

## A NEW SPECIES OF *CAULOKAEMPFERIA* (ZINGIBERACEAE) FROM LAOS, WITH FURTHER INFORMATION ON OTHER *CAULOKAEMPFERIA* SPECIES FROM LAOS

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### ABSTRACT

A new species of *Caulokaempferia* (family Zingiberaceae) from southern Laos, *C. bolavenensis* Picheans. & Koonterm, is described and illustrated. *C. alba* K. Larsen & R.M. Smith, a species previously reported from Thailand, is also recorded from central Laos for the first time. The geographical distribution and ecology of the two *Caulokaempferia* species from Laos: *C. bracteata* K. LARSEN & S.S. LARSEN and *C. burttii* K. LARSEN & JENJITT., previously reported uncertain, together with further information on floral color variation of *C. laotica* PICHEANS. & MOKKAMUL, are discussed in detail. A key to all five species currently enumerated for Laos is also provided.

Key words: new species, *C. bolavenensis*, southern Laos, new record, *C. alba*, geo-graphical distributions, *C. bracteata*, *C. burttii*, *C. laotica*.

In continuation of our work on the medicinal plant family Zingiberaceae in Thailand, particularly the genus *Caulokaempferia* (PICHEANSOONTHON & MOKKAMUL, 2004a and 2004b; PICHEANSOONTHON ET AL, 2007; PICHEANSOONTHON & KOONTERM, 2008; MOKKAMUL & PICHEANSOONTHON, 2004), we have extended our studies into Laos. As a result, *C. laotica* Picheans. & Mokkamul were reported from Laos with full detailed information on type locality and distribution (PICHEANSOONTHON & MOKKAMUL, 2006). However, *C. bracteata* K. Larsen & S.S. Larsen was previously described based on specimens purchased from Chatuchak Market in Bangkok with uncertain collecting locality, presumably from Nong Khai province (LARSEN, 2002). Later, *C. burttii* Larsen & Jenjitt. was also described from the specimens bought from the same market, again with uncertain collecting locality, presumably from the Bolaven Plateau in Southern Laos (LARSEN & JENJITIKUL, 2004).

In this paper, a new species, *C. bolavenensis* Picheans. & Koonterm, is described and illustrated. A known taxon previously reported from Thailand, *C. alba* K. Larsen & R.M. Smith, is also reported from Laos for the first time. Distribution of two other species previously reported uncertain, *C. bracteata* K. Larsen & S.S. Larsen and *C. burttii* K. Larsen & Jenjitt., are discussed. Keys to all five species currently enumerated for Laos are provided.

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## THE NEW SPECIES

***Caulokaempferia bolavenensis* Picheans. & Koonterm, sp. nov.**

**Type.**—*Picheansoonthon* & *Koonterm* 821. Tad Kamued Waterfall, the Bolaven Plateau, Paksong District, Champasak Province, Laos, 15° 04.330' N, 106° 42.152' E, alt. 932 m (holotype including dried and spirit materials: BKF; isotype: SING).

**Diagnose.**—*Caulokaempferia limianae* affinis, folii apice cordato, ligula deltoidea ad oblonga 0.6–1.4 cm longa, bracteis ovatis 1–4-floris, bracteola lata ovata, staminodio laterali obovato apice rotundato ad truncato, labello parte distali 3-lobata lobo mediano 2–3 mm extenco apice truncato ad emarginato differt.

Epilithic herbs, perennial, slender, with short rhizome; root fibrous, some form longish tuber. *Pseudostems* 5.3–15.7 cm, with 2–3 bladeless sheath or reduced lamina. *Leaves* 5–6, lower ones smaller, sessile, upper ones shortly petioles, 2–6 mm, two upper most ones the largest, ligules deltoid to oblong, membranous, 0.6–1.4 cm long, light reddish, apex narrowly acute; leaf blade broadly lanceolate, the largest ones 7.8–16.8 by 2.0–3.3 cm, glabrous, base oblique, apex caudate, margin entire to slightly undulate. *Inflorescences* terminal, 3.0–5.2 cm long, peduncle glabrous, inclosed in leaf sheathes of the two upper most leaves, 1.2–.5 cm long. *Bracts* 1–, tightly imbricate, unilateral with amplexicaul base, ovate, both sides glabrous, 3.4 by 1.2–.4 cm, apex acute, margin free to the base, lower one cover the axis of the upper one, each bract enclosing a cincinnus of 1–4 flowers. *Bracteole* broadly ovate, membranous, 0.6–0.8 by 0.8–1.0 cm, apex acute. *Calyx* tubular, hidden in the bract, 0.8–1.1 cm long, glabrous, apex rounded. *Corolla* tube 2.8–3.1 cm long, ca 2 mm wide, lobe 3, yellow; dorsal corolla lobe ovate, hooded with apex produced into ca 0.5 mm thorn-like point, 0.4–0.6 by 1.3–1.5 cm, apex acute, lateral corolla lobe ovate-oblong, 0.3–0.4 by 1.2–1.4 cm. *Lateral stamenodes* patent, 0.8–1.0 by 1.4–1.7 cm, obovate, apex rounded to truncate. *Labellum* flat with succate base, 2.1–2.3 by 2.0–2.1 cm, broadest about the middle, distal part 3-lobed with median lobe extending 0.2–0.3 cm, apex truncate to emarginate; filament very short, ca 1 mm; anther ca 2–3 by 3–4 mm, anther crest yellow, broadly ovate, 5–7 by 3–4 mm, wider than long, apex broadly rounded. *Ovary* glabrous, 2–3 by 5–7 mm, triangular, trilocular; stylodes 2, 1–2 mm long. *Fruit* fleshy capsule, oblong, 0.3–0.4 by 2.0–2.3 cm long, glabrous, greenish. *Seed* many, light greenish, narrowly ellipsoid, ca 2 mm long, hairy, base with white aril, apical with long tail-like appendage. Flowering July–August; fruiting August–September.

