



Two new species of *Kaempferia* L. (Zingiberaceae) from Thailand

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ABSTRACT: Two new species of *Kaempferia* L. (Zingiberaceae) from Thailand consisting of *Kaempferia maculifolia* Boonma & Saensouk sp. nov. and *Kaempferia takensis* Boonma & Saensouk sp. nov. are described, illustrated, and photographed. The conservation status is provided for both new species. An identification key to the species of the *Kaempferia* genus in Thailand is also revised and presented.

KEY WORDS: Endemic, *Kaempferia maculifolia*, *K. takensis*, new species, taxonomy, Thailand, Zingiberaceae.

INTRODUCTION

Zingiberaceae is a family of flowering plants made up of about 50 genera with a total of about 1,600 known species in the world (Christenhusz and Byng, 2016). Thailand has one of the richest ginger floras in the world, with 26 genera and over 300 species. *Kaempferia* L. belongs to the tribe Zingibereae, subfamily Zingiberoideae, family Zingiberaceae (Kress *et al.*, 2002). This genus is comprised of about 60 species distributed in India and throughout South East Asia (Larsen and Larsen, 2006). Larsen in 1980 divided the Thai species of *Kaempferia* into three groups based on pseudostem and inflorescence position, namely 'K. galanga-group', 'K. filifolia-group' and 'K. rotunda-group'. Currently, the genus *Kaempferia* is divided into two sub-genera based on the position of the inflorescence, namely subgenus *Kaempferia* (terminal inflorescences) and subgenus *Protanthium* (inflorescences directly from the rhizome) (Insisiengmay *et al.*, 2018). In Thailand, 15 species of *Kaempferia* were recognized by Sirirugsa in 1992. Later, Larsen and Larsen (2006) reported 17 species of Zingiberaceae in the Gingers of Thailand book. Techaprasan *et al.* (2010) recognized more than 20 species of *Kaempferia* in Thailand. Thereafter, many new species of genus *Kaempferia* have been found, and many taxonomic studies of this genus have been published.

During an exploration of the species diversity of family Zingiberaceae in Thailand, two undescribed species of *Kaempferia* were found. The first undescribed species was found from Lop Buri Province, Central Thailand. After comparing and examining species with similar characteristics, we found that this was an undescribed species of *Kaempferia* that did not match any known or published species, so we treated it as a new

species under the name *Kaempferia maculifolia* sp. nov. The second undescribed species is also in the genus *Kaempferia*. This undescribed species of *Kaempferia* was discovered by Watcharaporn Thongbai more than 10 years ago, at an elevation of 300 – 850 meters above sea level in a deciduous forest rich in bamboo in Tak Province. This species had an inflorescence arising directly from its rhizome enclosed by bracts appearing before the new leaves. After that, the authors identified this plant and found that it was an undescribed species of *Kaempferia* that did not match any known species; this species is described, illustrated and photographed under the name of *Kaempferia takensis* sp. nov. Therefore, both new species are described, illustrated and photographed via the specific epithet.

TAXONOMIC TREATMENT

Kaempferia maculifolia Boonma & Saensouk, *sp. nov.*

Fig. 1–2 & 5

Type: THAILAND. Lop Buri Province, Sa Bot District, 15°18'28.1"N 100°52'14.5"E, 98 meters above sea level. 29 August 2018, *Boonma T. No. 10* (Holotype: KKKU!; isotypes: QBG!, BKF!, BK!, TAI!)

Perennial herb with erect and elongate pseudostem. *Rhizome* erect, narrowly ovoid, light pale-yellow inside, fragrant. *Root* several fibrous without storage root. *Leafy shoots* erect, elongate, 20–35 cm tall. *Leafless sheaths* 2–3, dark red or green with red at the base, underground part white, apex mucronate, margin entire with pubescent, 3–10 cm long. *Leaf-sheaths* alternate, green with red at the base or dark red, pubescent; *ligule* bilobed, incision up to ca. 7.5 mm, triangular, ca. 12 mm, green or red, apex acuminate, pubescent. *Petiole* short, green or green mixed with red, 0.5–1 cm long, pubescent. *Leaf-blades* 3–4, thick, oblanceolate to elliptic, apex acuminate,

