunda* L. group**	Calyx tube	Corolla tube	Dorsal corolla lobe
10. K. *kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	3-3.7 cm long, split on one side, 0.5-1.5 cm long, apex bifid, hairy	5.9-7.5 cm long, whitish, hairy	oblong to narrowly ovate, 2.5-3.5 cm × 4-6 mm, apex acute, hooded
11. *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	3.4-5.2 cm long, split on one side, 4-8 mm long, apex bifid or trifid, hairy	3.5-7.9 cm long, whitish, glabrous	lanceolate-oblong, 2.4-3.1 cm × 5-6 mm, apex acute, hooded
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	3.4-6.3 cm long, split on one side, 0.8-1.1 cm long, apex bifid, hairy	4.2-7.9 cm long, whitish, hairy	oblong to narrowly ovate, 1.8-2.6 cm × 5-6 mm, apex acute, hooded;
13. *Kaempferia takensis* Picheans & Meechonk., sp. nov	2.4-2.8 cm long, split on one side, 0.5- 1.5 cm long, apex bifid, hairy	2.8-7.5 cm long, whitish, hairy	oblong to narrowly ovate, 2.5-3.5 cm × 4-6 mm, apex acute, hooded
14. *Kaempferia uttaraditensis* Picheans. & Meechonk, sp. nov.	3.8-5.5 cm long, split on one side, 1.1-1.6 cm long, white to pale greenish, apex bifid, hairy	3.6-6.6 cm long, white, glabrous	lanceolate-oblong, 2.9-4.1 cm × 4-7 mm, white, apex acute, hooded

***Kaempferia rotunda* L. group**	Lateral corolla lobe	Staminodes	Labellum
1. *Kaempferia rotunda* L.	oblong to narrowly ovate, 3.4-5.5 cm × 3-5 mm, apex aristate	oblong, 2.8-5.3 × 0.9-2.2 cm, white, purple-tinted apex rounded to acute	obovate, 3.3-4.9 × 2-2.9 cm, purple, deep purple toward the base apically bilobed for ca. 1/2 its length, each lobe elliptic, apex rounded to mucronate
2. *K. grandifolia* Saensouk & Jenjitt.	lanceolate oblong, incurved, 3.5-4.3 × 4-5 mm, white, apex acute	oblong to obovate, 2.9-3.8 cm × 4-5 mm, white, apex acute to acuminate	obovate, apically bilobed, 2.4-3.6 × 3.8-4.3 cm,white with pale yellow spot, each lobe apex acute or acuminate
3. *K. lopburiensis* Picheans.	oblong, incurved, 2.4-3.4 cm × 3-6 mm, white, apex acute	obovate, 2.6-3.1 × 1.2-1.8 cm, whitish, apex rounded	obovate to suborbicular, 3-3.2 × 2.3-3.3 cm, purple, deep purple toward the base, apex deeply bilobed, each lobe obovate, 1.8-2.6 × 1.3-1.6 cm
4. *K. udonensis* Picheans. & Phokham.	oblong to narrowly ovate, 2-3.3 cm × 4-6 mm, apex acute	broadly obovate, 2.1-3.2 × 1.8-2.9 cm, light purple, apex rounded	broadly obovate, 1.8-3 × 2.8-3.5 cm, light purple, deep purple at base, apex divided almost to the base, each lobe broadly obovate, 1.2-2.5 × 1.3-1.9 cm apex rounded
5. *K. xiengkhouangensis* Picheans. & Phokham	narrowly lanceolate, 2.1-3.5 cm × 3-5 mm, apex acute	obovate, 2-3.3 × 1.1-1.9 cm, deep pink, apex rounded to apiculate	broadly obovate, 1.7-3 × 2.5-4.3 cm, deep pink, violet at base, divided to the base, each lobe obovate, 1.3-2.2 × 1.1-2 cm, apex rounded to apiculate
6. *K. noctiflora* Noppornc. & Jenjitt.	lanceolate-oblong, 3.8-4 cm × 3-4 mm, apex aristate to acute	oblong- elliptic, 2.8-4 × 1-1.3 cm, white, apex acute	broadly obovate, 3.4-4 × 2.1-3.4 cm, pure white or white with pale yellow patch from the base, bilobed divided to 1/2 -2/3 of labellum, each lobe ovate, 2-2.2 × 1.3-1.6 cm, apex acute, rounded to slightly bilobed, partly overlapping
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	narrowly lanceolate, 3.5-4.8 cm × 3-6 mm, apex hooded	lanceolate to obovate, 3-4.1 × 1.2-1.6 cm, white to white proximally; pale purple distally, apex acute to rounded	broadly obovate, 3.5-4.4 × 2-3.1 cm, pale purple, deep purple at base, apically bilobed for ca. 1/2 its length, each lobe obovate, 1.5-2.8 × 1.2-1.8 cm, apex mucronate to acuminate or emarginate