**Distribution.**—This species has so far been found only at Tad Kramued Waterfall, the Bolaven Plateau of Champasak Province in southern Lao PDR.

**Ecology.**—On moist sandstone clefts and rocks facing the waterfalls and on the rock in the waterfall, under the shade of moisten evergreen forest.

**Etymology.**—The name “*bolavenensis*” refers to the type locality of this new species, the Bolaven Plateau. Literally, bolaven means the Laven’s place. The Laven, one of the sub-ethnic group of the Phuthai, is the major ethnic group lived on the plateau.

Table 1. Morphological character comparison of *C. bolavenensis* Picheans. & Koonterm, *C. limiana* Mookkamul & Picheans., and *C. pedemontana* Triboun & K. Larsen

Characters	<i>C. bolavenensis</i>	<i>C. limiana</i>	<i>C. pedemontana</i>
1. ligule	oblong, 0.6–1.4 cm, apex acute	deltoid, 0.4–0.7 cm, apex acute	deltoid, ca 0.5 cm, apex acute or subtruncate
2. number of bract per inflorescence	1–2	1–2(–3)	1–2
3. number of flower per bract	4–7	(1–)2–3(–4)	1
4. apex of calyx tube	round	round	bi-tridentate
5. dorsal corolla lobe	ovate	deltoid	lanceolate-oblong
6. lateral corolla lobe	ovate	deltoid	lanceolate-oblong
7. staminodes	obovate	elliptic-ovate	elliptic-oblong
8. labellum	3-lobe, median lobe apex round or slightly emarginate	3-lobe, median lobe apex bilobe	irregularly 3-lobe, apex emarginate
9. anther crest	broadly ovate, not reflexed	broadly ovate, slightly reflexed	reniform, reflexed
10. fruit	oblong	oblong-ellipsoid	ellipsoid

\* This information was not included in the original description of this species. The given descriptions were based on herbarium and spirit specimens collected from type locality.

**Notes.**—Morphologically this species is similar to *C. limiana* Picheans. & Mookkamul, but differs in the following characters: leaf margin entire to slightly undulate, ligule longer; bracts ovate, each bract subtends 1–4 flowers, bracteole broadly ovate, lateral stamenode obovate, apex rounded to truncate, labellum with distal part 3-lobed, median

lobe extending 2–3 mm, apex emarginate. This new species is also resemble *C. pedemontana* Triboun & K.Larsen (Larsen, Suksatan & Triboun 2004), but also differs in many characters. Comparison of morphological characters of these three species is provided in Table 1.

### Molecular Study

Molecular study of all currently-known *Caulokaempferia* species in Thailand and Laos, including some unknown taxa, was completed (CHAIYOOT, 2007). The result of which will be published in separate publications. However, for the purpose of understanding the relationship between *C. bolavenensis* Picheans. & Koonterm, *C. limiana* Mookkamul & Picheans, *C. pedemontana* Triboun & K.Larsen, and *C. bracteata* K.Larsen & S.S.Larsen (another species of yellow-flowered *Caulokaempferia* found in Laos), the results on these taxa will be discussed here. Corresponding sequencing data of *C. saxicola* K.Larsen retrieved from the GenBank (Accession No. AF478732) is used for the purpose of comparison.

Table 2. Comparison of the ITS1, 5.8S and ITS2 sequences of the *C. saxicola* K. Larsen, *C. bracteata* K. Larsen & SS. Larsen, *C. limiana* Mokkamul & Picheans., *C. pedemontana* Triboun & K. Larsen, and *C. bolavenensis* Picheans. & Koonterm

Taxon	Nucleotide positions starting from the 5/ end of the ITS1 region																														
	1	1	2	3	5	5	6	7	7	7	8	8	8	8	8	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
<i>C. saxicola</i>	-	-	T	T	C	T	T	C	G	T	T	A	C	G	C	G	T	T	A	G	A	C	G	A	G	C	-	T	C	A	T
<i>C. bracteata</i>	G	A	*	*	*	G	*	A	A	A	*	T	A	C	*	C	G	*	G	A	*	*	A	C	T	T	C	A	*	G	A
<i>C. limiana</i>	G	A	C	*	T	A	A	*	*	*	G	*	*	*	T	*	G	C	*	A	*	*	*	*	*	*	C	A	T	G	*
<i>C. pedemontana</i>	G	A	*	C	*	A	*	*	*	*	G	*	*	*	*	*	G	C	*	A	*	T	*	*	*	*	C	A	T	*	*
<i>C. bolavenensis</i>	G	A	*	*	*	A	*	*	*	*	G	*	*	*	*	*	G	C	*	A	G	T	*	*	*	*	C	A	T	*	*