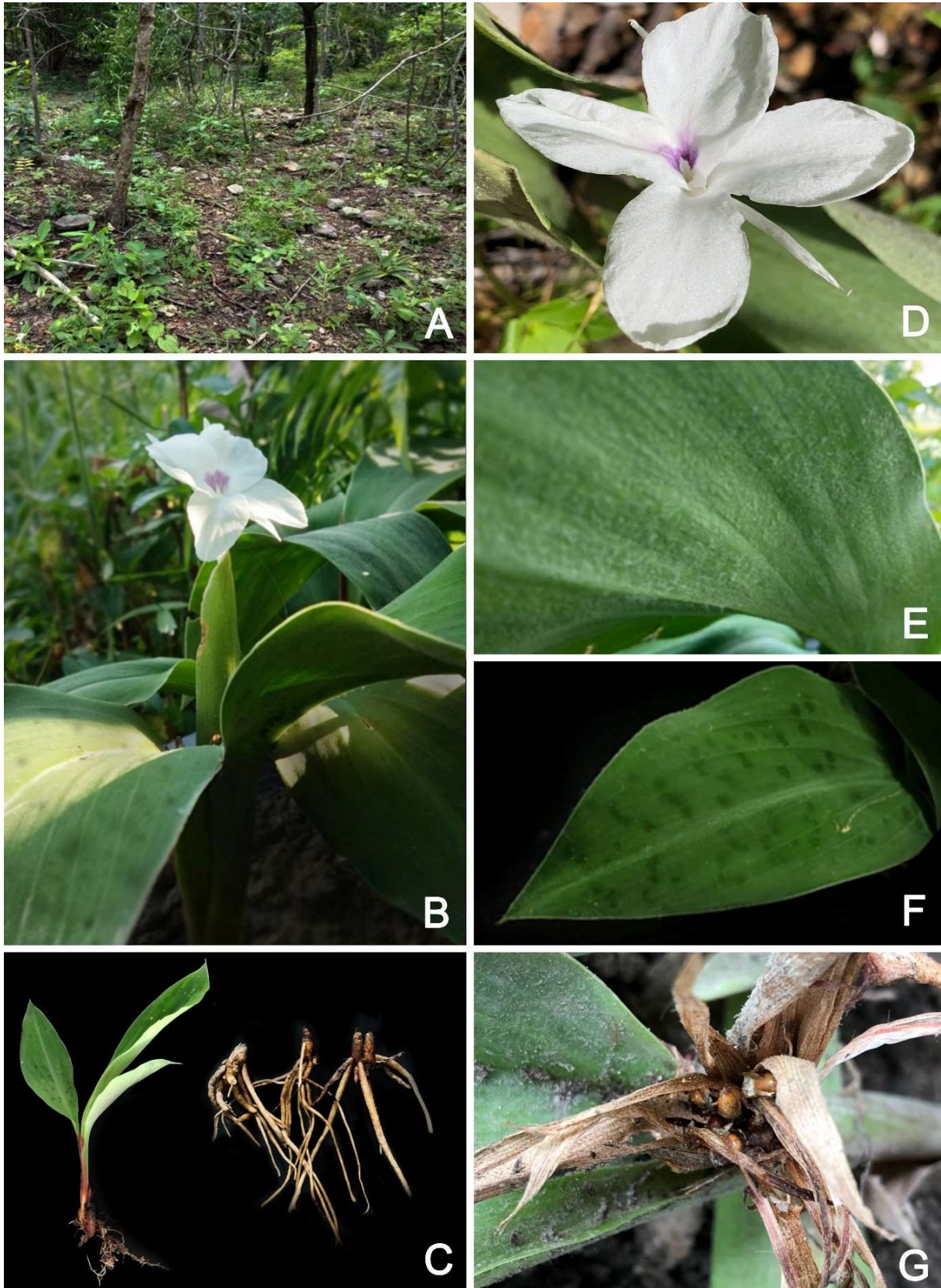


Fig. 1. *Kaempferia maculifolia* Boonma & Saensouk; **A.** habitat; **B.** inflorescence with flower; **C.** habit and rhizomes with roots; **D.** flower; **E.** lower surface of leaf; **F.** upper surface of leaf; **G.** dry bracts with old seeds. Photographed by Thawatphong Boonma.

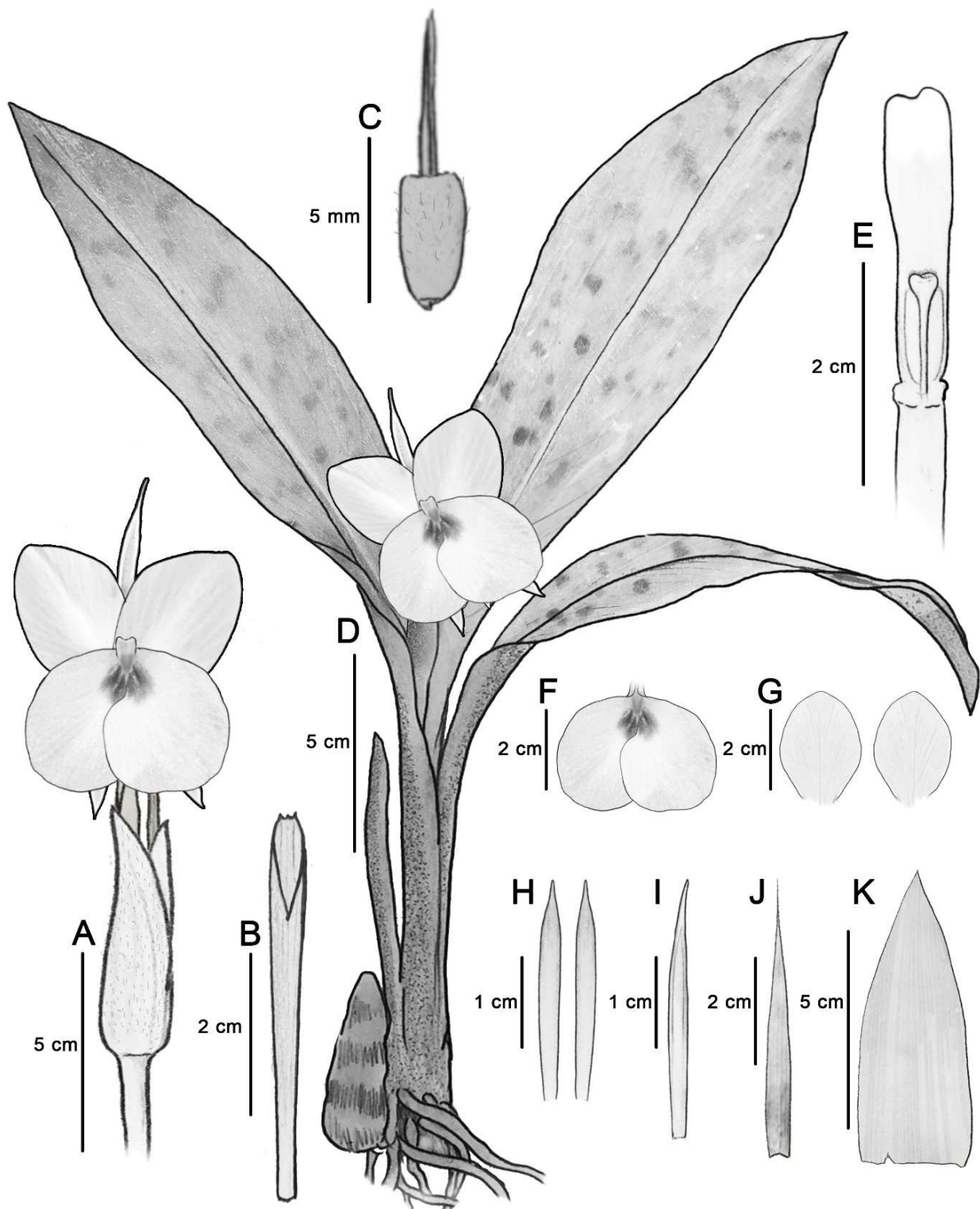


Fig. 2. *Kaempferia maculifolia* Boonma & Saensouk; **A.** inflorescence; **B.** calyx; **C.** ovary sparsely hairy with epigynous glands; **D.** habit; **E.** stamen with anther; **F.** labellum; **G.** lateral staminodes; **H.** lateral corolla lobes; **I.** dorsal corolla lobe; **J.** bracteole; **K.** bract. Drawn by Thawatphong Boonma.