***Kaempferia rotunda* L. group**	Lateral corolla lobe	Staminodes	Labellum
8. *K. grandis* Picheans. & Meechonk., sp. nov.	oblong to narrowly ovate, 2.7-3.1 cm × 3-4 mm, white, apex acute	obovate, 2.1-3.5 × 1.4-1.9 cm, pink, apex acute	obovate, 2.2-3.8 × 3.1-3.9 cm, pink, deep pink with white patch at the base, apex divided to the base, each lobe obovate, 1.5-3.1 × 1.2-2.3 cm, apex rounded to acute
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	oblong to narrowly ovate, 3.8-6.1 × 0.7-1.2 cm, apex acute	broadly obovate to oblong, 4.8-6.1 × 2.1-2.7 cm, white to purple, apex rounded to acute or cuspidate	obovate, 4.4-6 × 3.3-3.7 cm, purple, deep purple toward the base, apically bilobed for ca. 1/3 its length, 2.3-2.9 cm, each lobe narrowly obovate, apex rounded to slightly emarginate
10. *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	oblong to narrowly ovate, 1.5-2.8 cm × ca. 4 mm, apex acute	broadly obovate, 2.1-2.5 × 1.7-1.8 cm, purplish to violet, apex rounded	broadly obovate, purplish to violet, deep purplish to violet toward the base, 1.8-2.9 × 2.7-3.9 cm, apex divided almost to the base, each lobe broadly obovate, 1.5-2.1 × 1.6-2 cm, apex rounded
11.*Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	lanceolate-oblong, 2.2-2.9 cm × 3-4 mm, apex acute	obovate, 2.3-3.1 × 0.9-1.6 cm, pale purplish, apex rounded	broadly obovate, 1.9-3.1 × 2.3-2.8 cm, pale purplish, deep purple toward the base, apex divided to 2/3 of labellum length or almost to the base, each lobe obovate, 1.4-1.7 × 1-1.2 cm, apex rounded to emarginate or partly overlapping
12. K. *occidentalis* Picheans., Meechonk. & Phokham, sp. nov	oblong to narrowly ovate, 1.9-2.5 cm × 3-4 mm, apex acute	broadly obovate, 2.1-2.8 × 1.3-2 cm, lilac purple, apex rounded to slightly emarginate	broadly obovate, 1.8-2.9 × 2.7-3.9 cm, lilac purple, deep purple with yellow-orange line at base, apex divided almost to the base, each lobe broadly semi-circular, 1.5-2.1 × 1.6-2 cm, apex rounded to slightly emarginate

***Kaempferia rotunda* L. group**	Lateral corolla lobe	Staminodes	Labellum
13. *Kaempferia takensis* Picheans & Meechonk., sp. nov	oblong to narrowly ovate, 1.5-2.8 cm × ca. 4 mm, apex acute	broadly obovate, 2.1-2.5 × 1.7-1.8 cm, purple, apex rounded	broadly obovate, 2.4-3.2 × 2.7-4.8 cm, purple, deep purple toward the base, apex divided almost to the base, each lobe broadly obovate, 2.1-2.7 × 1.4-2.5 cm, apex rounded
14. *Kaempferia uttaraditensis* Picheans. & Meechonk, sp. nov.	lanceolate-oblong, incurved, 2.8-3.6 cm × 4-7 mm, white, apex acute	oblong or obovate, 2.5-4.3 × 0.4-1.2 cm, white, apex rounded to acute	broadly obovate, 3.1-4 × 1.9-2.7 cm, base attenuate into 0.8-1 cm × 4-5 mm claw, pure white or white with purplish patch at the base, apex bilobed divided to 1/2-2/3 of labellum length, each lobe obovate to narrow obovate, 1.4-2.2 × 0.8-1.1 cm, apex rounded to acute or emarginate or partly overlapping