Taxon	Nucleotide positions starting from the 5/ end of the ITS1 region (cont.)																														
	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
<i>C. saxicola</i>	C	C	G	C	C	C	G	T	T	T	C	C	A	C	A	C	T	G	C	A	T	T	C	T	C	T	T	G	G	G	-
<i>C. bracteata</i>	T	T	*	T	T	T	T	G	*	*	A	T	*	*	G	*	*	T	G	*	C	C	T	*	T	T	A	A	*	T	G
<i>C. limiana</i>	*	*	*	*	*	*	*	*	G	C	*	*	C	T	G	A	G	*	*	C	*	G	T	A	T	*	A	*	A	T	*
<i>C. pedemontana</i>	*	*	A	*	*	*	*	*	*	*	*	*	C	T	G	*	*	*	*	*	*	C	T	A	T	*	A	*	A	T	*
<i>C. bolavenensis</i>	*	*	A	*	*	*	*	*	*	*	*	C	T	G	*	*	*	*	*	*	C	T	A	T	*	A	*	A	T	*	*

Taxon	Nucleotide positions starting from the 5/ end of the ITS1 region (cont.)																												
	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
<i>C. saxicola</i>	-	C	T	T	C	C	A	T	C	G	C	G	T	A	A	C	T	T	G	A	T	C	C	G	T	C	A	G	T
<i>C. bracteata</i>	T	*	G	*	T	T	*	C	G	A	G	*	C	C	*	T	G	G	*	C	*	T	*	*	C	T	G	A	*
<i>C. limiana</i>	*	*	G	C	*	*	G	C	*	*	G	A	*	*	T	*	G	C	A	C	G	*	T	T	*	T	*	*	C
<i>C. pedemontana</i>	*	T	G	C	*	*	*	C	*	*	G	*	*	*	T	*	G	C	A	C	G	*	T	T	*	T	*	*	*
<i>C. bolavenensis</i>	*	T	G	C	*	*	*	C	*	*	G	*	*	*	T	*	G	C	A	C	G	*	T	*	*	T	*	*	*

Hyphen (-) denotes alignment gap. Asterisks (\*) indicates sequence identity with the *C. saxicola* K. Larsen, *C. bracteata* K. Larsen & SS. Larsen, *C. limiana* Mokkamul & Picheans., *C. pedemontana* Triboun & K. Larsen, and *C. bolavenensis*. Nucleotide positions indicate the aligned position starting from the 5/ end of the ITS1 region.

Young leaves of the first three species were collected from their type localities. However, those of *C. bracteata* K. Larsen & S.S. Larsen were collected from Phou Khao Khouay National Protected Area, Bolikhamxai Province, Lao PDR. Their total genomic DNA were extracted using DNeasy Kit®, cleaned with GeneClean II Kit®, and amplified ITS1-ITS2 region with 18S-26S-5’F and 18S-26S-3’R (18S-26S-5’F: 5’-GTAGGTGAACCTGCAAAGGATCA-3’, 18S-26S-3’R: 5’-CCATGCTTAAACTCA GCGGGT-3’). PCR products were purified with QIAquick PCR Purification Kit® and submitted for sequencing by Cybeles (Thailand), Co., Ltd.

Maximum parsimony analyses of the ITS1-ITS2 regions were done by PAUP\* 4.0 beta win with 1000 bootstrap replicates. Bootstrap support was categorized as strong (85–100%),