base attenuate, margin entire (part of margin of some leaves minutely undulate) with translucent white band ca. 0.3 mm wide, adaxially surface green with dark green spots (spots 1–7 mm in diameter), abaxially surface pale green, both surfaces pubescent, 5.2–11.3 cm wide and 14.5–30.1 cm long. *Inflorescence* terminal, 0.8–1.9 cm in diameter and 5.5–8.5 cm long, enclosed by the leaf-sheaths; *peduncle* pale green, minutely pubescent, 5.5–6.9 mm in diameter and 5–8 cm long. *Bracts* 15–35 per inflorescence, lanceolate, green or green with red at base, apex acuminate to mucronate, 0.8–3.5 cm wide and 4.5–7.6 cm long, pubescent, margin entire. *Bracteole* lanceolate, apex acuminate, margin entire, 4–5 mm wide and 2.8–5.2 cm long, translucent white, glabrous. *Calyx* translucent white, 3.7–4.8 cm long, apex 3-lobed with deep incision up to 1.25 mm, glabrous. *Flowers* 15–35 per inflorescence, lateral staminodes and labellum laid on same plane. *Floral tube* white, 8–10 cm long, glabrous; dorsal corolla lobe one, white, narrowly lanceolate, hooded, apex caudate, glabrous, 2.5–3 mm wide and 2.4–2.7 cm long; *lateral corolla lobes* 2, white, lanceolate, hooded, apex acuminate, glabrous, 2.5–3 mm wide and 2–2.4 cm long. *Lateral staminodes* white, obovate to elliptic, white, apex rounded to obtuse, margin entire, glabrous, ca. 2 cm wide and ca. 2.8 cm long. *Labellum* broadly spatulate, bilobed, deeply divided about 2/3 of the length of the labellum, each lobe broadly obovate, partly overlapping, ca. 2.3 mm wide and 2.8 mm long, white with two pale purple or purple patches at base, edges of labellum at base roll tube-like ca. 8 mm long, white with light pale yellow patch, apex rounded to obtuse, margin entire, glabrous. *Stamen* ca. 8.6 mm long with very short filament; *anther* white 1.4–1.5 mm wide and ca. 2.7 mm long; *anther crest* narrowly oblong to spatulate, white with light pale yellow at base, ca. 1.7 mm wide at base and ca. 16.4 mm long, apex emarginate, glabrous. *Stigma* inverted cone, 0.8–1 mm in wide, apex slightly lobed with ciliate. *Style* very slender, 8–9 cm long. *Epigynous glands* filiform 2, very slender ca. 5 mm long. *Ovary* cylindrical, light pale green, sparsely hairy, 2.5–3 mm in diameter and ca. 4 mm long, 3 carpels. *Ovule* axile placentation. *Seeds* brown with white lacinate arils, glabrous, ca. 2 × 3–4 mm. *Flowering period* in rainy season (July–September).

Conservation status: Only a few populations of *K. maculifolia* have been found, but it is expected to be found in adjacent areas as suitable habitats still seems to exist. Awaiting further field studies and observations, we suggest treating this rare and endemic species as data deficient (DD).

Distribution: *Kaempferia maculifolia* is endemic to Thailand, currently found in the type locality in Sa Bot District and Khok Charoen District, Lop Buri Province.

Ecology: In deciduous forest, 80–150 meters above sea level.

Etymology: The specific epithet “*maculifolia*” is

derived from two Latin words; “*maculi*” meaning “spots” and “*folia*” meaning “leaves” referring to its leaves with spots on the upper leaf surface.

Notes: It was found that some parts of the edges of some leaves are minutely undulated.

The morphology of *Kaempferia maculifolia* sp. nov. is similar to *K. mahasarakhamensis* Saensouk & Saensouk P. and *K. marginata* Carey ex Roscoe. in its flowers and some characters, but in others it differs. *Kaempferia maculifolia* has erect rhizome, narrowly ovoid, light pale yellow inside and fragrant while *K. marginata*'s rhizome is greenish-yellow inside; leafless sheaths, leaf sheaths, petioles and bracts of *K. maculifolia* are pubescent but in *K. mahasarakhamensis* and *K. marginata* they are glabrous. Leaves of *K. maculifolia* are pubescent on both surfaces but the leaves of *K. mahasarakhamensis* are glabrous on both surfaces and the leaves of *K. marginata* on the upper surface are glabrous, while on the lower surface they are pubescent. Remarkably, the adaxially surface of *K. maculifolia* is green with dark green spots, and this unique characteristic can be used to differentiate *K. maculifolia* from all other existing species of *Kaempferia*. The calyx of *K. mahasarakhamensis* and *K. marginata* has a bilobed apex, but the calyx of *K. maculifolia* is 3-lobed. The anther crest of *K. maculifolia* is narrowly oblong to spatulate, white with light pale yellow at the base, apex emarginate, glabrous but the anther crests of *K. mahasarakhamensis* and *K. marginata* are deeply divided. Ovary of *K. maculifolia* is cylindrical, light pale green with sparse hairs, while *K. mahasarakhamensis*'s and *K. marginata*'s ovaries are glabrous (Table 1 and Figs. 1–2).

***Kaempferia takensis* Boonma & Saensouk, sp. nov.**

Figs. 3–5

Type: THAILAND. Tak Province, 18 March 2019, Boonma. T. no. 12 (Holotype: KKKU!; isotypes: QBG!, BKF!, BK!, TAI!).

Perennial herb, erect and elongate pseudostems. *Rhizome* yellow inside and fragrant smell, short ovoid to long ovoid, 1–2 × 2–4 cm. *Root* several fibrous-fascicle roots with tuberous root at tip. *Leafy Shoot* 50–80(90) cm tall. *Bladeless sheaths* 1–3, brownish red, 5–8 cm long, pubescent; *Leaf-sheaths* alternate, green with brownish-red, pubescent; *ligule* membranous, 2 lobes, broadly triangular, each lobe 3–5 mm long, pubescent; *petiole* green, 4–5 cm long, 10–12 mm thick, pubescent. *Leaf-blade* 5–7 blades, elliptic, thick blade, apex acuminate, base decurrent to attenuate, margin entire and widely undulate, upper surface green with white or light pale green patches between leaf venation, scabrous, lower surface brownish red surface, pubescent, 18–22 × 30–50 cm. *Inflorescence* directly from leafless rhizome appears before new leaves; *peduncle* white and short, 0.5–3(–3.5) cm long, scabrous. *Bracts* ovate, light pale yellow with brownish-red at tip, apex acute, alternate,

