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Curcuma woodii (Zingiberaceae), a new species from Thailand

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Abstract

Curcuma woodii, a new species of *Curcuma* subg. *Ecomata* (Zingiberaceae) from Thailand is described and illustrated here. It differs from *C. rhomba* by the leaf blades abaxially pubescent, the bracts whitish green, the labellum white with orange bands at the center, the lateral staminodes white with orange dots at the apex, and the ovary nearly glabrous.

Key words: *Curcuma*, Thailand, new taxa, *Ecomata*, molecular diagnosis, DNA barcode

Introduction

Curcuma L. (1753: 2) is one of the largest genera in the Zingiberaceae which comprises of approximately 120 species, distributed in the tropics of Asia from India to South China, Southeast Asia, Papua New Guinea and Northern Australia (Wu & Larsen 2000). Tropical Asia and South Asia are the diversity hotspots of the genus. Recently, several new species of *Curcuma* from Asia were described: *C. bella* Maknoi, K. Larsen & Sirirugsa (2011: 121), *C. arracanensis* W. J. Kress & V. Gowda (2012: 10), *C. leonidii* Škorničk. & Luu (2013: 37), *C. newmanii* Škorničk. and *C. xanthella* Škorničk. (2013: 170, 172), *C. gulinqinensis* N. H. Xia & J. Chen (2013: 714), *C. pygmaea* Škorničk. & Šída f. (2014: 639), *C. peramoena* Souvann. & Maknoi (2014: 125), *C. arida* Škorničk. & N. S. Lý and *C. sahuynhensis* Škorničk. & N. S. Lý (2015: 182, 185). According to the recent study on the phylogeny of the genus *Curcuma*, three subgenera (subgen. *Curcuma*, subgen. *Hitcheniopsis*, and subgen. *Ecomata*) were proposed (Záveská *et al*. 2012). Five out of nine new species above (*C. newmanii*, *C. xanthella*, *C. peramoena, C. arida and C. sahuynhensis*) belong to subgen. *Ecomata*. Thailand, as one of *Curcuma* diversity centers, has nearly 40 *Curcuma* species (Sirirugsa *et al*. 2007). Among them, six species are also from subgen. *Ecomata*, e.g. *C. ecomata* Craib (1912: 401), and *C. bicolor* J. Mood & K. Larsen (2001: 208).

When many plants from Thailand were introduced by Tom Wood (ginger curator from US) to South China Botanical Garden, the *Curcuma* species "Band of Gold" (which is named for its distinctive bicolored flowers of orange and white) attracted our attention. Early in 1992, the second author bought them from the local wild plant market in Sae Kaeow and planted them at Nong Nooch Tropical Botanical Garden. Tom Wood imported them from Nong Nooch Tropical Botanical Garden to South China Botanical Garden in 2010. Under cultivation at South China Botanical Garden in Guangzhou, the vegetative growth started in May, maturing to about 60 cm tall in late August. The first inflorescence emerging from the base of the pseudostems as in *C. bicolor* consists of white floral bracts. The flowers are one of the showiest in the genus *Curcuma*. Further studies confirmed that this plant represented a new species which is described and illustrated below.

Taxonomy

Curcuma woodii N. H. Xia & J. Chen, *sp. nov.*

Similar to *Curcuma rhomba* J. Mood & K. Larsen (subgen. *Ecomata*) in several characters but differs in the leaf blades ab-

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axially pubescent, the bracts whitish green, the labellum white with orange bands at the center, the lateral staminodes white with orange dots at the apex, and the ovary nearly glabrous.