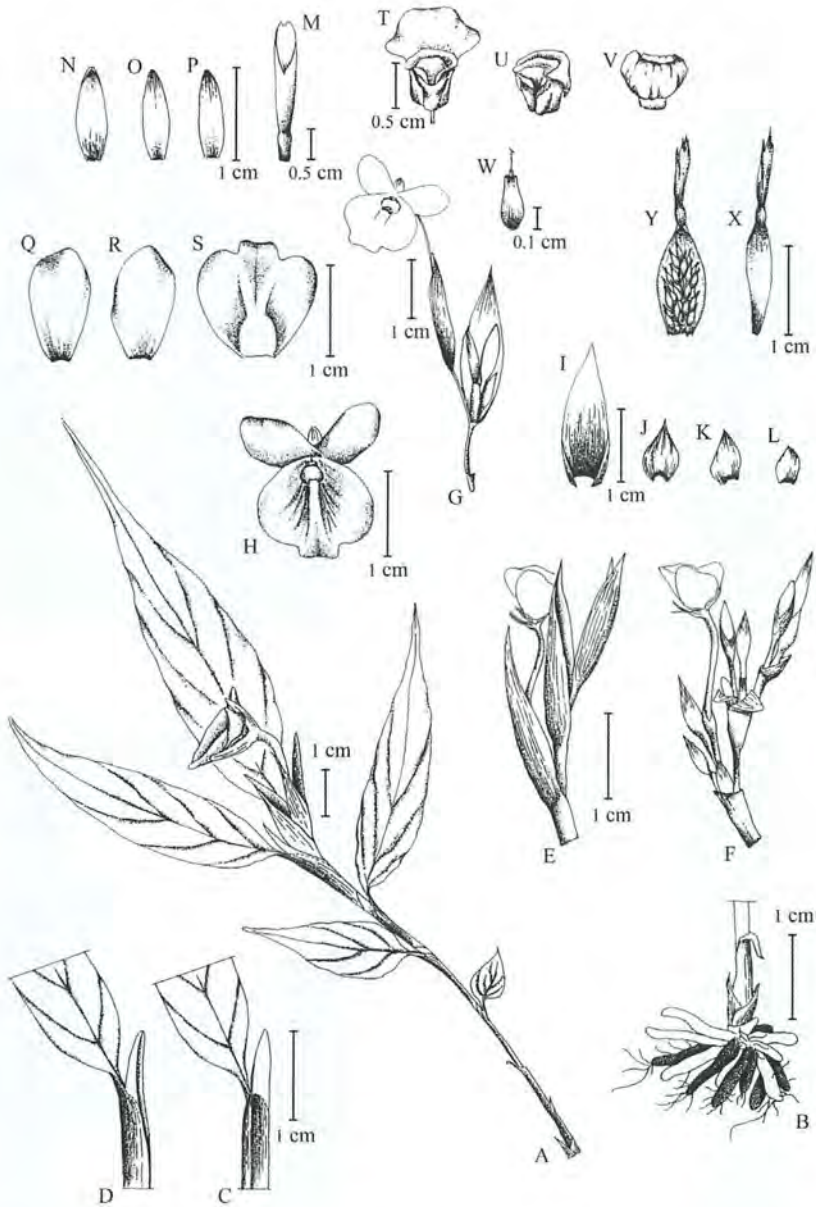


Figure 1. *Caulokaempferia bolavenensis* Pichans. & Koonterm

A. a plant showing habit, leaves, and inflorescence; B. root; C. & D. part of a leaf, showing a ligule; E. inflorescence; F. inflorescence with bracts removed; G. inflorescence showing inside of the lower bract; H. top view of a flower showing lateral staminodes and labellum; I. bract; J., K., & L. bracteoles; M. calyx tube; N. dorsal corolla lobe; O. & P. lateral corolla lobes; Q. & R. lateral staminodes; S. labellum; T., U., & V. different views of anther and anther crest; W. ovary, stylodial glands, and lower part of a style; X. fruit; and Y. longitudinal section of fruit (drawn by Chalermchoke Boonchit)



Figure 2. *Caulokaempferia bolavenensis* Picheans. & Koonterm in its habitat (photographed by Vitya Karndee)



Figure 3. *C. bolavenensis*, showing habit (photographed by Chayan Picheansoonthon)



Figure 4. *C. bolavenensis*, with detailed flowers (photographed by Chayan Picheansoonthon)

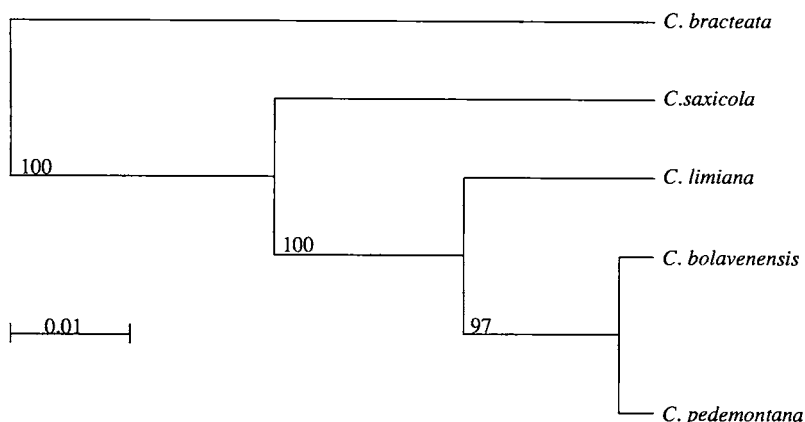


Figure 5. Dendrogram of *C. bolavenensis* Picheans. & Koonterm, *C. limiana* Mokkalul & Picheans., *C. pedemontana* Triboun & K. Larsen, *C. bracteata* K. Larsen & S.S. Larsen and *C. saxicola* K. Larsen based on maximum parsimony analyses of ITS1-ITS2 regions. The number above the line are bootstrap values. (total length 583, tree length = 41, consistency index = 1.0000, retention index = 1.0000, and rescaled consistency index = 1.0000)

moderate (70–84%), weak (50–69%), or poor (<50%). The resulting dendrogram and base different comparison is shown in Figure 5 and Table 2 respectively.

In conclusion, molecular study confirmed that *C. bolavenensis* Picheans. & Koonterm is a distinct species as proposed in this paper. This new species is phylogenetically closely related to *C. pedemontana* Triboun & K. Larsen and *C. limiana* Mokkalul & Picheans. Although there are only 3 bases different in ITS1, 5.8S and ITS2 sequences between *C. bolavenensis* Picheans. & Koonterm and *C. pedemontana* Triboun & K. Larsen (Table 1), morphologically they are distinct. Also, both species occur in different type of vegetation and altitude. From our intensive field studies throughout Thailand and Laos, members of the yellow-flowered *Caulokaempferia*, except *C. saxicola* K. Larsen, are endemic to certain small areas.