**Table 1.** Comparison between *Kaempferia mahasarakhamensis*, *K. marginata* and *K. maculifolia*.

Character	<i>K. mahasarakhamensis</i>	<i>K. marginata</i>	<i>K. maculifolia</i>
Rhizome and root	Rhizome short, not erect, bearing several roots and storage root	Rhizome not erect, greenish-yellow inside, short with few roots in fascicle and tuberous root	Erect, narrowly ovoid, light pale-yellow inside, fragrant, root several fibrous-fascicle without storage root.
Leafy shoot	Erect and elongate pseudostem, 25–30 cm high	Horizontal, 3–5 cm tall	Erect and elongate, 20–35 cm tall
Leafless sheaths	Glabrous	Glabrous	Pubescent
Leaf sheaths	Glabrous	Glabrous	Pubescent
Peteole	Up to 5 cm long, glabrous	-	Short, green or green mixed with red, 0.5–1 cm long, pubescent
Leaf-shape and size	2, broadly elliptic, 20–25 x 7–10 cm, always thickened	Usually 2, sessile, elliptic or orbicular, 8–14 x 5–11.5 cm, unequal sided,	3–4, thick, oblanceolate to elliptic, 5.2–11.3 cm wide and 14.5–30.1 cm long.
Leaf-upper surface	Moderately green, glabrous	Glabrous	Green with dark green spots, pubescent
Leaf-lower surface	Pale green, glabrous	Hairy	Pubescent
Leaf-apex	Acute, purple–blotched at the apex	Acute	Acuminate
Leaf-base	Attenuate	Cuneate	Attenuate
Leaf-margin	Purple coloration at the margin	Margin purple	Entire (parts of margin of leaves minutely undulate) with translucent white
Bracts	Lanceolate, greenish above, glabrous on both sides	Lanceolate, greenish-white, glabrous	Lanceolate, green or green with red at base, pubescent
Flower	10–15, exerted from bracts.	6–8	15–35 per inflorescence
Calyx	Tubular, 3–4.5 cm long, glabrous, translucent white, unilaterally slit at the apex, slit ca. 1 cm long	Ca. 2.5 cm long, apex bifid	Translucent white, ca. 3.7–4.8 cm long, apex 3-lobed with deep incision up to 1.25 mm, glabrous
Labellum	Broader than long, 3–3.2 x 4–5 cm, deeply bilobed with 2/3rds longitudinal cleft from tip towards base, lobes overlapping, white with 2 darker purple patches towards base further inside with longitudinal white band	Purple with lateral white bands between midrib and margin, obovate–cuneate, ca. 2.2 x 1.8 cm, deeply divided	Broadly spatulate, bilobed, deeply divided about 2/3 of length of labellum, each lobe broadly obovate, partly overlapping, ca. 2.3 mm wide and 2.8 mm long, white with two pale purple or purple patches at base, edges of labellum at base roll in a tube like structure ca. 8 mm long, white with light pale yellow patch, apex rounded to obtuse, margin entire, glabrous.
Anther crest	Ca. 8 x 8 mm, deeply bilobed, reflexed, white	Quadrate, ca. 5 x 4 mm, deeply divided	Narrowly oblong to spatulate, white with light pale yellow at base, ca. 1.7 mm wide at base and ca. 16.4 mm long, apex emarginate, glabrous
Ovary	Cylindrical, 5–7 x 3–4 mm, creamy white, 3-locule, axile placentation, ovules man, glabrous	Ca. 4 x 2 mm, glabrous, stylodes filiform ca. 4 mm long	Cylindrical, light pale green, sparsely hairy, ca. 2.5–3 mm in diameter and 4 mm long
Reference	Saensouk and Saensouk, 2019	Sirirugsa, 1992; Rajkumar, 2012	

pubescent, 45–98 mm long, 20–54 mm wide. *Bracteoles* lanceolate, light pale yellow to white, bilobed, each lobe apex acute, sparsely pubescent, 1.5–3 cm long. *Calyx* white, tubular, sparsely hairy, 7.5–8.5 cm long, unilaterally slit 14–17 mm long, apex trident. *Flowers* 27–35 per inflorescence, lateral staminodes and labellum laid on same plane. *Corolla tube* white, long and slender, 11.5–12.0 cm long, diameter ca. 2 mm, sparsely hairy; *dorsal corolla lobe* 1, white, narrowly lanceolate, hooded, apex caudate, 39–45 mm long, glabrous; *lateral corolla lobes* 2, white, narrowly lanceolate, apex acuminate, 35–42 mm long, glabrous. *Lateral staminodes* 2, light pink, broadly ovate, apex acute, 35–42 mm long, 28–35 mm wide, glabrous. *Labellum* light pale pink with deep pink

towards and almost reaching base with white at base, respectively, deeply bilobed incision ca. 26 mm, each lobe obovate, apex rounded and slightly acute at tip, 30–35 mm long, 22–26 mm wide, glabrous. *Stamen* with very short filament, ca. 14 mm long; *anther* white ca. 5.5 mm long; *anther crest* oblong with apex 3–4 lobed, outer lobes acute and elongate, slightly curved, middle 1–2 lobes shorter, light pale pink with pink patches and white at base, 10–16 mm long, glabrous. *Stigma* inverted cone, white, apex ciliate, ca. 1.0 × 1.5 mm. *Style* filiform, very slender, white, 10–11 cm long. *Epigynous glands* filiform 2, very slender ca. 3 mm long. *Ovary* cylindrical to obovoid, 3.5–5 mm long, 1.2–2 mm wide, hairy. *Ovule* axile placentation. *Fruit* and *seeds* not seen.

