

Curcuma achrae (Zingiberaceae), a new species from Central Thailand

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Abstract: *Curcuma achrae* Saensouk & Boonma, a new species of *Curcuma* subgenus *Ecomata* (Zingiberaceae) from Nakhon Nayok province, Central Thailand is described and illustrated along with photographs, notes on its distribution and habitat. A revised identification key to 68 species of the genus *Curcuma* in Thailand is also presented.

Keywords: *Curcuma flaviflora*, *C. xanthella*, Nakhon Nayok province, Taxonomy.

Introduction

The genus *Curcuma* L. is an important natural resource that provides many useful products and is one of the largest genera in the family Zingiberaceae, distributed from India to South China, Southeast Asia, Papua New Guinea and Northern Australia (Larsen & Larsen, 2006). Závěská *et al.* (2012) recognized three subgenera: *Curcuma* subgen. *Hitcheniopsis* (Baker) K.Schum. (Schumann, 1904) with an absence of epigynous glands, *Curcuma* subgen. *Ecomata* Škornièk. & Šída f. with the presence of epigynous glands, mostly acute anther spur, fertile bracts connate only at the base and lacking a conspicuous coma of sterile bracts, and leaves with well-developed ligules, whereas *Curcuma* subgen. *Curcuma* usually has well-developed coma bracts, a closed flower form, bullet-

type, and flat anther-spurs, acute, downward-pointed or absent. Subsequently, previously recognized genera, namely *Laosanthus* K.Larsen & Jenjitt., *Smithatris* W.J.Kress & K.Larsen and *Stahlianthus* Kuntze, are sunk *Curcuma* and two species previously recognized in the genus *Hitchenia* Wall., namely *H. caulina* (J.Graham) Baker and *H. glauca* Wall., transferred to *Curcuma* which caused an increase in the number of species in *Curcuma* (Leong-Škorniková *et al.*, 2015). Recently, five new species of *Curcuma* subgen. *Ecomata* were described, namely *C. chantaranothaii* Boonma & Saensouk, *C. rangsimae* Boonma & Saensouk, *C. aruna* Maknoi & Saensouk, *C. pitukii* Maknoi, Saensouk, Rakarcha & Thammar, and *C. siamensis* Saensouk & Boonma, bringing the number of species in the subgenus worldwide to 32 (Leong-Škorniková *et al.*, 2020; Tanaka *et al.*, 2020; Maknoi *et al.*, 2021; Saensouk *et al.*, 2021a, b; Saensouk P. *et al.*, 2021).

Thailand is one of the richest diversity hotspots of *Curcuma* with 70 species of which 26 belong to subgen. *Curcuma*, 23 to subgen. *Hitcheniopsis*, and 21 to subgen. *Ecomata* (Larsen & Larsen, 2006; Sirirugsa *et al.*, 2007; Maknoi *et al.*, 2021; Saensouk *et al.*, 2021a, b; Saensouk P. *et al.*, 2021). While investigating the species diversity of Zingiberaceae for the Flora of Thailand by the authors, plants of *Curcuma* were discovered by the second author (TB) in the Mueang Nakhon Nayok district in the Nakhon Nayok province, Central Thailand. After comparing and examining them with species with

similar morphological characteristics, we found that these specimen did not match with any existing taxa, hence it is described and illustrated here as new to science. A revised key to the 71 species of *Curcuma* in Thailand is presented, followed by an additional revised key to all species of *Curcuma* subgen. *Ecomata* for facilitating their identification.

Materials and Methods

Plant materials were collected and photographs taken in their habitat in the deciduous forest of Mueang Nakhon Nayok district, Nakhon Nayok province, Central Thailand from September 2019 to April 2021. Measurements of the living and preserved specimens were taken with Vernier-caliper, ruler, and morphologically examined under stereoscopic microscope (Stemi 2000-C, ZEISS, Oberkochen, Germany). The protologues of morphologically similar species, *Curcuma flaviflora* S.Q.Tong (Tong, 1986; Maknoi *et al.*, 2005), *Curcuma xanthella* Škorník. (Leong-Škorníková & Trần, 2013) and their type materials housed in various herbaria (AAU, BK, BKF, C, E, KKU, QBG, SING, VNM), and digital images available online, including all existing published literatures of *Curcuma* especially in subgen. *Ecomata* were compared *e.g.* Larsen and Larsen (2006), Sirirugsa *et al.* (2007), Leong-Škorníková and Newman (2015), Leong-Škorníková and Trần (2013), Maknoi *et al.* (2021), Saensouk *et al.* (2021a, b), Saensouk P. *et al.* (2021).

Taxonomic Treatment

***Curcuma achrae* Saensouk & Boonma, sp. nov.**

Figs. 1–5

Similar to *Curcuma xanthella* Škorník. but differs. *C. achrae* having pubescent petioles (*vs.* glabrous), green with a reddish tinge (*vs.* green); adaxially sparsely hairy leaves with fine hairs along the midrib (*vs.* glabrous on both surfaces); fertile bracts connate in the lower 1/7 (*vs.* connate in the lower 1/4), apex mucronate (*vs.* narrowly acute); base of labellum white, middle and apical part golden yellow, with embossed two golden yellow median band running

along the midrib from tip to base and divided into two Y-shaped patches at base (*vs.* base of labellum white to light yellow, middle and apical part warm yellow, with two yellow-orange swollen bars running across the center); staminodes irregularly ovate, apex acute, golden yellow gradually fades to pale yellow at base, with reddish V-shaped or triangle patch at base of staminodes (*vs.* staminodes irregularly oblong, apex obtuse, bright warm yellow without red patch); anther appear almost straight (*vs.* anther appear as L-shaped), spurs *c.* 3 mm long (*vs.* spurs *c.* 6 mm long), crest 3–4 mm long with apex acute to rounded or slightly truncate (*vs.* crest not obvious).

Type: THAILAND, Nakhon Nayok province, Mueang Nakhon Nayok district, 60–152 m, 05.04.2021, T. Boonma 24 (holo KKU!; iso QBG!, BKF!, BK!).