### Information on other *Caulokaempferia* Species in Laos

#### 1. New record

*Caulokaempferia alba* K. Larsen & R.M. Smith, Not. Roy. Bot. Gard. Edinb. 31(1972) 288, 289, f.1. — *C. thailandica* K. Larsen, Bot. Tidsskr. 68 (1973) 157, 159, f.2, **syn. nov.**; *C. violacea* K. Larsen & Triboun, Nord. J. Bot. 22 (2002) 413, f. 3, 4, **syn. nov.**

**Type.**—Larsen, Smitinand & Warncke 949 from top of Phu Miang, Pitsanulok province of Thailand (AAU holotype, BKF isotype)

**Lao specimens studied.**—Picheansoonthon 784 (18° 28.612' N, 103° 01.616' E, alt. 560 m, and Picheansoonthon 798 (18° 29.850' N, 103° 0.825' E, alt. 563 m; both from Phu Yom in Phou Khao Khouay National Park, Lao PDR.).

The description given below is based on these two Laotian specimens and the living specimens in their natural habitat (Figs. 6–10).

Perennial herbs with short rhizomes and spindle-shape storage roots. *Pseudostems* erect, to 75 cm; lower ones with 2–3 bladeless sheaths. *Leaves* 6–7, lower ones smaller; ligule membranous, 1–2 mm long, apex unequally bilobed; leaf blades elliptic to narrowly lanceolate, 16.2–20.4 by 3.0–4.3 cm, glabrous on both sides, apex acute-acuminate, sessile to sub-sessile, margin entire. *Inflorescence* with 12–19 flowers surrounded with 2 green bracts, with reduced lamina, lanceolate-ovate, 4.5–5.5 by 1.1–1.6 cm, each subtending one flower; first bract oblong, 5.9–7.1 by 2.0–2.2 cm, apex round, bracteole oblong, c. 2.5 cm, apex obtuse; inner bracts and bracteoles smaller; peduncle 1.1–2.8 cm long, rachis 1.9–2.3 cm long. *Calyx* tubular, 2.3–3.6 cm long, 6.2 cm long, white, lateral lobes white, oblong, 2.4–3.2 by 0.7–0.8 cm, apex slightly hooded, dorsal lobe white, oblong, apex hooded, 2.2–3.1 by 0.7–1.2 cm. *Lateral staminodes* obovate to elliptic-oblong, white, 3.3–3.9 by 1.6–2.0 cm. *Labellum* flat with clawed 0.8–1.7 by 0.6–0.8 cm, white with yellow spot at base, broadly obovate to suborbicular, crenulate, bilobe, 4.4–4.9 by 3.5–5.6 cm, clawed 0.8–1.7 cm long. *Anther locules* yellow, hairy on one side, subsessile, 0.9–1 cm by 2–8 mm, opening by one slits; anther crest reflexed, ligulate, membranous, whitish, c. 4 by 2 mm, apex varied from acute to multifid. *Style* extending 1–2 mm beyond anther crest; stigma c. 2.5 mm wide, cupular, finely ciliate. *Ovary* oblong c. 8 mm long, glabrous, 3-locular with axile placentation. *Stylodial glands* 2, subulate, c. 5 mm long. *Capsule* oblong to ovate, 3.1–4.4 by 0.4–0.5 cm, greenish white, glabrous, shining, crowned with the persistent calyx, dehiscing by 3 recurving valves. Seeds oblong-ellipsoid, 3–4 by 1–2 mm.

**Thai specimens examined.**—Larsen, Smitinand & Warncke 949 (isotype BKF) from top of Phu Miang, Pitsanulok province of Thailand; Smitinand 336 (BKF), from Phu Kradueng, Loei province of Thailand; Th. Wongprasert et al 406-34 (BKF) and P. Triboun 399 (BK, BKF) from Phu Rhua in Loei province; P.T. 1529 (l) (BK) and P.T. et al 840 (l) (BK) both from Phu Hin Rongkla in Pitsanulok province.

**Notes.**—This species was described from the specimen collected from Phu Miang in Uttaradit Province of northern Thailand (LARSEN & SMITH, 1972). During our intensive field works on the family Zingiberaceae in the past decade, we have recorded this species from other neighboring localities: Phu Hinrongkla and Thung Salangluang (in Pitsanulok Province), Phu Phachit (in Chaiyapoom Province), Phu Khon (in Loei Province), and recently in Central Laos.

The flower of this species was originally described as “white” with the labellum entire and the anther crest 4-dentate. However, investigation of the specimens collected from all these localities, including type locality, showed variations in many characters. The labella of these Thai specimens can be saccate (as described from type specimen) to flat with entire to emarginate apex, while the anther crests were ligulate with variable apexes ranged, from 4-dentate (as describe from type specimen), multifid, to truncate. The color of the flowers investigated from living specimens in various populations of all localities was pure white or white with purplish tips in the corolla lobes (which can be clearly seen right before the flowers open up).