Type:—China, Guangdong, Guangzhou, South China Botanical Garden (cultivated, introduced from Thailand), 28 September 2010, *J. Chen & T. Wood 201010* (holotype: IBSC). **Figs. 1 & 2.**

Herbs ca. 40–60 cm alt., perennial. *Main rhizome* slender, fibrous, multi-branched, 0.6–1 cm in diam., cream-colored inside; lateral rhizome creeping, slender, 0.6–1.0 cm in diam., white inside; *root tubers* ovate, white inside. *Leafy shoots* up to 60 cm tall, leaves 5; *leaf sheaths* green, pubescent; *petioles* 16–23 cm long, pubescent; *ligules* ca. 3 mm long, hairy on the margin; *blades* 26–30 × 9–12 cm, ovate to elliptic, green on both sides, adaxially glabrous, abaxially pubescent, base rounded, apex acuminate. *Inflorescence* terminal, ca. 4.5–5 × 4.5–5 cm; *peduncles* 2–3 cm long, pubescent; *bracts* ca. 2.5–3 × 3–3.5 cm, ovate to elliptic, whitish green, pubescent on both sides, apex obtuse; *bracteoles* absent. *Flowers* 4–4.7 cm long, exserted from the bracts, white. *Calyx* ca. 2 cm long, white, glabrous, 2-teethed. *Corolla tubes* ca. 3 cm long, white, pubescent; *lateral corolla lobes* ca. 1.4 × 0.5 cm, white to pinkish, glabrous; *dorsal lobe* ca. 1.5 × 0.6 cm, white, densely villous at throat. *Lateral staminodes* petaloid, ca. 1.5 × 0.9 cm, elliptic, white, deep orange dots at the top and deep purple dots at the base; *labellum* ca. 1.6 × 1 cm, suborbicular, unilaterally split for ca. 6 mm long, white, two deep orange bands at the center with deep purple lines at the base, 2-teethed. *Filament* broad, flat, white; *anther* ca. 9 mm long, white, crest ca. 1 × 1 mm, spur short, ca. 1 mm long, white. *Ovary* 2–4 mm long, nearly glabrous; *stigma* white, glabrous; *epigynous glands* 2, ca. 7 mm long, linear. *Capsule* subglobose, 3-valved, dehiscent; *Seeds* obovate, light brown, with white laciniate aril.

Molecular diagnosis:—The new species differs from all other species of *Curcuma* at the following nucleotide positions in the plastid *matK* gene, position 1008: Adenine not Guanine; in the plastid *trnH-psbA* spacer, position 102: Adenine not Thymine; 103: Guanine not Thymine; 109: Guanine not Thymine; 110: Adenine not Thymine; 184: Adenine not Cytosine; (Coordinates from *Curcuma rhomba* complete *trnK* region, GenBank accession no. JQ409668.1, *matK* gene from 780-2327; *C. rhomba* partial *trnH-psbA* spacer, Genbank accession no. JQ409783.1) (Table 1).

TABLE 1. *Curcuma*-specific substitutions in chloroplast and nuclear DNA regions as compared to 96 other accessions representing 49 species of *Curcuma*.

Position	Specific substitution	Notes
***Plastid matK* region**[1]		
1008	G → A	*Curcuma woodii*-specific
Plastid *trnH-psbA* spacer[2]		
102	T→ A	*Curcuma woodii*-specific
103	T→ G	*Curcuma woodii*-specific
109	T→ G	*Curcuma woodii*-specific
110	T→ A	*Curcuma woodii*-specific
184	C→ A	*Curcuma woodii*-specific

[1] coordinates from *Curcuma rhomba* complete *trnK* region (GenBank accession no. JQ409668.1), *matK* gene from 780 to 2327.

[2] coordinates from *Curcuma rhomba* partial plastid *trnH-psbA* spacer (GenBank accession no.JQ409783.1)

Cytology:—Chromosome numbers were counted in actively growing root tips from the cultivated plants at South China Botanical Garden. The root tips were pretreated with 0.002 M 8-hydroxyquinoline for 6 h and fixed in Carnoy I, then macerated in 1N HCl at 60°C for 5 min, and stained in Carbol fuchsin. Metaphase chromosomes were observed and photographs were taken under the OLYMPUS BX41 microscope (Olympus, Tokyo, Japan).

