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Taxonomic studies on the Chinese Costaceae I: a new name and two new combinations

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Abstract

Costus chinensis and *C. oblongus* (Costaceae) has been previously placed in synonymy under *C. lacerus*. Our critical examination of herbarium specimens including type material demonstrates that they are morphologically distinct from each other. Therefore, the independent specific status of *C. chinensis* and *C. oblongus* is reinstated. According to recent studies, *Costus chinensis* as well as other two Chinese species, *C. oblongus* and *C. viridis*, should be transferred to *Hellenia*. Thus, a new name for *C. chinensis*, and two new combinations are proposed. A detailed description of *C. chinensis* along with a distribution map of three allied species is also provided.

Keywords: Costaceae, *Hellenia*, new combination, new name

Introduction

Costaceae Nakai, a small family of Zingiberales widespread in humid tropical regions of the world, is easily distinguished from other families within the order by well-developed and sometimes branched aerial shoots that have a characteristic monistichous (one sided) spiral phyllotaxy, tubular leaf sheaths, and petaloid labellum formed by fusion of five sterile staminodes (Kirchoff & Ruitshauser 1990, Larsen 1998, Wu & Larsen 2000, Specht & Stevenson 2006). The family consists of more than 143 species and is classified into seven genera (Larsen 1998, Wu & Larsen 2000, Specht & Stevenson 2006). Among these genera, *Cheilocostus* C.D.Specht in Specht & Stevenson (2006: 159) was established to accommodate a group of SE Asian species with an open labellum, classified at that time as members of the broadly defined genus *Costus* Linnaeus (1753: 2). Later, Govaerts (2013) argued that *Cheilocostus* is superfluous and hence illegitimate, and *Hellenia* Retzius (1791: 18), which has priority to *Cheilocostus*, should be the correct name. So far, five *Costus* species from Asia were transferred to *Hellenia*, namely, *H. borneensis* (A.D.Poulsen in Poulsen & Specht 2010: 136) Govaerts (2013: 64), *H. globosa* (Blume 1827: 62) Dutta (2010: 152), *H. lacera* (Gagnepain 1903: 261) Govaerts (2013: 64), *H. sopuensis* (Mass & Mass 1983: 325) Govaerts (2013: 64) and *H. speciosa* (J.Koenig 1783: 75) Dutta (2013: 228).

Costus lacerus Gagnepain (1903: 261) (≡ *Hellenia lacera*) was firstly described based on the specimens (*unknown collector s.n.*, Fig. 1A–B) collected from Labdah [Ladak], Sikkim, India. Gagnepain (1903) stated that this species is characterized by the hairy inflorescence, the rounded instead of sharply pointed apex of bracts destroying itself into strips instead of being firm and persistent, and the short anther crest with an irregularly tridentate apex.

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FIGURE 1. Type specimens of *Hellenia lacera, H. deliniana* and *H. oblonga*. A. Holotype of *H. lacera* (*unknown collector s.n.*, herbarium no. P00686609). B. Isotype of *H. lacera* (*unknown collector s.n.*, herbarium no. G00164691). C. Holotype of *H. deliniana* (*P.Y. Mao 2687*, herbarium no. IBSC0005266). D. Holotype of *H. oblonga* (*S.Q. Tong & C.J. Liao 24866*, herbarium no. KUN1219295).

Costus chinensis Wu & Chen (1978: 41) (Fig. 1C) was described based on several specimens collected from Guangxi, Xizang and Yunnan of China and the specimen *P.Y. Mao 2687* (IBSC) was designated as the holotype. In the protologue, the authors stated that it is characterized by the densely hirsute bracts without a rigid tip. Maas (1979) thought that *C. lacerus* is rather variable with regard to the indumentum of bracts, bracteole and calyx, and as the indumentum variation is rather continuous, it cannot be used for distinguishing varieties or subspecies. Therefore, he identified some Chinese material (e.g. *Tsai 61176* collected from Pingbian County and *Henry 11265* collected

from Mengzi City) as *C. lacerus* rather than recognizing them as a different taxon, and extended the distribution of *C. lacerus* to China and Thailand. Tsai & Tong (1981) then reduced *C. chinensis* to a synonym of *C. lacerus*, and this treatment was followed by Wu & Larsen (2000).