Perennial herbs, up to 45 cm tall. Rhizome ovoid, 3.2–3.8 × 1–1.4 cm, brown externally, two layers of pale yellow internally, fragrant; root tubers ellipsoid, 2.5–3 × 1.2–1.4 cm, brown externally, white internally, fragrant, developing some distance from the rhizome. Leafy shoot with 6–8 leaves spread out in a circle parallel to the ground almost the same plane, developing after flowering; pseudostem 18–24 cm long, green with reddish brown tinge, composed of sheathing bracts and leaf sheaths; sheathing bracts 2–3, apex slightly mucronate, reddish when young with green tip and drying out and decaying while growing; leaf sheaths distichous, green with reddish brown tinge, pubescent; ligules up to 6 mm long, bilobed, hyaline, green with a reddish tinge, sparsely hairy; petioles up to 25 cm long (petiole of innermost leaves longest, outermost leaf shortest), canaliculate, green with a reddish brown tinge, pubescent; lamina narrowly ovate to narrowly elliptic, 26–45 × 10–13 cm, base cordate, margins slightly undulate, apex caudate, adaxially green, sparsely hairy, abaxially lighter green, puberulous, midrib green or brownish green, with fine hairs along the midrib, spread out into a circle shape, almost in the same plane parallel to the ground. Inflorescence lateral, peduncle and base of the spike often subterranean;

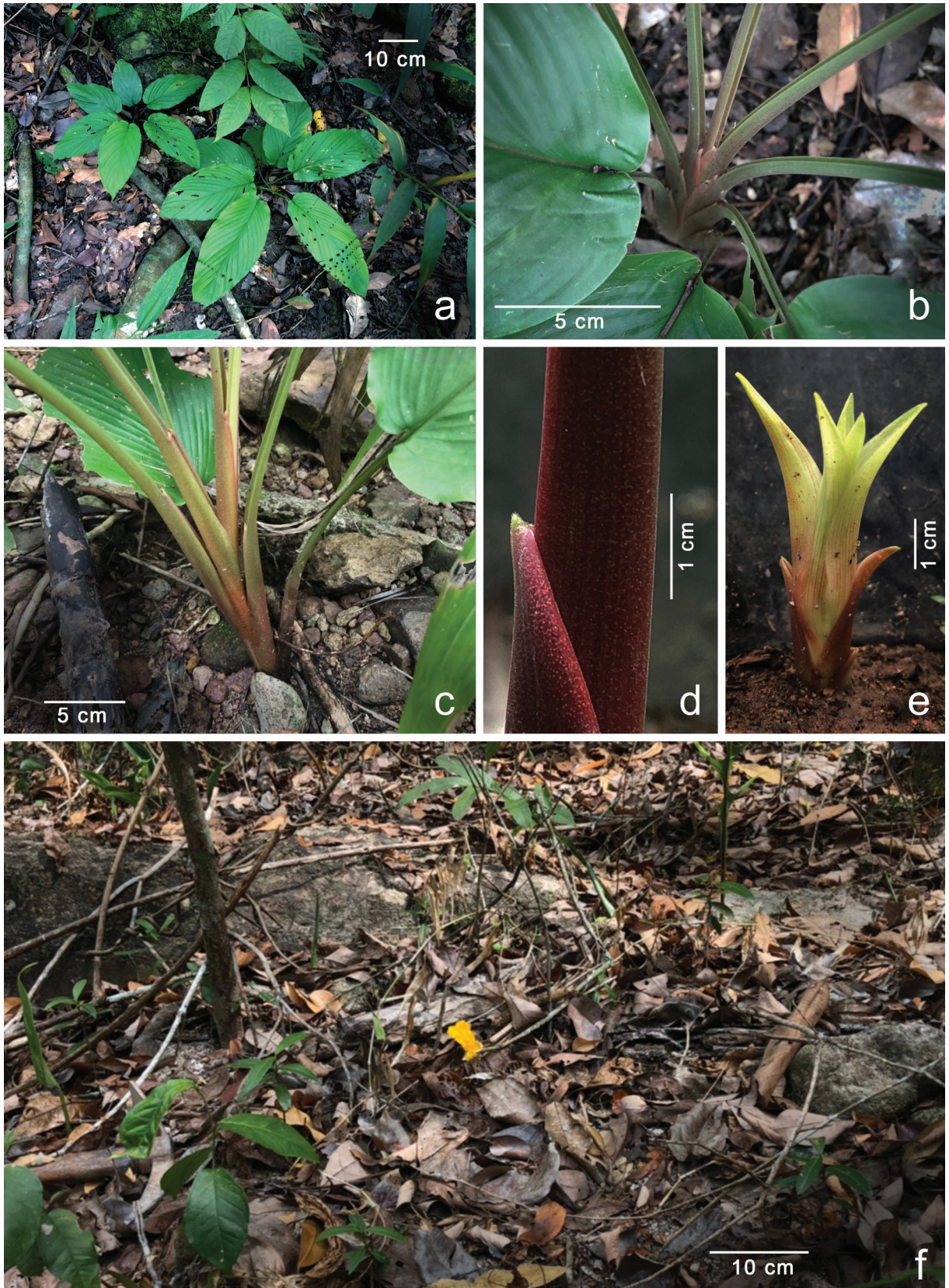


Fig. 1. *Curcuma achrae* Saensouk & Boonma: **a.** Plants in natural habitat; **b.** Pseudostem—top view; **c.** Pseudostem—side view; **d.** Distal part of sheathing bract—side view; **e.** Young inflorescence—side view; **f.** Anthesis in natural habitat (a–c in September 2019; d in late April 2020; e & f in late March 2020, 2021 respectively; photos by Thawatphong Boonma).