The metaphase chromosomes were counted to be $2n = 42$ (Fig. 2A). The chromosomes of *C. woodii* were very small, ca. 1.5 μm in lengths. As a result of the small chromosome sizes, no clear morphological differences were observed. Centromeres were difficult to detect; thus, karyotype analysis was not performed.

Distribution and Habitat:—This species was purchased at the local wild plant market in Sae Kaeow, just at the border of Cambodia. Its natural range is unknown.

Phenology:—Flowering from July to September at South China Botanical Garden.

Etymology:—The specific epithet, '*woodii*', was named after Tom Wood, who brought this species to South China

Botanical Garden. Tom Wood made a great contribution to collecting gingers from South Asia, Australia, America and Arica to South China Botanical Garden.

Notes:—This species is similar to *C. rhomba* by the inflorescence emerging from the base of the pseudostems and anther shape. Their major differences lie in the bracts color, the flower parts color and shape (Table 2, Figs 1 & 2).

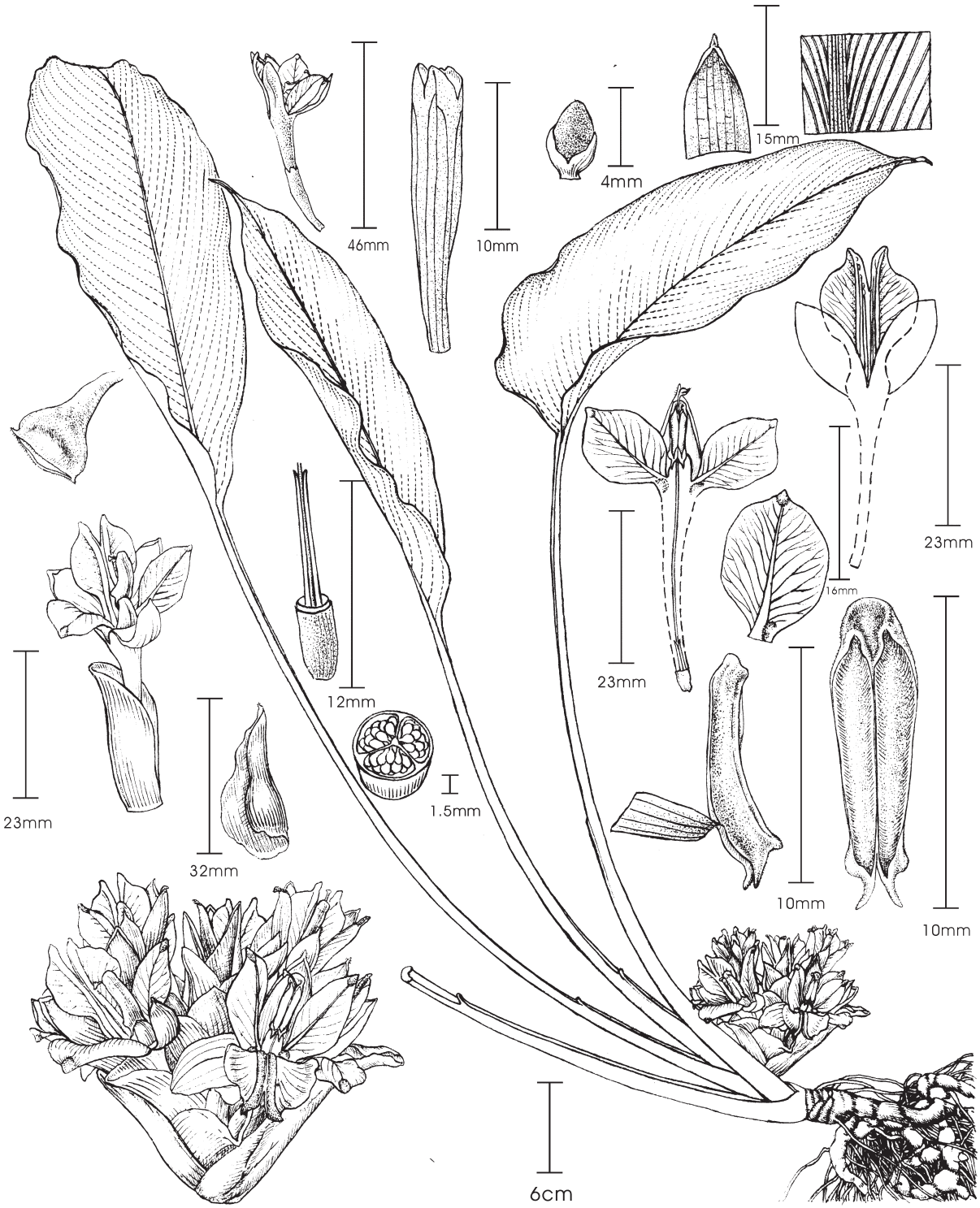

FIGURE 1. *Curcuma woodii* N. H. Xia & J. Chen *sp. nov*. A. Inflorescence with rhizomes and leaves. B. Detail of leave. C. Inflorescence. D. Flower (dorsal view). E. Bract. F. Flower (lateral view). G. Calyx. H. Corolla dorsal lobes, lateral staminodes and anther. I. Corolla lateral lobes and labellum. J. Corolla dorsal lobe. K. Detail of lateral staminode. L. Anther (front view). M. Anther (lateral view). N. Ovary (cross section). O. Stigma. P. Epigynous glands and ovary. Q. Seed. Drawn by: Liu Yun-Xiao.