***Kaempferia rotunda* L. group**	Anther	Anther crest	Ovary
1. *Kaempferia rotunda* L.	5-8 mm long	oblong, 7-10 × 2-4 mm, white, the outers acute and elongate, the middle one shorter, entire or emarginate	cylindrical or rectangular or oblong, 4-7 × 2-3 mm, hairy
2. *K. grandifolia* Saensouk & Jenjitt.	3-4 mm long	conspicuously bilobed, apex of lobes acute, 4-7 x 2-4 mm, white	ellipsoid, oblique, 5-7 × 0.2 mm, sparsely hairy
3. *K. lopburiensis* Picheans.	4-5 mm long	rectangular or broadly obovate, 0.4-0.9 cm × 3-6 mm, white to violet; apex tri-dent to crenate	cylindrical, 4-6 × 2-3 mm long, pubescent toward the upper part
4. *K. udonensis* Picheans. & Phokham.	4-6 mm long	rectangular, 5-9 × 6-8 mm, white to violet, apex acute to trifid	rectangular, 4-7 mm long, pubescent
5. *K. xiengkhouangensis* Picheans. & Phokham	4-6 mm long	ovate or rectangular, 6-8 × 2-3 mm, apex bilobe, tri-dent, or variable	cylindrical, 4-6 × 2 mm, sparsely hairy
6. *K. noctiflora* Nopporne. & Jenjitt.	5-6 mm long	oblong, 7-9 × 3-5 mm, white, apex biobed	cylindrical, ca. 6 × 2-2.2 mm, creamy yellow, sparsely hairy
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	6-7 mm long	ovate, 5-9 × 3-5 mm, apex bilobe or tri-dent	ovary cylindrical, 4-8 × 2-3 mm, hairy
8. *K. grandis* Picheans. & Meechonk., sp. nov.	4-5 mm long	ovate to rectangular, 6-7 × 3-4 mm, pink, apex bifid to trifid	oblong to obovate, 3-6 × ca. 2 mm long, whitish, hairy
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	7-8 mm long	ovate, 0.8-1.6 cm × 4-7 mm, white to violet, apex 4-lobed to 5-lobed; the outer lobes acute and elongate, the middle shorter	oblong or cylindrical, 4-6 × 2-3 mm, glabrous

***Kaempferia rotunda* L. group**	Anther	Anther crest	Ovary
10. K. *kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	4-6 mm long	orbicular to rectangular, 5-8 × 3-7 mm, white to violet	oblong to obovate, 3-5 × ca. 2 mm long, glabrous to sparsely hairy
11. *Kaempferia nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	3-4 mm long	oblong, 6-7 × 3-5.5 mm, purplish, apex trilobe	cylindrical or ellipsoid, 4-7 × 2-3 mm, pubescence or hairy
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	5-6 mm long	ovate to rectangular, 5-8 × 4-8 mm, white to violet	oblong to cylindrical, 3-5 × 2 mm long, sparsely hairy
13. *Kaempferia takensis* Picheans & Meechonk., sp. nov	4-6 mm long	oblong to rectangular, 5-8 × 3-7 mm, white to purple	oblong to obovate, 3-5 × 2 mm long, glabrous to sparsely hairy
14. *Kaempferia uttaraditensis* Picheans. & Meechonk, sp. nov.	3-5 mm long	oblong, broadly obovate, or rectangular, 4-5 × 3-5 mm, white, apex bilobed to crenate	oblong to cylindrical, 4-6 × 2-3 mm, whitish, glabrous

***Kaempferia rotunda* L. group**	Stylodial grand	Fruits	Seeds
1. *Kaempferia rotunda* L.	ca. 5 mm long	ovate to oblong, 1.6-2.5 × 0.7-1.1 cm, whitish	numerous, ovate, whitish, 4-7 × 2-4 mm; capped with white membranous aril.
2. *K. grandifolia* Saensouk & Jenjitt.	ca. 5 mm long	narrowly obovoid to ellipsoid, 3-4.5 × 0.9-1.2 cm, whitish.	numerous, greenish to brown green with white aril.
3. *K. lopburiensis* Picheans.	ca. 5 mm long	cylindrical to ellipsoid, 3.3-4.4 cm × 1.1-1.3 cm, whitish	numerous, ovate, whitish to brownish, 4-6 × 2-3 mm; capped with white aril.
4. *K. udonensis* Picheans. & Phokham.	ca. 5 mm long	fleshy, ovate, oblong to obovate, 1.2-3.4 × 0.8-1.4 cm	numerous, ovate, reddish, 3-6 × 2-4 mm; capped with whitish membranous aril.
5. *K. xiengkhouangensis* Picheans. & Phokham	ca. 5 mm long	obovate-oblong to oblong, 1-1.8 cm × 6-9 mm	numerous, narrowly ellipsoid to ovate, brownish, ca. 3 × 2-3 mm; capped with whitish aril.