Tong (1989) described *C. oblongus* Tong (1989: 291) (Fig. 1D) based on several specimens collected from Yunnan and Xizang. Two collections originally cited under *C. chinensis* by Wu & Chen (1978), i.e. *J.S. Xin 482* and *Qinghai-Xizang Expidition s.n.*, were redetermined as *C. oblongus* by Tong. Meanwhile, he accepted Tsai & Tong's treatment to reduce *C. chinensis* as synonymy under *C. lacerus*. *Costus oblongus* is said to differ from *C. lacerus* in white (vs. pink) flowers, oblong (vs. ovate or broadly ovate) bracts, narrowly oblong (vs. ovate) bracteoles, triangular (vs. rounded) calyx lobes and oblong stamen without (vs. with) a convex apex. *Costus oblongus* was accepted by some researchers as a distinct species (Tong 1997, Wu & Larsen 2000), but Specht (2004) reduced it to a synonym of *C. lacerus* without further elucidation.

The present study was aimed to clarify the identities of *Costus chinensis*, *C. lacerus* and *C. oblongus*, which was part of the revision of Costaceae in China. The review of literature of the genus *Costus* showed that the correct generic placement has not been done for all Chinese *Costus* species. Meanwhile, lack of taxonomically important morphological features of herbarium specimens of *Costus* species from China, in particular, the floral structure and colour of flowers and bracts and the number and shape of buds at each node, which are important characters for species determination, as well as poor original descriptions and/or type material, hindered a satisfactory systematic treatment of the genus in this country. There are also several presumably well-known species to which a certain name has been applied for an extended period of time, sometimes simultaneously to more than one species, and yet an understanding of what these species really are is difficult. Thus, an updated revision of *Costus* species from China is needed.

Materials and methods

For morphological comparisons, the herbarium specimens deposited in KUN and IBSC (acronyms according to Thiers, continuously updated) were examined. Specimens of related species deposited in major Chinese herbaria (IMDY, NAS and PE) were accessed via the Chinese Virtual Herbarium (https://www.cvh.ac.cn). Additional specimens from Asian countries were accessed as high-resolution digital images from the following herbaria: K, MICH, P, and US via their herbaria websites or Global Biodiversity Information Facility (GBIF, https://www.gbif.org/).

The redescription of *C. chinensis* was based on the specimens collected by *Pingbian Chinese Medicine Expedition* and the specimens from the type locality (collection details were given in the "Taxonomic treatments" part). The style of description followed Maas-van de Kamer *et al.* (2016) and the terminology in general followed Beentje (2016). The map resources came from Chinese Society for Geodesy, Photogrammetry and Cartography, No. GS (2019) 1078 (http://bzdt.ch.mnr.gov.cn). Adobe Illustrator 2020 and Adobe Photoshop 2020 were used for image editing.

Results and discussion

Our results showed that *Costus chinensis* can be readily distinguished from *C. lacerus* by the apex of the anther appendage (slightly incised vs. deeply tridentate, Fig. 2A–B), the shape (oblong or flabellate vs. ovate or rounded, Fig. 2G–H), the indumentum (densely villous externally vs. villous externally) and the dilacerations (not decaying into fibers at anthesis vs. decaying into fibers at anthesis) of bracts, the indumentum of bracteoles (densely villous externally, margin ciliate vs. villous externally, margin arachnoid), the shape (narrowly triangular vs. oblong), the indumentum (margin ciliate vs. margin arachnoid) and the apex (acute, not decaying into fibers at anthesis, margin ciliate vs. obtuse, decaying into fibers at anthesis, margin arachnoid, Fig. 2J–K) of calyx lobes.

Costus chinensis differs from *C. oblongus* in the number of buds at each node (3 vs. 1, Fig. 2E–F), the shape (oblong or flabellate, nearly fattened, margin apically not rolled inwards vs. oblong or boat-shape, slightly convex, margin apically rolled inwards), the texture (chartaceous vs. coriaceous), the dilaceration (apex not decaying into fibers at anthesis vs. apex decaying into fibers at anthesis, Fig. 2H–I) of bracts, the shape (oblanceolate vs. narrowly oblong), the size (1.1–1.3 × ca. 0.4 cm vs. 1.6–2.8 × 0.6–0.7 cm) and the indumentum (densely villous externally, margin ciliate vs. villous or sparsely villous externally, margin arachnoid) of bracteoles, and the shape (narrowly triangular vs. broadly ovate-triangular) and the dilaceration (apex not decaying into fibers at anthesis vs. apex decaying into fibers at anthesis, Fig. 2K–L) of calyx lobes.