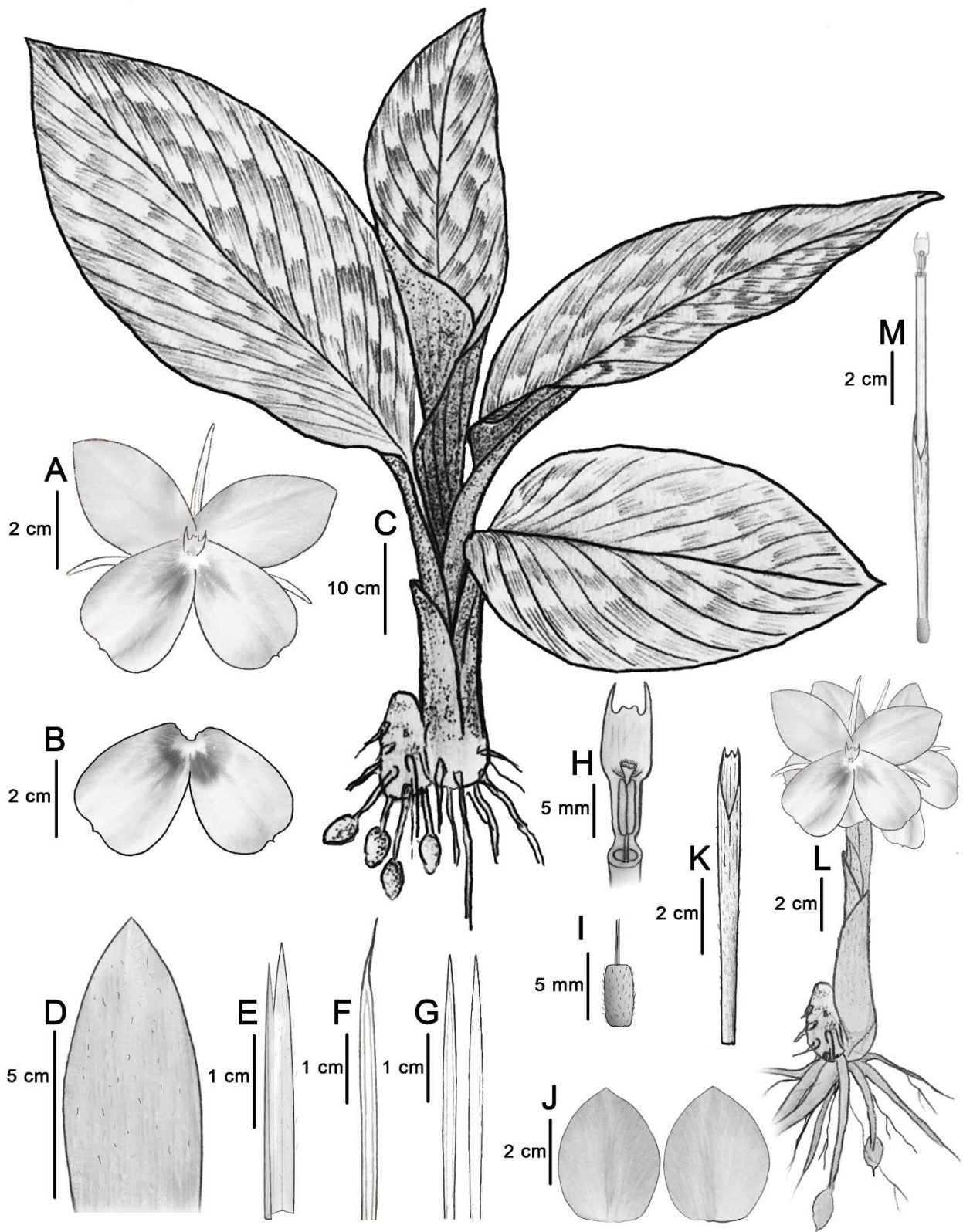


Fig. 3. *Kaempferia takensis* Boonma & Saensouk; **A.** flower; **B.** labellum; **C.** habitat; **D.** bract; **E.** bracteole; **F.** dorsal corolla lobe; **G.** lateral corolla lobes; **H.** stamen with anther, anther crest and stigma; **I.** ovary with epigynous glands; **J.** lateral staminodes; **K.** calyx; **L.** inflorescence; **M.** corolla tube with calyx, ovary and stamen. Drawn by Thawatphong Boonma.



Fig. 4. *Kaempferia takensis* Boonma & Saensouk; **A.** habitat; **B.** pseudostems; **C.** habitat – before new leaves; **D.** flowers. Photographed by Watcharaporn Thongbai and Thawatphong Boonma.

Conservation status: Only a few populations of *K. takensis* have been found, but it is expected more will be found in adjacent areas as suitable habitat still seems to exist. Awaiting further field studies and observations, we suggest treating this rare and endemic species as data deficient (DD).

Distribution: *Kaempferia takensis* is endemic to Thailand, Tak Province and Uthai Thani Province.

Ecology: In mixed deciduous forests rich in Bamboo 300–850 meters above sea level.

Etymology: “*takensis*” is derived from the name of “Tak Province”, where it was discovered.

Notes: The inflorescence appeared before the pseudostem from the same rhizome. The inflorescence

and flowers were collected on 18 March 2019, while the pseudostems were collected on 15 November 2019.

In its habitat, it is found that the length of the peduncle of this plant will vary in size, but not too much, depending on the depth of the underground rhizomes and the thickness of the dry bamboo leaves that fall in the deciduous season to be able to lift the inflorescence and flowers higher than the dry leaves. We found the longest length of the peduncle to be ca. 3.5 cm, and the shortest length of ca. 0.5 cm, but most are very short. This plant has an inflorescence before the pseudostem. There were two collection dates, and both specimens were from the same rhizomes, and the other isotypes were also collected from the same locality.



The morphology of *Kaempferia takensis* sp. nov. is similar to *Kaempferia xiengkhouangensis* Pichens. & Phokham in its flower color. When comparing to *K. rotunda* L. and *K. xiengkhouangensis*, which are both species in the same subgen. *Protanthium*, they are similar in that their inflorescences come directly from the rhizome that appears before the pseudostem, and in *Kaempferia takensis* it can grow up to 90 cm tall, but it is distinctly different to *K. rotunda* in the color of its flowers. Comparing to the most similar species, *K. xiengkhouangensis*, the upper surface of *K. takensis* is scabrous and the lower surface pubescent; corolla tubes are sparsely hairy while in *K. xiengkhouangensis* they are glabrous. The leaves of *K. xiengkhouangensis* are only green on the upper surface and pale green on the lower surface, but in *K. takensis* they are green with white or light pale green patches between the leaf venation, and the lower surface of *K. takensis* is brownish-red. The petiole of *K. xiengkhouangensis* is sessile while in *K. takensis* it is 4–5 cm long and pubescent. Moreover, the floral tube of *K. takensis* is longer and slender than in *K. xiengkhouangensis* and sparsely hairy, but in *K. xiengkhouangensis* it is glabrous; the lateral staminodes of *K. takensis* has an apex acute while in *K. xiengkhouangensis* the apex is rounded to apiculate. The labellum of *K. xiengkhouangensis* is deep pink with violet at the base, but in *K. takensis* it is light pale pink with dark pink almost reaching the base and with white at the base (Table 2 and Figs. 3–4).

Key to species of genus *Kaempferia* in Thailand (Including *K. xiengkhouangensis* from Laos PDR)