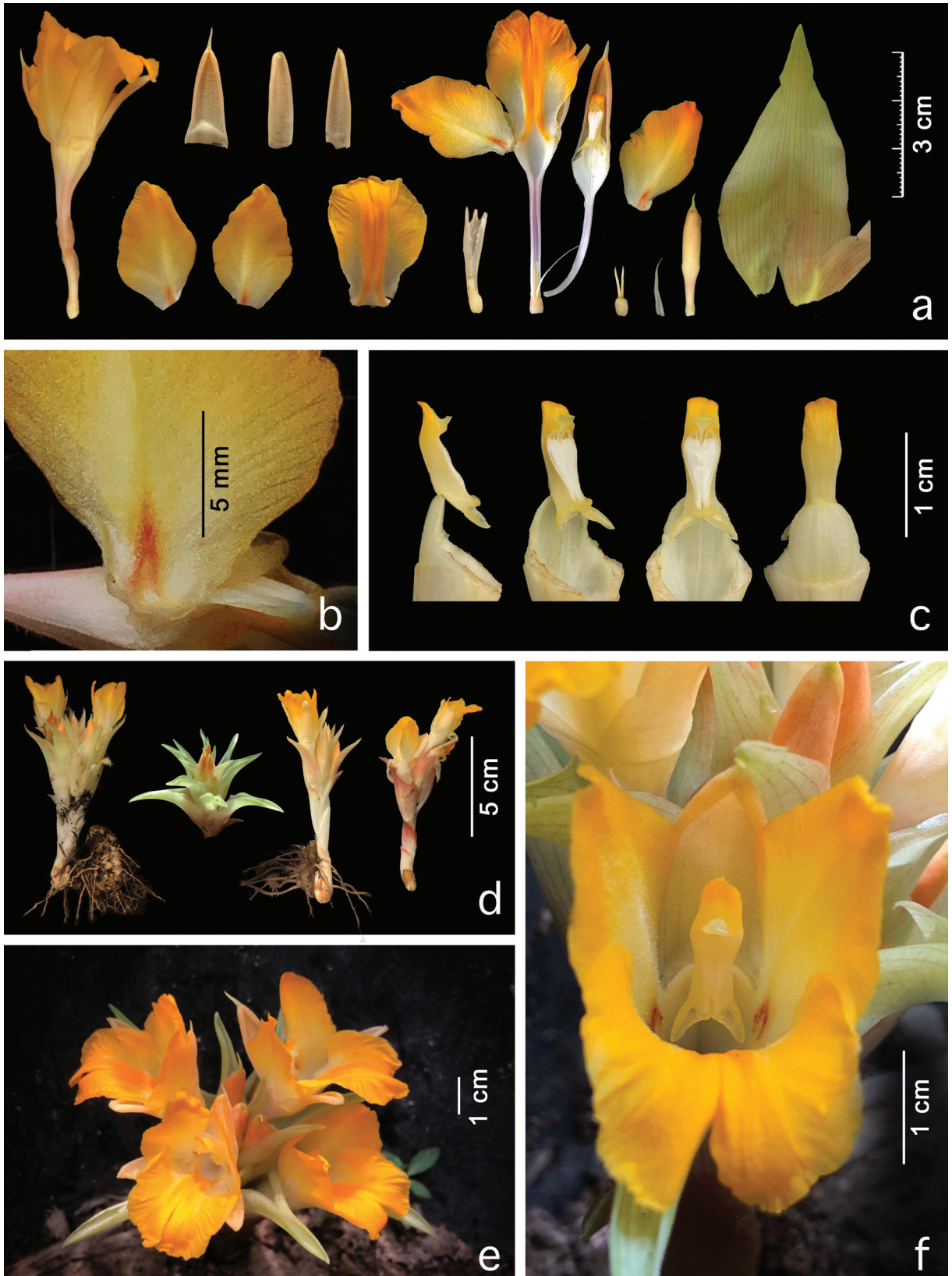


Fig. 2. *Curcuma achrae* Saensouk & Boonma: **a.** Flower, (upper row) dorsal corolla lobe and lateral corolla lobes, (lower row) two lateral staminodes, labellum, calyx, cross-section of flower, ovary with epigynous glands, bracteole, flower bud, and bract; **b.** Reddish V-shaped patch at base of staminode; **c.** Stamen-side, oblique side, front and back view; **d.** Inflorescence with rhizome, spike varied in sizes and colours-side view; **e.** Inflorescence-oblique top view; **f.** Close up flower-front view (photos by Thawatphong Boonma).