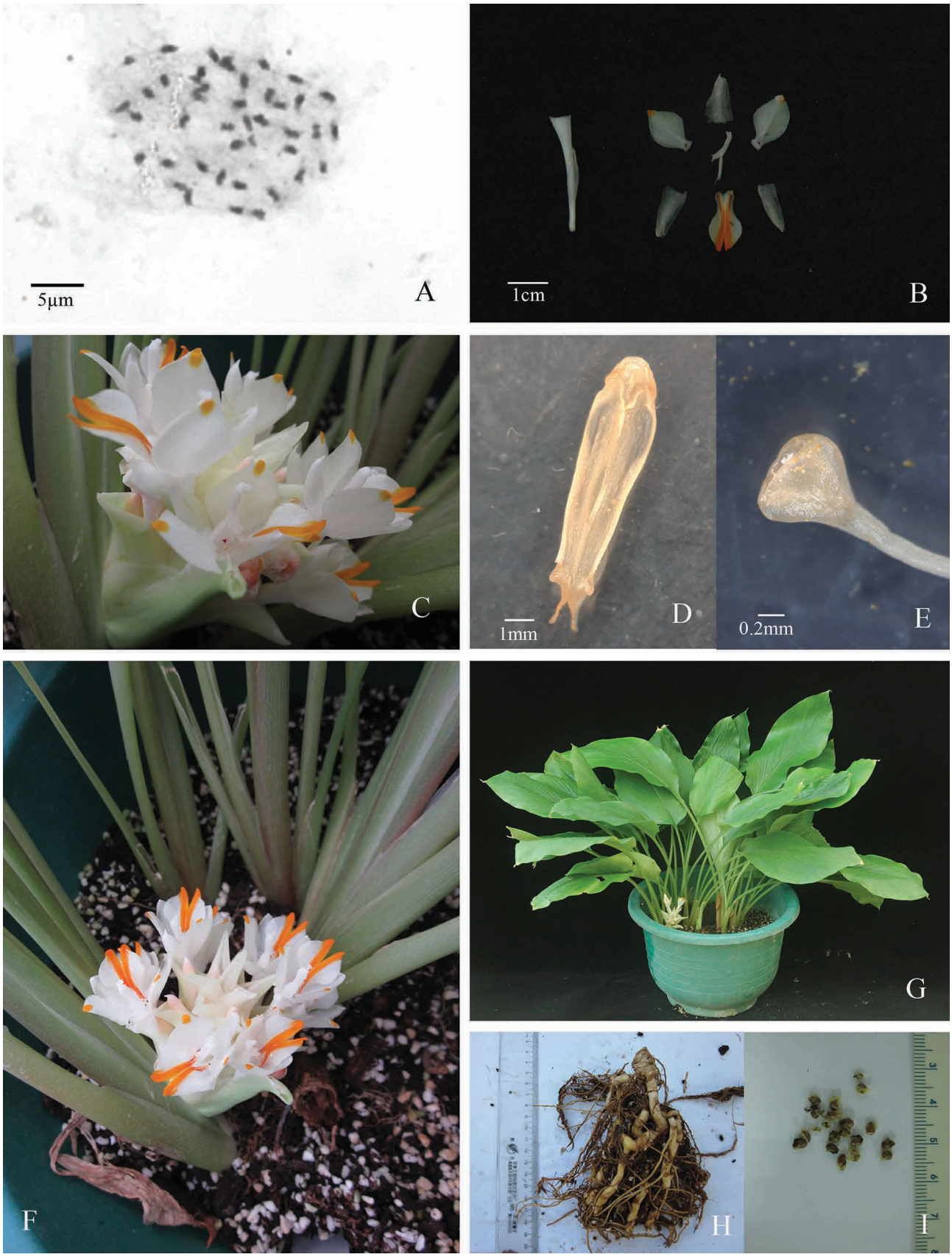

FIGURE 2. *Curcuma woodii* N. H. Xia & J. Chen *sp. nov*. A. Chromosome number 2*n* = 42. B. Flower dissection. C. Flowers. D. Detail of anther. E. Detail of stigma. F. Terminal inflorescence emerging from the base of the pseudostems. G. Whole plants showing leaves and terminal inflorescence. H. Rhizomes. I. Seeds.

The flower shape of *C. woodii* is similar to *C. pierreana* Gagnepain (1907: 405) and *C. peramoena*. But this species is different from them by the leaf blades larger, the bracts whitish, the lateral staminodes white with orange dots at the apex and the ovary nearly glabrous (Table 2).

TABLE 2. Characters comparison of *Curcuma woodii*, *C. rhomba, C. pierreana* and *C. peramoena*

	C. *woodii*	*C. rhomba*	*C. pierreana*	*C. peramoena*
Plant height (cm)	40–60	ca.110	ca. 20	Up to 35
Petiole length (cm)	16–23	6–27.5	9–11	10–17
Leaves length (cm)	26–30 × 9–12	29–46 × 9–18.3	15–20 × 6–8	15–19 × 5–8
Purple cloud in the upper side of Lamina	absent	absent	present	absent
Lamina	adaxially glabrous, abaxially pubescent	glabrous	glabrous	adaxially glabrous, abaxially pubescent
Peduncle length (cm)	2–3	ca. 2	sessile	4–6
Fertile bracts color	whitish green	red	pink	light brown to red at the base to light green at the apex
Corolla color	white to pinkish	white	white	red
Labellum color	white with two wide deep orange bands at the center	orange	white with yellow bands at the center	white with two wide yellow bands at the center
Lateral staminoide color	white with orange dots at the apex	orange, dotted dark red at the base	white with purple at the apex	white
Epigynous glands Length (mm)	ca.7	ca. 9	unknown	ca. 9
Ovary	nearly glabrous	pubescent	pubescent	densely pubescent

Only a single specimen (D. J. Middleton *et al.* 1220, barcode No.: E00196143) deposited at Royal Botanical Garden Edinburgh (E) and collected from Kui Buri National Park in Prachuap Khiri Khan in Thailand on 19th August, 2002, is a possible match for *C. woodii.* However, to confirm the identity of this specimen, re-collection from Kui Buri National Park is needed.