- 1a. Inflorescence terminal on pseudostem 2
- 1b. Inflorescence directly from rhizome appears before new leaf 23
- 2a. Leaves erect 3
- 2b. Leaves horizontal, near the ground 13
- 3a. Leaf-blade filiform, linear or less than 4 cm broad 4
- 3b. Leaf-blade broader, lanceolate to orbicular or more than 4 cm broad 8
- 4a. Leaves villous on lower surface *K. spoliata*
- 4b. Leaves glabrous on both surfaces 5
- 5a. Staminodes absent *K. sisaketensis*
- 5b. Staminodes present 6
- 6a. Ligule present; leaf-blade elliptic-linear to linear, 0.5–1 cm broad *K. larsenii*
- 6b. Ligule absent; leaf-blade filiform, less than 0.5 cm broad 7
- 7a. Leaves up to 14 cm; anther-crest not divided or crenate *K. fallax*
- 7b. Leaves 15–20 cm long; anther-crest divided *K. filifolia*
- 8a. Petiole up to 1 cm long 9
- 8b. Petiole 1–10 cm long 10
- 9a. Ovary glabrous; leaf-blade glabrous on both surfaces with wavy margin *K. angustifolia*
- 9b. Ovary sparsely hairy; leaf-blade adaxially surface green with dark green spots, abaxially surface pale green, both surfaces pubescent *K. maculifolia*
- 10a. Ovary glabrous; leaves glabrous on both surfaces with purple coloration at margin *K. mahasarakhamensis*
- 10b. Ovary hairy 11
- 11a. Leaves tomentose on both surfaces; labellum divided into one-third, pubescent *K. koontermii*
- 11b. Leaves glabrous on upper surface and lower surface pubescent; labellum glabrous 12
- 12a. Labellum shallowly divided or emarginate; staminodes oblong, 1–1.3 × 0.3 cm *K. parviflora*
- 12b. Labellum divided to base; staminodes broadly obovate or sub-orbicular, 1.5–2 × 1–1.7 cm *K. elegans*
- 13a. Calyx and ovary hairy 14
- 13b. Calyx and ovary glabrous 16
- 14a. Leaves hairy on both surfaces; anther crest reniform, recurved, ca 1.5 × 4–5 mm *K. glauca*
- 14b. Leaves glabrous on upper surface and lower surface pubescent ... 15
- 15a. Staminodes lilac; labellum lilac with white spot at base . *K. pulchra*
- 15b. Staminodes white; labellum white, sometimes with darker reddish patch at inner base of each lobe with longitudinal white line at base of lobes *K. phuphanensis*
- 16a. Leaves glabrous on both surfaces 17
- 16b. Leaves glabrous on upper surface and lower surface pubescent 19
- 17a. Labellum white with yellow spot at base; two leaves *K. roscoeana*
- 17b. Labellum pink, lilac or purple; one leaf 18
- 18a. Calyx apex acute, 1.6–2.2 cm long; staminodes obovate, purple, apex rounded; labellum purple with deep purple at base, divided to middle, each lobe broadly obovate, apex rounded 16. *K. picheansoonthonii*
- 18b. Calyx apex bifid *K. siamensis*
- 19a. Labellum divided to middle, violet, darker at base broadly obovate, each lobe obovate apex rounded; staminodes obovate, light brown, apex rounded *K. saraburiensis*
- 19b. Labellum divided to base 20
- 20a. Bract hairy 21
- 20b. Bract glabrous 22
- 21a. Labellum white with purple blotch at centre *K. laotica*
- 21b. Labellum white with yellow spot at base *K. koratensis*
- 22a. Leaf-margin purple; rhizome greenish-yellow inside . *K. marginata*
- 22b. Leaf-margin usually white or green; rhizome white inside ... *K. galanga*
- 23a. Leaves horizontal, near ground 24
- 23b. Leaves erect, pseudostem well developed 26
- 24a. Leaf upper surface sparse hairs, suborbicular to orbicular, 22.5–32 × 21.5–25 cm, pale green with light purple band along margin, lower surface pale green, pubescent; staminodes white to pale purple, obovate; labellum light purple, deep purple toward base, obovate to suborbicular, deeply bilobed *K. lopburiensis*
- 24b. Leaf upper surface glabrous, lower surface pubescent, elliptic to orbicular 25
- 25a. Staminodes light purple, broadly obovate; labellum light purple, deep purple at base, broadly obovate; anther crest white to violet, rectangular; ovary pubescent; leaf 3, blades elliptic to orbicular, 10–30.6 × 7.1 × 22.1 cm, surface green with several silvery markings, hairy at base of midrib, lower surface reddish-brown, pubescent *K. udonensis*
- 25b. Staminodes white, oblong, apex acute or acuminate; labellum white with pale yellow spot at base, obovate, apex bilobed, apex of lobes acute or acuminate *K. grandifolia*
- 26a. Leaves linear grass-like to narrowly lanceolate, less than 5 cm wide *K. graminifolia*
- 26b. Leaves more than 5 cm wide 27
- 27a. Habit clump-forming, several shoots from each rhizome; labellum white with pale yellow patch from sinus towards base, broadly obovate, bilobed, divided for half to two-thirds of labellum length; staminodes white, obovate to elliptic, cuspidate, acute to rounded at apex *K. caespitosa*
- 27b. Habit single shoot from each rhizome 28
- 28a. Petiole more than 5 cm long 29
- 28b. Petiole sessile to subsessile, up to 5 cm long 30
- 29a. Labellum white to purple with deep purple at center and prominent yellow patch from base to sinus, apex rounded to slightly bilobed; anther crest narrowly ovate, apex obtuse to shallowly 3-lobed, middle lobe more elongate than outer lobes *K. simaensis*
- 29b. Labellum white to purple with deep purple at center, apex rounded to acute; anther crest oblong to ovate, bilobed, apex acute *K. rotunda*
- 30a. Nocturnal anthesis, start opening flower around 6 p.m. 31
- 30b. Diurnal anthesis 32