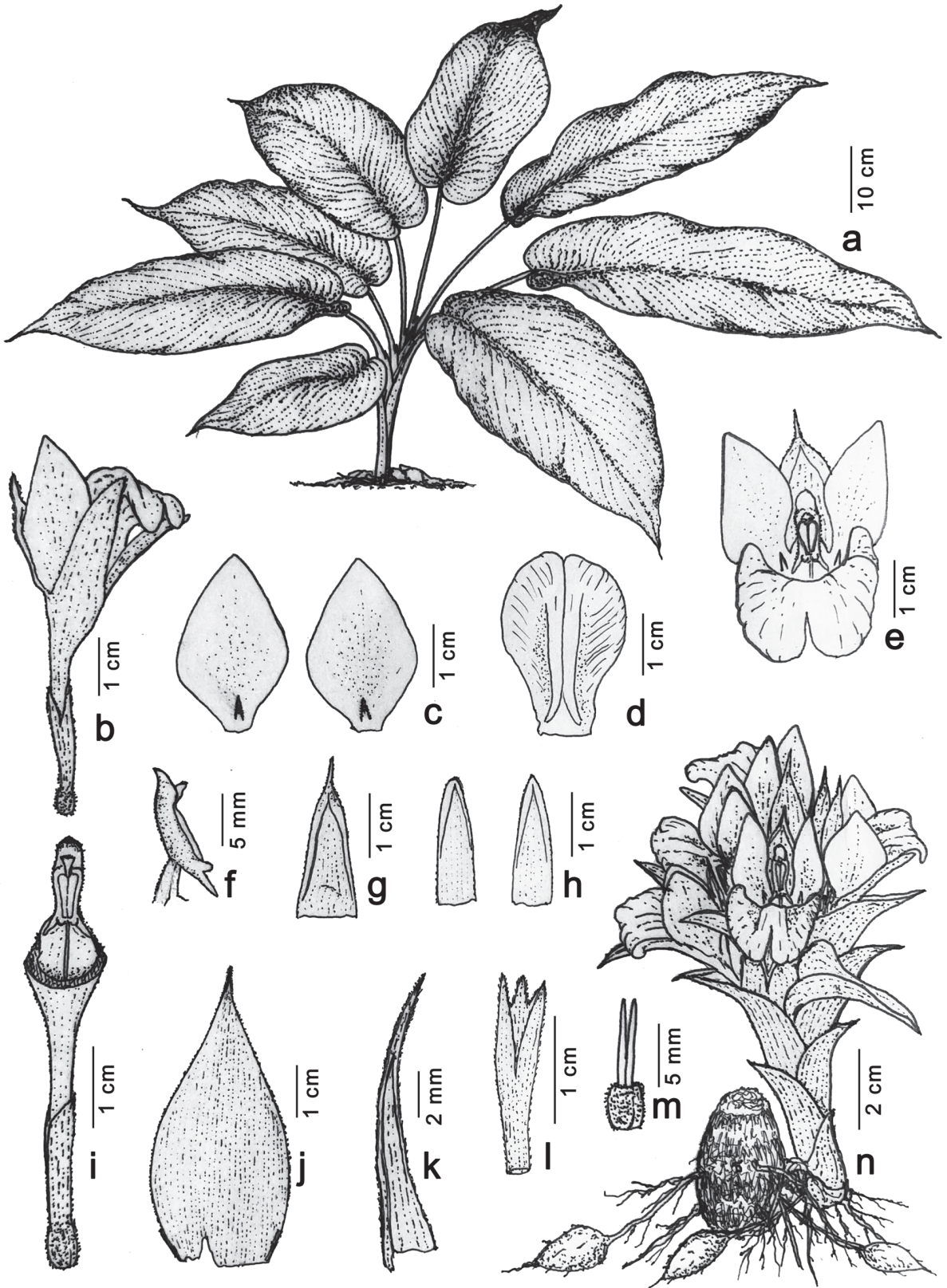


Fig. 3. *Curcuma achrae* Saensouk & Boonma: **a**. Habit—oblique top view; **b**. Flower—side view; **c**. Lateral staminodes; **d**. Labellum; **e**. Flower—front view; **f**. Stamen—side view; **g**. Dorsal corolla lobe; **h**. Lateral corolla lobes; **i**. Floral tube with ovary, calyx, and front view of stamen; **j**. Bract; **k**. Bracteole; **l**. Calyx; **m**. Ovary with epigynous glands; **n**. Inflorescence with flowers, rhizome, and tuberous roots (from *T. Boonma* 24; drawn by Thawatphong Boonma).

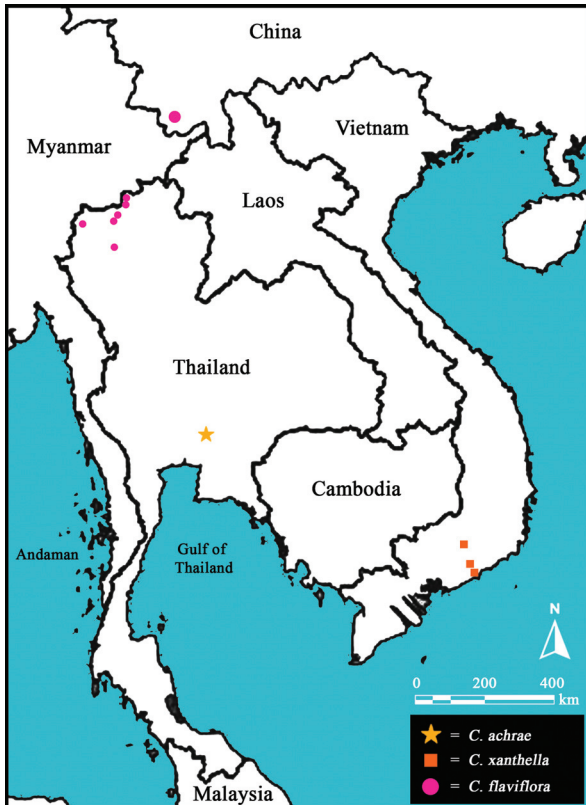


Fig. 4. Map showing the distribution points of *Curcuma achrae* Saensouk & Boonma, *C. xanthella* Škorniček, and *C. flaviflora* S.Q. Tong. (The references of each locality are described in Notes). (Map created with "Pixelmator Pro" in MacBook Pro-Apple M1 by Thawatphong Boonma).

peduncles 3–5 cm long, with up to 6 mm diam., white, pubescent, with up to 6 sheathing bracts (sheathing bracts red or reddish tinge with white at base, apex mucronate, pubescent); spike 4–6.5 cm long, 2–3 cm diam. in the middle, wider apically, coma absent; fertile bracts 10–18, narrowly ovate to lanceolate, smaller and narrowly ovate at the apex, 2.5–5.8 × 1–2.5 cm (larger at the base of the inflorescence), apex mucronate, both sides pubescent, pale green with various degrees of reddish tinge, connate in the lower 1/7; cincinni with 3–4 flowers at the base of the inflorescence, 1–2 flowers at the top; bracteoles one per flower, narrowly triangular, 7–12 × 1–2.7 mm (outer ones larger, inner ones are gradually smaller), pubescent, translucent white. Flowers 5.8–6.4 cm long; calyx tubular, 18–20 mm long, 3-toothed, with unilateral incision up to 8 mm long, pubescent, translucent white; floral tube 30–32 mm long, externally

yellowish white with pale pink tinge, pubescent, white internally, with white hairy at throat; dorsal corolla lobe narrowly triangular ovate, 21–26 × 9–11 mm, concave, sparsely hairy, apex mucronate, 3.3–4.8 mm long, sparsely hairy, pale yellowish white at base, yellowish with pale pink tinge towards the apex; lateral corolla lobes narrowly triangular-ovate; 18–24 × 7–9 mm, concave, apex slightly mucronate, sparsely hairy, pale yellowish white at base, yellowish with pale pink tinge towards the apex; labellum obovate, 27–29 × 18–20 mm, apex emarginate, incision to 7 mm, base of labellum white, middle and apical part golden yellow, with embossed two golden yellow swollen bars running along the midrib from tip to base and divided into two patches at base like a Y-shape (forming a median band), fine and short hairy along both sides of median band; lateral staminodes irregularly ovate, 24–26 × 14–17 mm, apex acute, with short fine hairy on the adaxial side, golden yellow gradually fades to pale yellow at base, with reddish V-shaped or forming of triangle patch at base of staminodes. Stamen 12–14 mm long; filament 4–5 mm long, pale yellowish-white, *c.* 5 mm broad at the base, *c.* 3 mm broad at the apex (the point of attachment to the connective), covered with short fine hairs; anther 12.5–14 mm long (measured in side-view including spurs and crest), yellowish, spurred, pubescent; connective yellowish-white, covered with short fine hairs; anther spurs *c.* 3 mm long, conical, pale yellow, covered with transparent jelly on both spurs, pointing outwards; anther crest 3–4 mm long, 2.7–3 mm wide, golden yellow, apex acute to rounded or slightly truncate, rarely retuse, covered with short fine hairs; anther thecae 6.5–7 mm long. Epigynous glands two, 5–7 mm long, 0.7–0.8 mm across, pale yellow, apex acute. Style thin, white, glabrous, placed in the groove in the dorsal side of floral tube; stigma *c.* 1.7 × 1.8 mm, pale yellow; ostiole ciliate. Ovary *c.* 3.8 × 3 mm, trilocular, puberulent. Fruits and seeds not seen.