Molecular study of young leaf samples of *C. violacea* K. Larsen & Triboun [collected from Khok Nok Kraba (Phu Luang) and from Phu Rueda (type locality) both of Loei province (Thailand)], and *C. thailandica* K. Larsen [also collected from Phu Kradueng (type locality)],



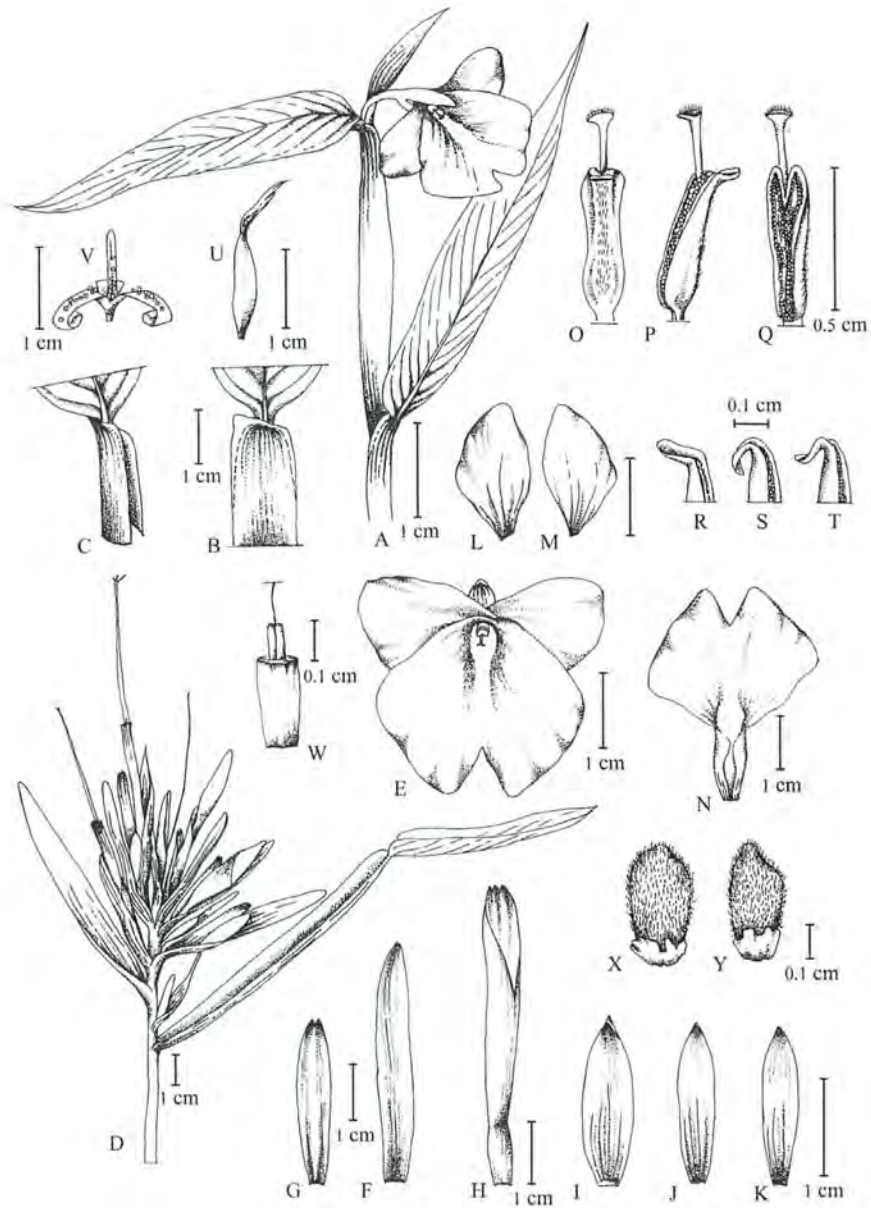


Figure 6. *Caulokaempferia alba* K. Larsen & R.M. Smith

A. upper part of a plant showing leaves and inflorescence; B. & C. part of a leaf, showing a ligule; D. inflorescence with uppermost leaf sheath and bracts opened up to show floral arrangement; E. top view of a flower, showing part of dorsal corolla lobe, lateral staminodes, and labellum; F. bract; G. bracteole; H. calyx tube; I. dorsal corolla lobe; J. & K. lateral corolla lobes; L. & M. lateral staminodes; N. labellum; O., P. & Q. different views of anther and anther crest; R., S. & T. different views of anther crest; U. fruit; V. dehiscent fruit with seeds; W. Ovary and styliodial glands; X. and Y. seeds (drawn by Chalermchoke Boonchit)



Figure 7. *C. alba*, plants habit showing leaves and white flowers (photographed by Chayan Picheansoonthon)



Figure 8. *C. alba*, white flowers showing emarginate labellum (photographed by Chayan Picheansoonthon)



Figure 9. *C. alba*, infructescence showing fruits with persistent calyx (photographed by Chayan Picheansoonthon)



Figure 10. *C. alba*, dehiscent fruits showing seeds (photographed by Chayan Picheansoonthon)



Figure 11. *C. bracteata*, leaves and inflorescence showing characteristic unilateral imbricate bracts with amplexicaul bases (photographed by Chayan Picheansoonthon)



Figure 12. *C. bracteata*, top view of an inflorescence, showing flowers and bracts (photographed by Chayan Picheansoonthon)



Figure 13. *C. bracteata*, showing details of the flowers (photographed by Chayan Picheansoonthon)