**Table 2.** Comparison between *Kaempferia rotunda*, *K. xiengkhouangensis* and *K. takensis* sp. nov.

Character	<i>K. rotunda</i>	<i>K. xiengkhouangensis</i>	<i>K. takensis</i> sp. nov.
Rhizome	Rhizome with roots bearing tubers	Short, erect, bearing several roots in fascicle	Yellow inside and fragrant smell, short ovoid to long ovoid, 1–2 × 2–4 cm, root several fibrous-fascicle roots with tuberous root at tip and fibrous roots
Leafy shoot	12–30 cm tall	29.5–58.3(-80) cm tall	50–80(90) cm tall
Bladeless sheath	4–6 cm long, hairy.	undescribed	1–3, brownish red, 5–8 cm long, pubescent
Leaf-sheaths	6–10 cm long, hairy	8.9–12 cm long, sparsely hairy	Green with brownish-red, pubescent
Ligule	Membranous, broadly triangular, 3–4 mm long, hairy	Membranous, 2 lobes, 4–8 mm long, hairy	membranous, 2 lobes, broadly triangular, each lobe 3–5 mm long, pubescent
Leaves-shape and size	2–4, erect, elliptic to lanceolate–oblong, 12–25 × 4–6 cm	5–6(–8), sessile, blade distichous, broadly elliptic to lanceolate, (10–) 22.5–42.5(–55) × 7.6–12.2(–17) cm,	5–7 blades, elliptic, thick blade, 18–22 × 30–50 cm
Leaves-upper surface	Glabrous	Green, glabrous	Green with white or light pale green patches between leaf venation, scabrous
Leaves-lower surface	Hairy	Pale green, pubescent	Brownish red surface, pubescent
Leaves-apex	Acute	Acute to acuminate	Acuminated
Leaves-base	Cuneate	Cuneate	Decurrent to attenuate
Leaves-margin	Entire	Slightly undulate,	Entire and widely undulate
Inflorescence	Appearing from leafless rhizome	Appearing from leafless rhizomes	Directly from leafless rhizome appears before new leaves
Flower	Several	10–19	27–35
Bracts	Lanceolate, 20–40 mm long, 10–20 mm wide, apex mucronate, hairy	Ovate to broadly ovate, 1.4–2.6 cm × 4–9 mm, apex acute, hairy	Ovate, light pale yellow with brownish-red at tip, apex acute, alternate, pubescent, 45–98 mm long, 20–54 mm wide.
Bracteoles	Keeled, lanceolate, 1.8–2.3 × 1 cm, hairy, apex acute, ciliate	Bracteole 1, 1.1–1.5 cm × 2–6 mm, apex 2 lobes, acuminate, reddish, hairy	Lanceolate, light pale yellow to white, bilobed, each lobe apex acute, sparsely pubescent
Calyx	3–5.2 cm long, hairy, apex bilobed	Tubular, 5.1–5.5 cm long, split on one side, 1.2–1.5 cm long, reddish, hairy, apex trifid	White, tubular, sparsely hairy, 7.5–8.5 cm long, unilaterally slit 14–17 mm long, apex trident
Corolla tube	5–5.5 cm long, lobes linear	6.3–7.5 cm long, whitish, glabrous	White, long and slender, 11.5–12.0 cm long, diameter ca. 2 mm, sparsely hairy
Dorsal corolla lobe	4–5 × 0.6 cm, apex hooded, aristate	Narrowly lanceolate, 3–3.4 cm × 3–5 mm, apex hooded	Narrowly lanceolate, hooded, apex caudate, 39–45 mm long, white, glabrous
Lateral corolla lobes	3.6–4.2 × 0.5 cm, apex aristate	Narrowly lanceolate, 2.5–3.2 cm × 2–4 mm, apex acute	narrowly lanceolate, apex acuminate, 35–42 mm long, white, glabrous
Staminodes	White, purple-tinted, oblong, 3–4 × 1.6 cm, apex rounded	Obovate, deep pink, 2.5–3 × 1–1.6 cm, apex rounded to apiculate	Light pink, broadly ovate, apex acute, 35–42 mm long, 28–35 mm wide, glabrous
Labellum	Purple, 4 × 2–2.5 cm, deeply bilobed, each lobe elliptic, apex rounded or mucronate	Deep pink, violet at base, broadly obovate, 2.5–3 × 2.8–3.7 cm, divided to base, each lobe obovate, 1.8–2.2 × 1.4–1.9 cm, apex rounded to apiculate	Light pale pink with deep pink towards and almost reaching base with white at base, respectively, deeply bilobed ca. 26 mm, each lobe obovate, apex rounded and slightly acute at tip, 30–35 mm long, 22–26 mm wide, glabrous
Anther crest	Oblong, 9–12 × 3–4 mm, 3-lobed; outer lobes acute and elongate, middle one shorter, entire or emarginate	Ovate or rectangular, 6–8 × 2–3 mm, apex bilobed, tri-dent, or variable	Oblong with apex 3–4 lobed, outer lobes acute and elongate, slightly curved, middle 1–2 lobes shorter, light pale pink with pink patches and white at base, 10–16 mm long, glabrous
Ovary	4–6 mm long, 2–4 mm wide, hairy	Cylindrical, 4–5 × 2 mm, sparsely hairy	Cylindrical to obovoid, 3.5–5 mm long, 1.2–2 mm wide, hairy
Reference	Sirirugsa, 1992	Picheans. et al., 2013	

31a. Staminodes and labellum laid on same plane; sinus depth two-third of labellum length; petiole subsessile to 2.5 cm long; anther crest irregular tridentate apex, middle tooth shorter and wider than outers *K. albiflora*
 31b. Staminodes upright with deflexed distal half of labellum; sinus depth half of labellum length; petiole subsessile to 1 cm long; anther

crest with bilobed apex, usually with two small teeth between lobes *K. noctiflora*
 32a. Leaf upper surface glabrous 33
 32b. Leaf upper surface scabrous or sparsely hair 34
 33a. Labellum white with pale yellow to white band from sinus towards base, surrounded by two purple stripes from base toward



- sinus and spreading to half of each lobe *K. aurora*
- 33b. Labellum deep pink, violet at base, broadly obovate, divided to base each lobe obovate, apex rounded to apiculate; staminodes deep pink, obovate, apex rounded to apiculate *K. xiengkhouangensis*
- 34a. Ovary glabrous; staminodes erect with deflexed distal half of labellum; staminodes white to purple; labellum deep purple toward base, apically bilobed, each lobe narrowly obovate, apex rounded to slightly emarginate; leaves sparse hairs on both surfaces *K. kamohwaniae*
- 34b. Ovary hairy; staminodes and labellum laid on same plane; staminodes light pink, broadly ovate, apex acute; labellum light pale pink with dark pink towards and almost reaching base with white at base, respectively, deeply bilobed, each lobe obovate, apex rounded and slightly acute at tip; leaf upper surface scabrous, lower surface pubescent *K. takensis*

Notes: The key to species of genus *Kaempferia* in Thailand (including *K. xiengkhouangensis* from Laos PDR), excluding four species, namely *K. albomaculata* Jenjittikul & Larsen K., *K. bambusetorum* Larsen K. & Jenjittikul., *K. minuta* Jenjittikul & Larsen K., *K. pardi* Larsen K. & Jenjittikul, which are without documentation, and they are not similar to *K. takensis*.

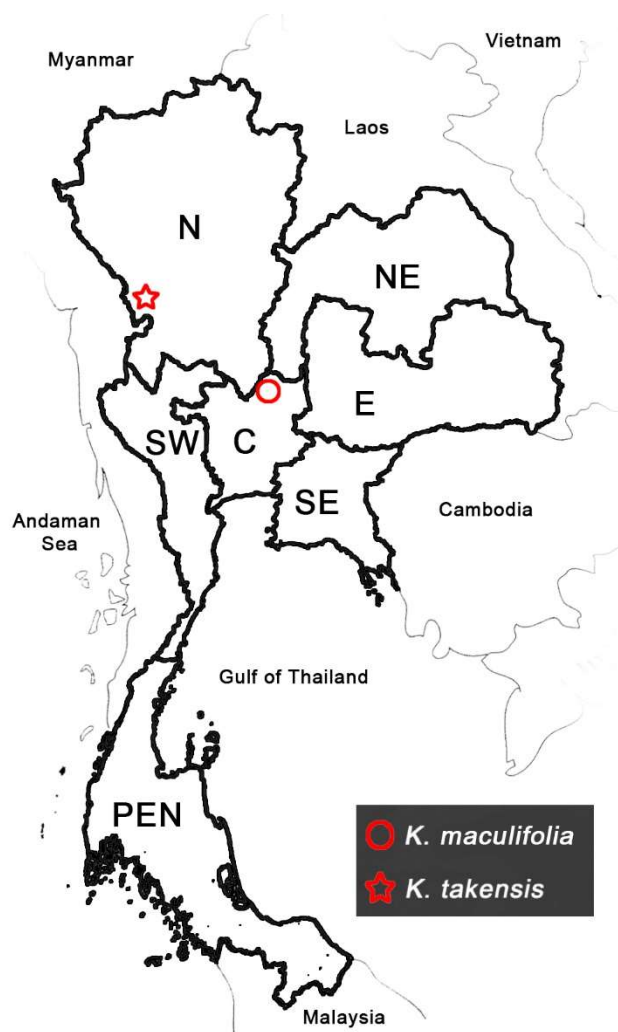


Fig. 5. Habitat map of two new species treated in this paper. Symbols in picture show habitat area of each species according to their habitat, which is currently found in Thailand. (Map of Thailand showing floristic regions: Northern, Northeastern, Eastern, Central, Southeastern, Southwestern and Peninsular. Refer to map of floristic regions of Flora of Thailand).