***Kaempferia rotunda* L. group**	Stylodial grand	Fruits	Seeds
6. *K. noctiflora* Nopporne. & Jenjitt.	4-5 mm long	ellipsoid, 1.7-2 cm × 8-9 mm, yellowish green, glabrous	numerous, ovate to ellipsoid, yellowish, 5-7 × 2-3 mm; capped with whitish membranous aril.
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	6-8 mm long	obovate or ovate, 0.9-1.7 cm × 5-9 mm, whitish	numerous, narrowly ellipsoid to obovate, whitish, 3-5 × 1-2 mm; capped with whitish membranous aril.
8. *K. grandis* Picheans. & Meechonk., sp. nov.	ca. 5 mm long	ovate to oblong, 1.4-2 cm × 1-1.4 cm, pink, hairy	numerous, ovate to oblong, yellowish, ca. 5 × 4 mm; capped with white membranous aril.
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	ca. 5 mm long	ovate to oblong, 1.2-3.4 × 0.8-1.5 cm, whitish and many red spot at the top	numerous, ovate, yellow-green, ca. 6 × 3 mm; capped with white membranous aril.
10. K. *kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	ca. 5 mm long	ovate to oblong, 2-2.4 cm × 0.7-0.9 cm, sweet purple	numerous, ovate to oblong, sweet purple, ca. 5 × 4 mm; capped with whitish membranous aril.

Kaempferia rotunda **L. group**	Stylodial grand	Fruits	Seeds
11. *K. nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	4-5 mm long	oblong, 3.9-4 cm × 8-9 mm, whitish, curved, upper part red-brownish, hairy	numerous, ovate to elliptic, yellowish, 5-5.5 × 2.5-3 mm; capped with whitish membranous aril.
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	ca. 5 mm long	obovate to elliptic, 3-3.6 × 1.2-1.7 cm, sweet purple	numerous, ovate, yellow, ca. 4 ×3 mm; capped with whitish membranous aril.
13. *K. takensis* Picheans & Meechonk., sp. nov	ca. 5 mm long	ovate to oblong, 1.1-2.4 cm × 0.7-1 cm, yellow-green.	numerous, ovate to oblong, yellow-green, 5-8 × 3-4 mm; capped with white membranous aril.
14. *K. uttaraditensis* Picheans. & Meechonk, sp. nov.	ca. 5 mm long	elliptic, whitish, ca. 7.5 × ca. 4 mm,	numerous, ovate, whitish; capped with whitish membranous aril.

***Kaempferia rotunda* L. group**	Petiole
1. *Kaempferia rotunda* L.	1.4-8.7 cm long, hairy
2. *K. grandifolia* Saensouk & Jenjitt.	sessie
3. *K. lopburiensis* Picheans.	sessile
4. *K. udonensis* Picheans. & Phokham.	1.5 -2 cm long hairy
5. *K. xiengkhouangensis* Picheans. & Phokham	sessile
6. *K. noctiflora* Nopporne. & Jenjitt.	ca. 1 cm long, sparsely hairy
7. *K. doisaketensis* Picheans., Meechonk & Yupparach, sp. nov.	0.5-3.1 cm long hairy
8. *K. grandis* Picheans. & Meechonk., sp. nov.	0.6-6 cm long, hairy
9. *K. kamolwaniae* Picheans., Meechonk. & Wongsuwan, sp. nov.	sessile
10. *K. kanchanaburiensis* Picheans., Meechonk. & Phokham, sp. nov.	1-3.4 cm long, hairy
11. *K. nakhonsawanensis* Picheans., Meechonk. & Yupparach, sp. nov.	sessile
12. *K. occidentalis* Picheans., Meechonk. & Phokham, sp. nov	sessile
13. *K. takensis* Picheans & Meechonk., sp. nov	sessile
14. *K. uttaraditensis* Picheans. & Meechonk, sp. nov.	1-3.5 cm long, hairy

BIOGRAPHY

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