Figure 14. *C. burttii*, plants in their natural habitat, illustrated leaves detailed violet flowers (Dan Nong Luang, Paksong Town, Champasak Province, Lao PDR (photographed by Chayan Picheansoonthon)



Figure 15. *C. laotica*, plants in their natural habitat showing linear leaves and white flowers (Huai Hoa Dam, Phu Luang, Champasak Province, Lao PDR) (photographed by Chayan Picheansoonthon)

compared with those of *C. alba* K. Larsen & R.M. Smith [collected the above six localities], indicated that all the sample may be of the same taxon (CHAIYOOT, 2007). From our field observation, all these species are morphologically resembled. Within one population, the plants could be varied in many previously considered distinguished characters, such as shape of labella and anther crests. However, they are all alike, except for the color of the flowers which may be ranged from violet, pinkish, to pure white. Therefore, in this account we treat three of them as one taxon, ie. *C. alba* K. Larsen & R.M. Smith. As we experienced from *C. burttii* K. Larsen & Jenjitt. and *C. laotica* Pichens. & Mokkaumul, the color of flowers can be varied greatly from violet, pale violet, pinkish, to pure white, within the same population which will be discussed later in this paper.

## 2. Distribution and ecology of *C. bracteata* K. Larsen

*Caulokaempferia bracteata* K. Larsen & S.S. Larsen, *Nord. J. Bot.* 22 (2002) 411, f. 2.

**Type.**—*K. Larsen* 47337 from Chatuchak Market in Bangkok brought in from Nong Khai (AAU holotype, BKF isotype).

The information on distribution and ecology of this taxon was uncertain in the original paper published on this species (LARSEN, 2002). Based on our extensive field studies in Laos, the following information is added.

**Distribution.**—Endemic to Central Laos, in Phou Khao Khouay National Park, Lao PDR. This national park covers approximately 2,000 square kilometers in Kamphaeng Nakhon Viang Chan, Khet Piset Xaisomboun, Viang Chan District, and Bolikhamxai District.

**Ecology.**—On sandstone rock in the waterfalls and in dried evergreen forest, at the altitude of 437–608 m.

**Notes.**—This species was described from uncertain locality as noted in the publication that “...This collection was discovered by Supee S. Larsen at the Chatuchak flower market in Bangkok. Unfortunately the collection site was not precisely documented but vaguely mentioned as from the Laos border...” (LARSEN, 2002). The author included this taxon in the list of the genus *Caulokaempferia* in Thailand (LARSEN & LARSEN, 2006) and assumed that it was collected from the Laos border in Nong Khai Province of Thailand (LARSEN, 2002).

However from our intensive field works in Nong Khai-Nakhon Panom provinces of Thailand and across the Mekhong River in Central Laos, we confirm that *C. bracteata* K. Larsen & S.S. Larsen (Figure 11–13) is the Lao taxon. The *C. bracteata* K. Larsen & S. S. Larsen is common in Phou Khao Khouay National Park. The nearest site found is at Phou Yom (18° 27.148' N, 103° 04.140' E, alt. 437 m), only less than 25 km from the Mekong River.

Until recently, the wildlife in this national park is collected intensively for trans-border trade. The *C. bracteata* K. Larsen & S. S. Larsen was sometimes collected mistakenly as terrestrial orchids and brought across the river to sell with wild orchids and other wildlife. The first author had seen this plant sold at Amphoe Phon Pisai and Amphoe Pak Khat (Pengchan Village), both of Nong Khai Provinces of Thailand, every year. The first three authors did follow the Laotian villagers who sold the plant to the collecting sites in Phou Yom (Phou Khao Khouay National Park) in 2005, where the plant can be found in abundance.

So far, this species is not yet found in Thailand. One of the taxa found in Nong Khai Province of Thailand is *C. jirawongsei* Picheans. & Mokkamul (Picheansoonthon & Mokkamul, 2005). It is found in several locations of Phu Woa Wildlife Sanctuary of Nong Khai Province of Thailand. This location is approximately 100 kilometers from the nearest site of *C. bracteata* K. Larsen & Jenjitt. Molecular study indicated that they are two distinct taxa, the result of which will be discussed in the forthcoming publications.

### 3. Distribution and ecology of *C. burttii* K. Larsen & Jenjitt.

***Caulokaempferia burttii* K. Larsen & Jenjitt., *Edinb. J. Bot.* 60 (2004) 509, 511, f. 1.**

**Type.**—*Jenjittikul* 8263, from Chatuchak Market, Bangkok, Thailand (AAU holotype; BKF, E, PBM isotypes)

The information on distribution and ecology of this taxon was uncertain in the original paper published on this species (LARSEN, 2002). Based on our extensive field studies in Laos, the following information is added.

**Distribution.**— Endemic to Southern Laos, restricted to only two small areas of “Dan Sinxai (दानสินไชย)” and “Dan Nong Luang (दानหนองหลวง)” around Paksong District of Champasak Province, Lao PDR. The most abundant location found is at Dan Nong Luang (15° 03.480' N, 106° 38.803' E).

**Ecology.**— Seasonal wetland (blanket marsh) vegetation on sandstone mountain covered with lower montane rain forest of the Bolaven Plateau at the altitude of 895-902 m.