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LITERATURE CITED

- Christenhusz, M. J. M. and J. W. Byng.** 2016. The number of known plants species in the world and its annual increase. *Phytotaxa* **261(3)**: 201–217.
- Gagnepain, F.** 1908. Zingibéracées. In: Lecomte, H. (Ed.) *Flore générale de l'Indo-Chine*, vol. **6**:25–121.
- Holttum, R. E.** 1950. Zingiberaceae of the Malay Peninsula. *Gard. Bull. Singapore* **13**:1–249.
- Insisiengmay, O., M. F. Newman and T. Haevermans** 2018. (2581) Proposal to conserve the name *Kaempferia rotunda* (Zingiberaceae) with a conserved type. *Taxon* **67(1)**: 207–208.
- Insisiengmay, O., T. Haevermans and M. F. Newman** 2019. Typification of names in *Kaempferia* (Zingiberaceae) in the flora of Cambodia, Laos, and Vietnam. *PhytoKeys* **122**: 97–102.
- IUCN Standards and Petitions Committee.** 2019. Guidelines for using the IUCN red list categories and criteria, ver. **14**. The Standards and Petitions Committee. www.iucnredlist.org/documents/RedListGuidelines.pdf; Accessed 12 April 2020.
- Kress, W. J., L. M. Prince and J. K. Williams** 2002. The phylogeny and a new classification of the Gingers (Zingiberaceae): evidence from molecular data. *Am. J. Bot.* **89(10)**: 1682–1696.
- Larsen, K.** 1980. Annotated key to the genera of Zingiberaceae of Thailand. *Nat. Hist. Bull. Siam Soc.* **28**: 151–169.
- Larsen, K. and S.S. Larsen** 2006. *Gingers of Thailand*. Queen Sirikit Botanic Garden, The Botanical Garden Organization Thailand: 6–61.
- Leong-Škorničková, J. and M. Newman.** 2015. *Kaempferia*. In: *Gingers of Cambodia, Laos and Vietnam*. Singapore Botanic Gardens, National Parks Board, Singapore.
- Nopporncharoenkul, N. and T. Jenjittikul.** 2017. *Kaempferia noctiflora* (Zingiberaceae), a new species from northern Thailand. *Phytotaxa* **316(1)**: 67–72.
- Nopporncharoenkul, N. and T. Jenjittikul.** 2018. *Kaempferia graminifolia* (subgen. *Protanthium*: Zingiberaceae), a new endemic species from Thailand. *Phytotaxa* **379(3)**: 261–266.
- Nopporncharoenkul, N., W. Laongsri and T. Jenjittikul** 2020. Two new species of *Kaempferia* subgenus *Protanthium* (Zingiberaceae) from northern Thailand. *Nordic J. Bot.* **38(2)**: <https://doi.org/10.1111/njb.02633>
- Nopporncharoenkul, N., P. Soontornchainaksaeng, T. Jenjittikul, N. Chuenboonngarm and U. Viboonjun.** 2016. *Kaempferia simaoensis* (Zingiberaceae), a new



- record for Thailand: evidence from nuclear ITS2 sequence analyses. *Thai. J. Bot.* **8(1)**: 81–91.
- Picheansoonthon, C.** 2010. *Kaempferia lopburiensis* (Zingiberaceae), a new species from Central Thailand. *J. Jpn. Bot.* **85**: 148–152.
- Picheansoonthon, C.** 2011. Two new *Kaempferia* (Zingiberaceae) from Thailand. *J. Jpn. Bot.* **86**: 1–8.
- Picheansoonthon, C. and S. Koonterm** 2009. A new species of *Kaempferia* L. (Zingiberaceae) from Northern Thailand. *Taiwania* **54(1)**: 52–56.
- Phokham, B., P. Wongsuwan and C. Picheansoonthon.** 2013. Three new species of *Kaempferia* (Zingiberaceae) from Thailand and Laos. *J. Jpn. Bot.* **88**: 297–308.
- Rajkumar, K.** 2012. Rediscovery of *Kaempferia marginata* (Zingiberaceae) after a lapse of 100 years from India. *Rheedea* **22(1)**: 28–31
- Ridley, H. N.** 1924. *Flora of the Malay Peninsula 4*: 1–458 London, L. Reeve & co., ltd., UK.
- Saensouk, S. and T. Jenjittikul.** 2001. *Kaempferia grandifolia* sp. nov. (Zingiberaceae), a new species from Thailand. *Nord. J. Bot.* **21(2)**: 139–142.
- Saensouk, S. and P. Saensouk.** 2019. *Kaempferia mahasarakhamensis* (Zingiberaceae), a new species from Thailand. *Taiwania* **64(1)**: 39–42.
- Saensouk, S. and P. Saensouk.** 2019. *Kaempferia phuphanensis* (Zingiberaceae), a new species from Thailand. *J. Jpn. Bot.* **94(3)**: 149–152.
- Sirirugsa, P.** 1989. The genus *Kaempferia* (Zingiberaceae) in Thailand. *Nord. J. Bot.* **9(3)**: 257–260.
- Sirirugsa, P.** 1992. Taxonomy of the genus *Kaempferia* (Zingiberaceae) in Thailand. *Thai Forest Bulletin (Botany)* **19**: 1–15.
- Techaprasan, J., S. Klinbunga, C. Ngamriabsakul and T. Jenjittikul** 2010. Genetic variation of *Kaempferia* (Zingiberaceae) in Thailand based on chloroplast DNA (*psbA-trnH* and *petA-psbJ*) sequences. *Genet. Mol. Res.* **9(4)**: 1957–1973.
- Wongsuwan, P., S. Prasarn and C. Picheansoonthon** 2015. *Kaempferia koontermii* (Zingiberaceae) – A new species from Thailand. *J. Jpn. Bot.* **90**: 29–33.
- Wongsuwan, P., P. Meechonkit, B. Phokham, S. Sangnark, P. Yupparach and C. Picheansoonthon** 2020. A new species of *Kaempferia* (Zingiberaceae) from Northern Thailand. *J. Jpn. Bot.* **95**: 34–38.