Vernacular name: *Khamin Thong.*

Flowering & fruiting: Flowering from late March to early May; flowers open in the morning and last a



Fig. 5. Comparison of anthers in front and side view, and flowers of the newly described species and its similar species: **a & b.** *Curcuma achrae* Saensouk & Boonma *sp. nov.*; **c & d.** *Curcuma xanthella* Škorniček.; **e & f.** *Curcuma flaviflora* S.Q.Tong. (from Leong-Škorničeková & H.Đ. Trần, 2013; Photos a-b by Thawatphong Boonma; c-f from Leong-Škorničeková & H.Đ. Trần, 2013).

single day. Leafy shoot emerging in late May and dormancy begins in November. Fruiting was not observed.

Habitat: Occurring at elevations of 60–152 m, growing in sandy loam soil at the boundary, close to the watercourse, in semi-open area in a deciduous forest.

Distribution: *Curcuma achrae* is known from the southwestern part of the Sankamphaeng mountain range in Mueang Nakhon Nayok district, Nakhon Nayok province, Central Thailand (Fig. 4).

Etymology: The specific epithet “*achrae*” is chosen to honour Assistant Professor Dr. Achra Thammathaworn (botanist of Khonkaen University), who is a specialist in botany and teacher of many Thai botanists.

Specimens examined: *Curcuma xanthella* Škorniček.: VIETNAM, **Binh Thu-n province**, Hàm Thu-n Nam district, Tà Kóu Nature Reserve,

145 m, 11.06.2009, *Lý* 348 (holo SING; iso E, VNM); Tà Kóu mountain, 30.05.2009, Nguyễn Thiện Tích (under Trần collection number), *Trần*158 (E, SING, incl. spirit). **Lâm Đông province**, Bào Lộc pass, 22.06.2008, Trần *et al. s.n.* (collected from cultivation, 06.05.2013), *GRC*-147 (SING, incl. spirit).

Curcuma flaviflora S.Q.Tong: CHINA, **Yunnan australis**, Menhai Xian, 1400 m, *S.Q.Tong & A.M. Li* 32855 (holo YNTBI). THAILAND, **Chiang Mai province**, Doi Angkang, Fang, 12.06.1999, *Srisanga* 721 (QBG). *Ibid.*, 21.07.2003, *Maknoi* 356 (AAU, PSU, QBG). *Ibid.*, 15.05.2004, *Maknoi* 535 (AAU, PSU, QBG). Chiang Dao, *Norsaengsri* 1476 (QBG). Doi Pui, Huai Hi, Mueang, 25.07.2003, *Maknoi* 382 (AAU, PSU, QBG). Khun Huai Mae Kok, 05.06.2001, *Wongprasert* 015–05 (BKF). **Mae Hong Son province**, 15 km N.W. of Mae Hong Son, 18.06.1973, *Geesink, Panichapol & Santisuk* 5960 (C, E).

Conservation status: This new species is hitherto known from the type locality in Nakhon Nayok province, Central Thailand (the Southwest part of the Sankamphaeng mountain range). Available information about this species is insufficient for a proper assessment of its conservation status. Thus according to IUCN criteria (IUCN, 2022) it should be listed as Data Deficient (DD). However, we expect this plant to be found distributed elsewhere in the Sankamphaeng mountain range and nearby in the Khao Yai National Park where suitable habitats still seems to exist. Further fieldwork and observations are needed to assess changes in population, distribution, and abundance of this taxon in the future.

Notes: *Curcuma achrae* belongs to subgen. *Ecomata* (Záveská *et al.*, 2012) because of the absence of a coma bract, open-form flower, presence of epigynous glands, and conical anther spur. This species has varied size and colour of bracts but produces almost the same size of flowers (Fig. 2d).

Curcuma achrae is similar to *C. flaviflora* S.Q.Tong, *C. aruna* Maknoi & Saensouk, and *C. xanthella* Škornièk. in having yellow flowers, an inflorescence produced directly from the rhizome before the new leaves, lacking coma bracts, open flowers, and presence of epigynous glands. *Curcuma flaviflora* is a high-elevation species known to occur in pine forests in the mountains of northern Thailand and southern China. *Curcuma aruna* occurs in scrub forests at foothills of limestone mountains and is currently only found in Sukhothai province in northern Thailand, while *C. xanthella* is so far recorded from two places in southern Vietnam and differs from *C. achrae* by many characteristics *e.g.*, shape and surfaces of leaves, and different shapes, colors, sizes, and proportions of various flower parts, especially in having an L-shaped anther whereas in *C. achrae* it is almost straight. The morphological comparison of *C. achrae* with its allied species *C. xanthella* and *C. flaviflora* is provided in table 1. A comparison of anthers in front and side view, and flowers of the newly described species and its similar species are

additionally provided in figure 5. A key to the species of *Curcuma* distributed in Thailand and a revised key to species of *Curcuma* subgen. *Ecomata* are provided for facilitating their identification in the field.

Key to the species of *Curcuma* in Thailand

1. Epigynous glands absent (subgen. *Hitcheniopsis*) 2
1. Epigynous glands present 24
 2. Bracts not laterally connate, campanulate involucre with two slits 3
 2. Bracts laterally connate to each other for about half of their length and forming basal pouches 6
 3. Bracts purplish-brown *C. macrochlamys*
 3. Bracts green or red 4
 4. Leaves glabrous adaxially, pubescent abaxially; bracts green with dense stripes from the base to apex or red *C. pedicellata*
 4. Leaves glabrous on both surfaces; bracts green 5
 5. Leaves 2–3, lanceolate; flowers 15–20 *C. campanulata*
 5. Leaves 4–5, oblanceolate-oblong; flowers 6–8 *C. involucrata*
 6. Inflorescence without coma 7
 6. Inflorescence with well-developed coma .. 15
 7. Bracts pink with green or purple at the tip, or reddish-brown with green margin 8
 7. Bracts pale green to dark green 10
 8. Labellum light purple to purple, basally with two bright to dark red thick bands (one on each side), distally pale to bright purple, median band only slightly darker than remainder of labellum *C. lithophila*

Table 1. Morphological comparison of *Curcuma achrae*, *C. xanthella* and *C. flaviflora*