**Notes.**— This species was also described from an uncertain locality as the authors stated that “...material of an undescribed species collected in Laos was discovered at the flower market in Bangkok, where it had been brought by local traders from Champasak province in Laos” and “...So far known only from the type collection from the Bolaven Plateau in Champasak Province. It is also said by local market traders to have been found in Attapeu Province covering the eastern slopes of the Bolaven Plateau...” (LARSEN & JENJITIKUL, 2004). From our intensive field work in Laos. This species (Figure 14) is restricted to only two localities. The species covering the eastern slope of the Bolaven Plateau is the other different taxon, *C. laotica* Picheans. & Mokkamul.

### 4. Color variation in the flowers of *C. laotica*

***Caulokaempferia laotica* Picheans & Mokkamul, *Nat. Hist. Bull. Siam Soc.* 54 (2006) 75, 76, f. 1–5.**

**Type.**— *Picheansoonthon* 581, from Phu Luang of the Bolaven Plateau in Champasak Province, Lao PDR. (BKF holotype; SING isotype)

When the first author and his colleague reported this taxon, the flower color of this species was described to be “pale violet, rarely white” (PICHEANSOONTHON & MOKKAMUL, 2006). However, the first two authors of this paper have recently discovered several large populations of pure white-colored flowers, as shown in Figure 15, in the area around the type locality.

Molecular study on the genus *Caulokaempferia* in Thailand and Laos indicated that this species belong to the same clade as *C. alba* K. Larsen & R. M. Smith and *C. burttii* K. Larsen & Jenjitt. (CHAIYOOT, 2007). Among these three taxa of the non-yellow-flowered *Caulokaempferia*, this species is the closest to *Boesenbergia rotunda*.

## CONCLUSIONS

Two species, *C. burttii* K. Larsen & Jenjitt., *C. laotica* Pichens. & Mookamul, were previously reported from southern Laos. In this paper, we add a new species, *C. bolavenensis* Pichens. & Koonterm, and a new record, *C. alba* K. Larsen & R.M. Smith. The distribution and endemic status of *C. bracteata* K. Larsen & S. S. Larsen in central Laos is also reported. Distribution and ecology of the two taxa previously uncertain are also given in details. Therefore, a total of five *Caulokaempferia* species are currently enumerated for Laos, among these, two taxa are found in central Laos and three species are distributed in southern Laos.

## Key to Species in Laos

1. Inflorescence produced beyond the uppermost leaf sheath ..... 2
1. Inflorescence never produced beyond the uppermost leaf sheath ..... 3
2. Bracts 3–10, imbricate, bearing 1–2(–3) flower(s)..... *C. bracteata*
2. Bract(s) 1–2, tightly imbricate, 4–7 flowers ..... *C. bolavenensis*
3. Leaf blade linear, flowers white, pinkish, or pale violet..... *C. laotica*
3. Leaf blade lanceolate, flower white or violet..... 4
4. Labellum emarginate to shallowly bilobed, anther crest ligulate with a variable apex....  
..... *C. alba*
4. Labellum entire to slightly crenate, anther crest minute..... *C. burttii*

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## REFERENCES

- CHAIYOOT, A. 2007. Molecular studies of the genus *Caulokaempferia* (Zingiberaceae) in Thailand and Laos. Master's thesis, Khon Kaen University, Thailand.
- LARSEN, K. 1973. Studies in Zingiberaceae VI. *Bot. Tidskr.* 68: 157, 158 fl.
- LARSEN, K. 2002. Three new species of *Caulokaempferia* (Zingiberaceae) from Thailand with a discussion of the generic diversity. *Nord. J. Bot.* 22(4): 409–17.
- LARSEN, K., AND T. JENJITIKUL. 2004. A new species of *Caulokaempferia* (Zingiberaceae) from Laos. *Edinb. J. Bot.* 60(3): 509–12.
- LARSEN, K., AND S. S. LARSEN. 2006. *Gingers of Thailand*. Queen Sirikit Botanic Garden, Chiang Mai, Thailand. 161 pp.
- MOKKAMUL, P., AND C. PICHEANSOONTHON. 2004. A new *Caulokaempferia* (Zingiberaceae) from southern Thailand. *Folia Malaysiana* 5(3&4): 187–194.
- PICHEANSOONTHON, C., AND S. KOONTERM. 2008. Three new species of yellow-flowered *Caulokaempferias* (Zingiberaceae) from northeastern Thailand. *Taiwania* 53 (in press).
- PICHEANSOONTHON, C., C. K. LIM, S. SUKRONG, AND A. CHAIYOOT. 2007. A new *Caulokaempferia* (Zingiberaceae) from southern Thailand. *Folia malaysiana* 8(2): 53–61.
- PICHEANSOONTHON, C., AND P. MOKKAMUL. 2004a. A new species of *Caulokaempferia* from southern Thailand. *Folia Malaysiana* 5(1): 1–8.
- PICHEANSOONTHON, C., AND P. MOKKAMUL. 2004b. Two new *Caulokaempferia* (Zingiberaceae) from northeastern Thailand. *Folia Malaysiana* 5(2): 69–80.
- PICHEANSOONTHON, C., AND P. MOKKAMUL. 2006. A new species of *Caulokaempferia* (Zingiberaceae) from southern Laos. *Nat. Hist. Bull. Siam Soc.* 54(1): 75–80.