Additional specimens examined (paratypes):—China, Guangdong, Guangzhou, South China Botanical Garden (cultivated, introduced from Thailand), 9 September 2013, *J. Chen 201343* (IBSC).

Discussion

We initially thought *Curcuma woodii* might be an artificial hybrid. After molecular-phylogenetic work and blasting in NCBI website, we are confident that *C. woodii* is a new species. Sequencing of 96 accessions of *Curcuma* representing 49 species (plus relevant outgroups) for the nuclear ITS2 region, and the plastid *rbcL*, *matK*, *trnH-psbA* and *trnL-F* spacer region revealed that *C. woodii* has its specific DNA barcode and represents a new species (Chen *et al*. 2015). Our molecular phylogeny study of *Curcuma* showed that *C. woodii* is closely related to *Smithatris supraneanae* W. J. Kress & K. Larsen (2001: 226), which were nested within subgen. *Ecomata* (see Figure 3 in this paper, Figure 2 in Chen *et al*. 2015: 344). The phylogeny study also supported that *Curcuma* and *Curcuma*-like genera were paraphyletic, which was in conjunction with earlier investigations (Kress *et al*. 2002, Ngamriabsakul *et al*. 2004, Záveská *et al*. 2012). Based on the molecular phylogeny study of *Curcuma*, Zaveska *et al*. (2012) suggested *Curcuma*-like genera must be transferred to the genus *Curcuma*. Later, the *Curcuma*-like genera are formally sunk to *Curcuma* by Leong-Škorničková *et al*. (2015). But we did not get enough samples of *Curcuma*-like genera to reconstruct the phylogeny of these genera, which need further study to make it success.