Characters	<i>C. achrae</i> Saensouk & Boonma	<i>C. xanthella</i> Škornièk.	<i>C. flaviflora</i> S.Q.Tong
Rhizome	Pale yellow inside	Light yellow inside	White inside
Petiole	Up to 25 cm long, pubescent, green with reddish tinge	Up to 23 cm long, glabrous, green	4–7 cm long, glabrous, green
Leaves	Narrowly ovate to narrowly elliptic, 26–45 × 10–13 cm, cordate at base, caudate at apex	Elliptic-lanceolate, c. 32 × 9.5 cm, rounded to cordate at base, acuminate at apex	Oblanceolate, 18–30 × 6–8.5 cm, cuneate at base, acuminate at apex
Leaf surfaces	Sparsely hairy adaxially, puberulous abaxially and fine hairy along the midrib	Glabrous on both surfaces	Glabrous adaxially, pubescent abaxially
Peduncles Fertile bracts	3–5 cm long, narrowly ovate to lanceolate, 2.5–5.8 × 1–2.5 cm, apex mucronate, connate in the lower 1/7	c. 15 cm long, ovate to narrowly ovate, 4.5 × 2.1 cm, apex narrowly acute, connate in the lower 1/4	5–9 cm long lanceolate, 4–4.5 × 2.6–3 cm, apex acuminate, connate in the lower 1/3
Bracteoles	One per flower, 7–12 × 1–2.7 mm	One per flower, 2–8 × 1–1.5 mm	Absent
Calyx	18–20 mm long, unilateral incision up to 8 mm, pubescent	Up to 30 mm long, unilateral incision c. 11 mm, sparsely puberulous	c. 21 mm long, unilateral incision 7 mm, hairy along ridges
Corolla tube	3–3.2 cm long, yellowish white with pale pink tinge, pubescent	c. 3.5 cm long, white and almost glabrous in the basal part, yellowish and shortly densely hairy in the apical part (2/3)	3.8–4.2 cm long, with white hairs
Dorsal corolla lobe	21–26 × 9–11 mm, apex mucronate, mucro 3.3–4.8 mm, sparsely hairy	30–34 × 10–12 mm, apex mucronate, mucro 2–3 mm, glabrous, sometimes with a few short hairs	24 × 9 mm, apex acuminate, scattered hairy
Lateral corolla lobes	18–24 × 7–9 mm, sparsely hairy, apex mucronate, pale yellowish white at base, yellowish with pale pink tinge towards the apex	27–28 × 9–10 mm, glabrous, apex obtuse white at base, yellow towards the apex	c. 18 × 7 mm, sparsely hairy, apex obtuse, yellow
Labellum	27–29 × 18–20 mm, apex emarginate, incision to 7 mm, base of labellum white, middle and apical part golden yellow, with embossed two golden yellow median band running along the midrib from tip to base and divided into two Y-shaped patches at base, fine and short hairy along both sides of median band	32–35 × 22–25 mm, apex emarginate, incision to 12 mm, base of the labellum white to light yellow, middle and apical part warm yellow, with two yellow-orange swollen bars running across the centre, densely puberulent with glandular hairs	c. 25 × 20 mm, apex deeply bifid, incision to 7 mm, yellow with bright yellow mid-band, rarely with red streaks at sinus, glandular hairy more densely on either side of mid-band

Staminodes	Irregularly ovate, 24–26 × 14–17 mm, short fine hairs on adaxial side, apex acute, golden yellow gradually fades to pale yellow at base, with reddish V-shaped or triangular patch at base of staminodes	Irregularly oblong, 32–35 × 15–16 mm, short glandular hairs on adaxial side, apex obtuse, bright warm yellow	Elliptic, <i>c.</i> 22 × 12 mm, glabrous, apex obtuse, yellow
Anther	12.5–14 mm long, yellowish	<i>c.</i> 8–9 mm long, cream white	<i>c.</i> 9 mm long, yellow
Anther spurs	<i>c.</i> 3 mm long, pointing outwards (anther appear almost straight)	<i>c.</i> 6 mm long, pointing outwards (making the anther appear L-shaped)	5 mm long, pointed forwards diverging at apex (making the anther appear L-shaped with obtuse angle)
Anther crest	3–4 mm long, apex acute to rounded or slightly truncate	Not obvious	<i>c.</i> 1 mm long, emarginate
Anther thecae	6.5–7 mm long	3–4 mm long	5–6 mm long
Epigynous glands	5–7 mm long	<i>c.</i> 15 mm long	<i>c.</i> 7 mm long

8. Labellum not purple as above 9
9. Bracts pink with green or purple at tip, apex acute; labellum pale to dark red with bright yellow patches on the bright red swollen band at the base half of the labellum, yellow towards the apex *C. sparganiifolia*
9. Bracts reddish-brown with green margin, apex rounded; labellum white with pink apex and yellowish band in centre *C. bella*
10. Bracts puberulent on both sides
..... *C. papilionacea*
10. Bracts glabrous on both sides 11
11. Labellum with prominently fimbriate margins, fimbriae *c.* 1.5 mm long, curly *C. fimbriata*
11. Labellum not fimbriate at margins 12
12. Bracts lanceolate, with upper half, suddenly narrowed to acute apex *C. harmandii*
12. Bracts almost orbicular or broadly ovate or broadly obovate 13
13. Flowers slightly exserted from bracts; bracts almost orbicular *C. prasina*
13. Flowers exserted from bracts; bracts broadly ovate or broadly obovate 14
14. Labellum with two dark yellow spots at base and a small pale-yellow line at mid lobe from sinus almost to base; bracts broadly ovate; staminodes pale pinkish purple to pale purple with white at base *C. charanii*
14. Labellum without two dark yellow spots at base, with short yellow dashes along each side of incision margin about half-length; bracts broadly obovate; staminodes white
..... *C. puangpeniae*
15. Labellum red 16
15. Labellum not red 20
16. Staminodes pale purple or violet 17
16. Staminodes yellow or white 18
17. Anther spurred, L-shaped, connective white to cream, sometimes very pale purple dorsally, covered with short glandular hairs
..... *C. rufostriata*
17. Anther not spurred *C. rhabdota*
18. Labellum yellow with red lines; staminodes pale yellow to yellow with red tinge
..... *C. gracillima*
18. Labellum white with red; staminodes white with red 19