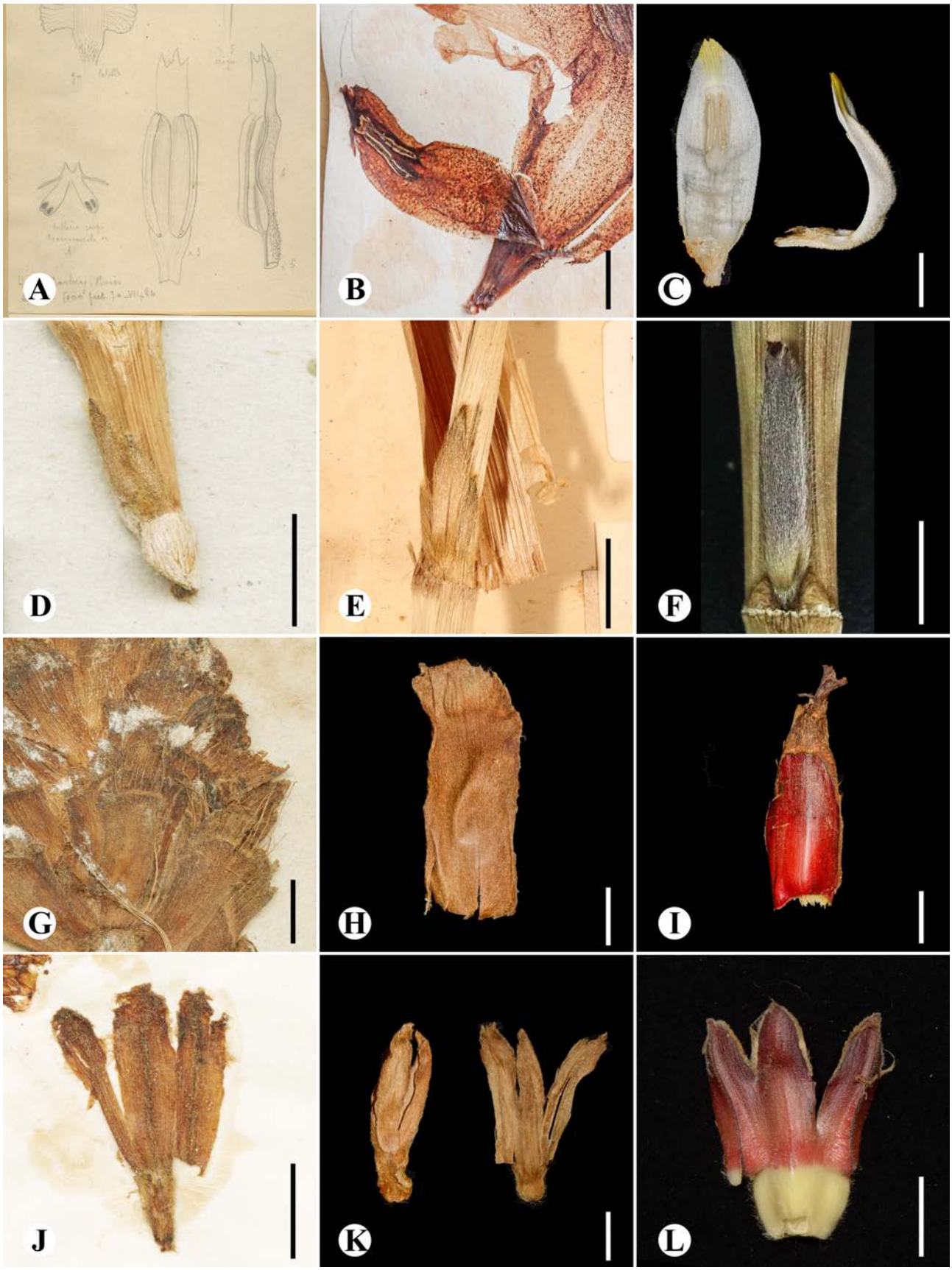

FIGURE 2. Morphological comparison among *Hellenia lacera* (A, D, G, J), *H. deliniana* (B, E, H, K) and *H. oblonga* (C, F, I, L). A–C. Petaloid stamen. D–F. Bud. G–I. Bract. J–L. Ovary, calyx and calyx lobes. Scale bars = 1 cm.

Costus oblongus can be distinguished from *C. lacerus* by the apex of the anther appendage (slightly incised vs. deeply tridentate, Fig. 2A & C), the number of buds at each node (1 vs. 3, Fig. 2D & F), the shape (oblong or boat-shape, slightly convex, margin apically rolled inwards vs. ovate or rounded, nearly fattened, margin apically not rolled inwards) and the texture (coriaceous vs. chartaceous, Fig. 2G, I) of bracts, and the apex of calyx lobes (acute vs. rounded, Fig. 2J & L).