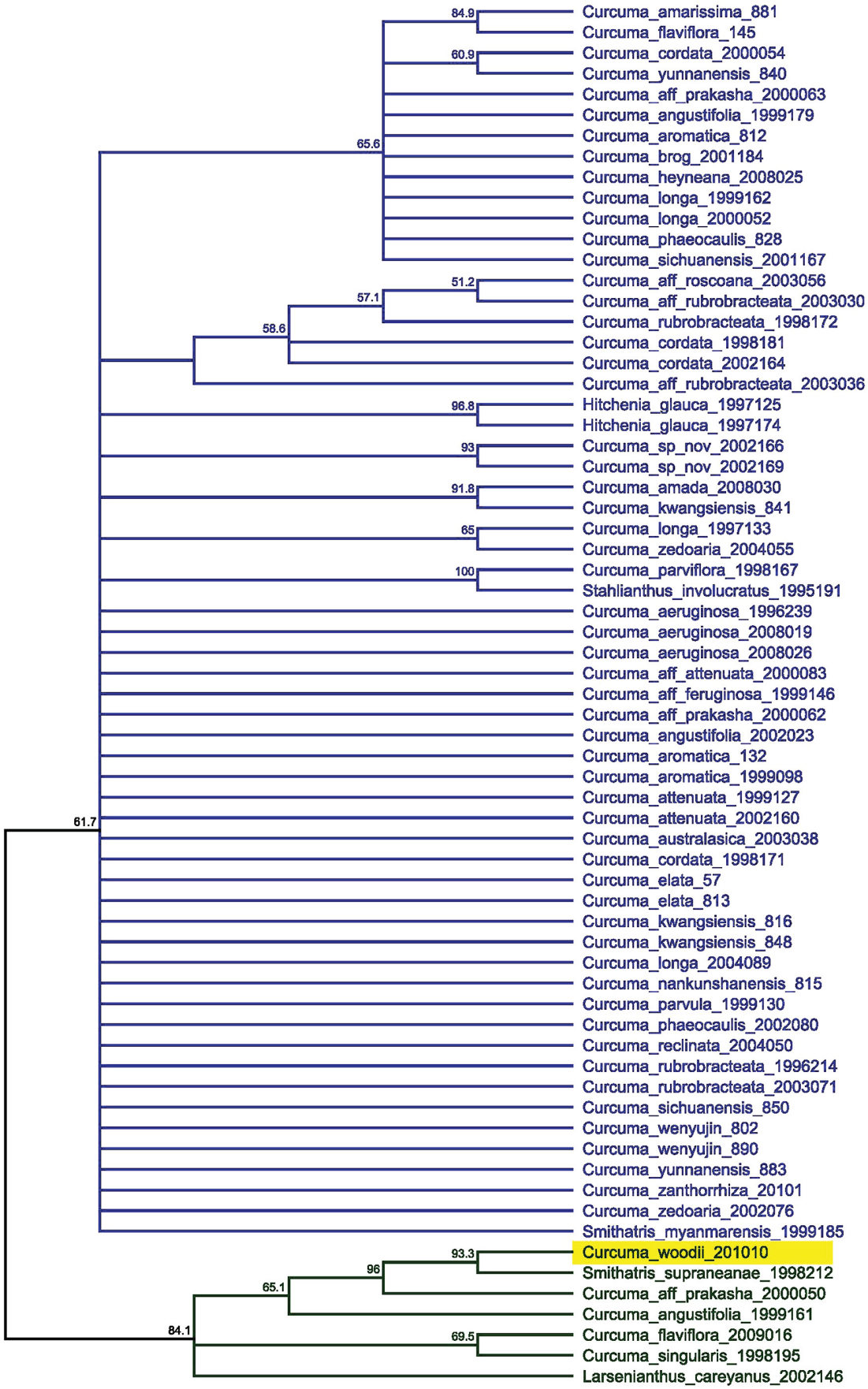

FIGURE 3. Neighbor-joining tree for *Curcuma* and closely related genera using the ITS2 DNA barcode. Accessions were suffixed by voucher numbers, and corresponding subgenera were color-coded. Blue color, subg. *Curcuma*; green, subg. *Ecomata*. Clade nomenclature followed Záveská *et al.* (2012).

The different ploidy levels in *Curcuma* were indicated in many cytological studies (Chen *et al*. 2013). The widely accepted basic chromosome number $x = 21$ (Ramachandran 1961, Chen and Chen 1984, Joseph *et al*. 1999, Islam 2004). However, Leong-Škorničková *et al*. (2007) suggested that $x = 7$ should be considered a primary basic chromosome number, at least for the majority *Curcuma* species belonging to subgenus *Curcuma*. The basic number $x = 21$ appeared too high to be the primary one. Raghavan and Venkatsubban (1943), Venkatasubban (1946), and Ramachandran (1961) (1946) believed that this basic number might have been derived either by dibasic amphidiploidy (by combination of lower basic numbers of nine and 12 found in some genera in the family) or by secondary polyploidy. Nevertheless, based on the common basic number of $x = 21$, this species corresponds to $2x$ cytotypes.

The position of the inflorescence was very important characters to distinguish different *Curcuma* species, especially in 19th century. *Curcuma* species have terminal, or lateral inflorescences or both in the same species. For example, *C. longa* L. (1753: 2) only produces typical terminal inflorescences; *C. aromatica* Sablisbury (1807: pl. 96) produces typical lateral inflorescences; Santapau (1945) reported that *C. pseudomontana* Graham (1839: 210) can produce both early lateral and later central inflorescences. However, *C. woodii* produced non typical terminal inflorescences. Its terminal inflorescences with very short peduncles emerge at ground level, pushing the leaf sheaths apart centrally or out to side, as in *C. bicolor*, and *C. rhomba* J. Mood & K. Larsen (2001: 213). This characteristic of inflorescence position may represent a third inflorescence type in *Curcuma* species.

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