19. Fertile bracts light green with two white circle patches and light pale green or white longitudinal line; coma bracts outer light green with green longitudinal line alternating with light green or white lines, inner white with green edges *C. saraburiensis*
19. Fertile bracts pale green to cream without white circle patches and without longitudinal line; coma bracts white *C. spathulata*
20. Coma bract pink *C. alismatifolia*
20. Coma bract green or white 21
21. Fertile bracts green with rich reddish-brown tinge *C. micrantha*
21. Fertile bracts green without reddish-brown tinge 22
22. Corolla tube longer than bract, flower distinctly protruding from the inflorescence; staminodes white; coma bracts green on both surfaces *C. purpurata*
22. Corolla tube shorter than bract; staminodes purple or violet; coma bracts white or with green 23
23. Labellum deeply bilobed; coma bracts pure white *C. thorelii*
23. Labellum with fringed edge; coma bracts white with green at apex *C. parviflora*
24. Inflorescences lacking a conspicuous coma of sterile bracts, fertile bracts connate only at the base, open flower form; anther spurs filamentous or conical, forward-pointed (subgen. *Ecomata*) 25
24. Inflorescences usually with a coma bract, closed flower form, bullet-type; anther spurs, flat, acute, downward-pointed or absent (subgen. *Curcuma*) 46
25. Corolla tube longer than bracts, narrow; petioles very distinct from leaf blade *C. supranezana*
25. Corolla tube shorter than bracts, broad; leaf-blade tapering into petioles 26
26. Anther spurs filamentous, 0.5–1.5 mm long 27
26. Anther spurs conical or cylindrical, > 2 mm long 31
27. Staminodes white with dark purple tips *C. pierreana*
27. Staminodes white or white with yellowish patch in centre and apex 28
28. Leaves puberulous on both surfaces *C. chantaranothaii*
28. Leaves adaxially glabrous 29
29. Rhizomes creeping; leaf base attenuate *C. cochinchinensis*
29. Rhizomes ovoid; leaf base cuneate to rounded, or sub-cordate 30
30. Calyx white, glabrous; filament 2 mm long; anther 8–9 mm long *C. eburnea*
30. Calyx pale purple, puberulent; filament 5–8 mm long; anther 2.5–4 mm long *C. pitukii*
31. Inflorescence terminal 32
31. Inflorescence lateral 40
32. Leaves adaxially glabrous. 33
32. Leaves adaxially hairy along the veins or pubescent 37
33. Staminodes without red spots at the base ... 34
33. Staminodes with dark red or dark purple spots at the base 35
34. Midrib adaxially green *C. rangsimae*
34. Midrib adaxially red *C. siamensis*
35. Leaves abaxially glabrous; labellum yellow with inside half orange *C. rhomba*
35. Leaves abaxially pubescent; labellum not as above 36
36. Labellum sub-orbicular, white with an orange median band and deep purple lines at the base; staminodes white with orange tip *C. woodii*

36. Labellum diamond-shaped, white with a yellow median band and red spots at the base; staminodes white without orange tip *C. peramoena*
37. Corolla lobes whitish-green to pale green; leaf base cuneate to attenuate *C. putii*
37. Corolla lobes pink, red or purple; leaf base oblique, rounded or cordate 38
38. Staminodes dark red in the lower half, upper half orange-yellow *C. bicolor*
38. Staminodes pale yellow to yellow 39
39. Thyrses <10 cm long; flowers open form; corolla lobes red *C. stenochila*
39. Thyrses >10 cm long; flowers closed form; corolla lobes white to yellow *C. cinnabarina*
40. Staminodes purple *C. ecomata*
40. Staminodes white or yellow 41
41. Labellum yellow 42
41. Labellum white with yellow median band 44
42. Anther almost straight in sideview; staminodes with reddish V-shaped or triangular patch at the base *C. achrae*
42. Anther L-shaped in sideview; staminodes without red patch as above 43
43. Staminodes ovate to elliptic; leaf base cuneate *C. flaviflora*
43. Staminodes obovate; leaf base rounded *C. aruna*
44. Leaves adaxially with red patch along the midrib *C. candida*
44. Leaves adaxially with green midrib 45
45. Staminodes white *C. singularis*
45. Staminodes lower half white, upper half yellow, central with purple patch *C. glans*
46. Rhizome not branched 47
46. Rhizome branched 49
47. Inflorescence lateral and terminal *C. angustifolia*
47. Inflorescence terminal 48
48. Sheaths glabrous; leaf abaxially glabrous *C. plicata*
48. Sheaths pubescent; leaf abaxially hairy or glabrescent at least at the apex *C. attenuata*
49. Inflorescence terminal 50
49. Inflorescence usually lateral 60
50. Rhizome creeping *C. rubrobracteata*
50. Rhizome with branches non-creeping 51
51. Anther ecalcarate 52
51. Anther calcarate 53
52. Flowers yellow or orange-yellow *C. aurantiaca*
52. Flowers cream-white with yellow median band *C. roscoeana*
53. Bracts glabrous. 54
53. Bracts pubescent 55
54. Ovary glabrous *C. antinaia*
54. Ovary pubescent *C. sattayasaorum*
55. Coma bracts greenish-white *C. viridiflora*
55. Coma bracts pink or white with pink at tip .. 56
56. Peduncle red *C. phrayawan*
56. Peduncle green 57
57. Ovary glabrous *C. petiolata*
57. Ovary pubescent 58
58. Leaves reddish-purple along the midrib adaxially *C. wanenlueanga*
58. Leaves green along the midrib adaxially ... 59
59. Rhizome pale yellow with the smell of green mango *C. amada*
59. Rhizome deep orange-yellow without the smell of green mango *C. longa*

- 60. Leaves abaxially pubescent 61
- 60. Leaves abaxially glabrous 65
- 61. Leaves adaxially green with green midrib .. 62
- 61. Leaves adaxially green with red or reddish-purple patch along the midrib 63
- 62. Rhizome yellow; lamina broadly lanceolate ..
..... *C. aromatica*
- 62. Rhizome pale yellow; lamina oblong
..... *C. elata*
- 63. Bracts glabrous *C. zedoaroides*
- 63. Bracts pubescent 64
- 64. Inflorescence cylindrical, >10 cm long; bracts green, short hairy on both surfaces
..... *C. latifolia*
- 64. Inflorescence almost globular, <10 cm long; bracts bright green to brownish green with pale green venation, adaxially puberulent, abaxially glabrous *C. globulifera*
- 65. Petioles and leaf-sheaths reddish brown
..... *C. rubescens*
- 65. Petioles and leaf-sheaths green 66
- 66. Leaves adaxially green with red or reddish-purple patch along the midrib 67
- 66. Leaves adaxially green with green midrib .. 69
- 67. Rhizome aeruginous green *C. aeruginosa*
- 67. Rhizome yellow or orange 68
- 68. Corolla lobes whitish or with very slight pinkish shade; rhizome pale straw coloured to yellowish white *C. picta*
- 68. Corolla lobes conspicuously pink to reddish; rhizome deep bright orange to yellow-orange *C. zanthorhiza*
- 69. Fertile bracts pale pink; rhizome pale ochraceous *C. comosa*
- 69. Fertile bracts green; rhizome white to pale yellow 70

- 70. Bracts glabrous *C. leucorrhiza*
- 70. Bracts minutely puberulous on both sides
..... *C. mangga*

Key to all species of *Curcuma* subgenus *Ecomata*

- 1. Corolla tube longer than bracts; petiole very distinct from leaf blade *C. supraneana*
- 1. Corolla tube shorter than bracts; leaf-blade tapering into the petiole 2
- 2. Anther spurs filamentous or <2 mm long ... 3
- 2. Anther spurs conical or cylindrical or >2 mm long 10
- 3. Staminodes with purple colour 4
- 3. Staminodes without purple colour 5
- 4. Inflorescence terminal; staminodes white with dark purple at apex *C. pierreana*
- 4. Inflorescence lateral; staminodes light yellow to white with a dark purple patch at base
..... *C. pambrosima*
- 5. Leaves puberulous on both surfaces
..... *C. chantaranothaii*
- 5. Leaves adaxially glabrous or glabrous on both surfaces 6
- 6. Staminodes yellow-orange with light yellow at base *C. vitellina*
- 6. Staminodes white, or with yellow in the centre or at the apex 7
- 7. Rhizome crawling; leaf base attenuate
..... *C. cochinchinensis*
- 7. Rhizome ovoid; leaf base oblique, rounded to sub-cordate 8
- 8. Calyx pale purple, puberulent; filament >5 mm long *C. pitukii*
- 8. Calyx white, glabrous; filament <5 mm long 9
- 9. Anther crest pure white, apex rounded, 1.5–2 mm long *C. eburnea*

9. Anther crest yellow, apex obtuse, 1.0–1.5 mm long *C. arida*
10. Inflorescence terminal 11
10. Inflorescence lateral 22
11. Leaves adaxially glabrous 12
11. Leaves adaxially with hairy along the veins or pubescent 17
12. Stamines yellow or light orange; leaves abaxially glabrous 13
12. Stamines white; leaves abaxially pubescent 16
13. Leaf adaxially usually green with red patch along the midrib 14
13. Leaf adaxially green without red patch along the midrib 15
14. Flowers opened-form; peduncle <10 cm long *C. siamensis*
14. Flowers closed-form; peduncle >10 cm long *C. stolonifera*
15. Stamines rhomboid, with dark red dot at the base *C. rhomba*
15. Stamines asymmetrical trullate to ovate, without red dot at the base *C. rangsimae*
16. Labellum diamond-shaped, white with a yellow patch in centre and red spots at the base, white with dark purple spots at base *C. peramoena*
16. Labellum suborbicular, white with two deep orange bands at the centre with deep purple lines at the base *C. woodii*
17. Corolla lobes whitish-green to pale green; leaf base cuneate to attenuate *C. putii*
17. Corolla lobes pink, red or purple; leaf base oblique, rounded or cordate 18
18. Stamines lower half red to dark red, upper half orange-yellow 19
18. Stamines pale yellow to yellow 20
19. Inflorescence almost sessile with peduncles *c.* 1.5 cm long; bracts light green with more or less reddish tinge and prominent veins; Labellum yellowish orange with reddish to purple margins *C. bicolor*
19. Inflorescence with longer peduncles to 13 cm long; bracts white, pink to dark red; labellum bright orange with various degrees of red ornamentation *C. flammea*
20. Spike >8 cm long; stamines pale yellow; corolla lobes white to pale yellow *C. cinnabarina*
20. Spike <8 cm long; stamines yellow; corolla lobes red 21
21. Anther spurs *c.* 2 mm long; bracts pubescent on both surfaces *C. stenochila*
21. Anther spurs *c.* 5 mm long; bracts glabrous on both surfaces *C. kayahensis*
22. Stamines purple or with purple at base .. 23
22. Stamines white or yellow or orange 25
23. Leaf base cuneate; labellum pale pink to dark purple with yellow median band .. *C. ecomata*
23. Leaf base cordate or rounded; labellum white with yellow or light orange 24
24. Labellum apex strongly recurved with horn-like lobes, light orange with the deep orange line up; stamines bright orange with dark purple tinge at base *C. corniculata*
24. Labellum apex curved inward, white with yellow margins, and golden yellow line up; stamines lower half white, upper half golden yellow, and a purple patch at base *C. glans*
25. Labellum yellow or orange 26
25. Labellum white or cream white with a yellow median band 30
26. Anther almost straight in the side view; stamines golden yellow, gradually fades to pale yellow at base, with reddish V-shaped or triangular patch at base *C. achrae*
26. Anther L-shape; stamines without reddish patch at base as above 27

- 27. Leaves base cuneate; sheath and petiole pubescent *C. flaviflora*
- 27. Leaves base obtuse or rounded to cordate; sheath and petiole glabrous 28
- 28. Epigynous glands c. 15 mm long; anther thecae 3–4 mm long *C. xanthella*
- 28. Epigynous glands 4–6 mm long; anther thecae 6–7 mm long 29
- 29. Anther crest apex emarginate; long peduncle; bract with various degree of red tinge
.....*C. sahuynhensis*
- 29. Anther crest apex obtuse to rounded; short peduncle; bract green *C. aruna*
- 30. Leaves adaxially green with red patch along the midrib 31
- 30. Leaves adaxially green without red patch along the midrib 32
- 31. Anther almost straight in side view
.....*C. candida*
- 31. Anther L-shaped (obtuse angle) in side view
..... *C. newmanii*
- 32. Bract green; labellum white, with yellow median band *C. singularis*
- 32. Bracts cream white at the base with increasing red tinge towards apex and margins; labellum cream white, sometimes pale pinkish basally, with deep purple–red or dark red bands placed next to the yellow median band *C. tongii*

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