Maas (1979), Tong (1997) and Wu & Larsen (2000) all recognized *C. lacerus* as a widespread species occurring from Sikkim, India, southwestern China to Thailand, but our study demonstrated that the present defined *C. lacerus* includes three species, namely *C. lacerus*, *C. chinensis* and *C. oblongus*, which are morphologically distinct from each other (see Table 1 and Fig. 2), and *C. lacerus* is endemic to Sikkim and Khasia, India, while *C. oblongus* is distributed in West Yunnan and Southeast Xizang, and *C. chinensis* is restrict to South Yunnan (Pingbian County and adjacent areas) (Fig. 5). Therefore, we reinstated the independent specific status of *C. chinensis* and *C. oblongus*.

However, when *C. chinensis* was transferred to *Hellenia*, a later homonym of the previously and validly published *H. chinensis* (Retzius 1791: 18) Willdenow (1797: 5) will be created. Hence, a new replaced name is needed according to Art. 53.1 of the International Code of Nomenclature for algae, fungi, and plants (ICN) (Turland *et al*. 2018). Among the other four Chinese *Costus* species, the combination of *H. speciosa* has been made (Dutta 2013), but the identity and placement of *C. tonkinensis* Gagnepain (1902: 248) is still unclear yet (Maas 1979, Specht 2004). Therefore, only two new combinations for *C. oblongus* and *C. viridis* are proposed here.

Table 1. Morphological comparison among *Hellenia deliniana*, *H. lacera* and *H. oblonga*

Character	*H. deliniana*	*H. lacera*	*H. oblonga*
Bud at each node	3	3	1
Bract			
Shape	Oblong or flabellate, nearly fattened, margin apically not rolled inwards	Ovate or rounded, nearly fattened, margin apically not rolled inwards	Oblong or boat-shape, slightly convex, margin apically rolled inwards
Texture	Chartaceous	Chartaceous	Coriaceous
Indumentum	Densely villous externally	Villous externally	Villous or sparsely villous externally
Dilaceration	Apex not decaying into fibers at anthesis	Apex decaying into fibers at anthesis	Apex decaying into fibers at anthesis
Bracteole			
Shape	Oblanceolate	Narrowly oblong	Narrowly oblong
Size (cm)	1.1–1.3 × ca. 0.4	1–2 × ca. 0.4	1.6–2.8 × 0.6–0.7
Texture	Chartaceous	Chartaceous	Coriaceous
Indumentum	Densely villous externally, margin ciliate	Villous externally, margin arachnoid	Villous or sparsely villous externally, margin arachnoid
Calyx lobe			
Shape	Narrowly triangular	Oblong	Broadly ovate-triangular
Texture	Chartaceous	Chartaceous	Coriaceous
Indumentum	Densely villous externally, margin ciliate	Villous externally, margin arachnoid	Villous or sparsely villous externally, margin arachnoid
Apex	Acute, not decaying into fibers at anthesis	Obtuse, decaying into fibers at anthesis	Acute, decaying into fibers at anthesis
Anther appendage	1–1.1 cm long, apical slightly incised	0.4–0.5 cm long, apical deeply tridentate	1.2–1.3 cm long, apical slightly incised

Taxonomic treatments

Hellenia deliniana Juan Chen, L.Y.Zeng & N.H.Xia, *nom. nov.* Figs. 1C & 3

Replaced name:—*Costus chinensis* Wu & Chen (1978: 41), non *Hellenia chinensis* (Retzius 1791: 18) Willdenow (1797: 5).

Type:—CHINA. Yunnan: Ping-Pien Hsien [Pingbian County], 1260 m, 23 July 1953, *P.Y. Mao 2687* (holotype IBSC0005266!; isotypes IBSC00022238! KUN0335078!, KUN0335079!, PE00075117!).

Perennial *herbs*, 1–2 m high; *stems* stout, spirally twisted, few branched or unbranched at higher nodes. *Leaves* many, spirally arranged on the stem, subsessile, seasonally deciduous; *sheaths* closed, green, coved with coarse and long hairs,

apex arachnoid, deciduous with age; *ligule* 1–2 mm long, truncate, chartaceous; *lamina* elliptic or lanceolate-oblong, 25–40 × 7–13 cm, green, adaxially glabrous, abaxially densely villous, base attenuate or cuneate, apex acuminate; buds 3 at each node, middle one larger and longer than the other two. *Inflorescence* terminal on leafy shoot, ovate, 6–11 × 4.5–8.5 cm; upper *bracts* oblong, lower ones flabellate, 4–5 × 1.5–2.5 (–3) cm, chartaceous, green tinged with red, later becoming red wholly, together with bracteole densely villous externally, glabrous internally, margin with ca. 2 mm long cilia, apically not rolled inwards, apex rounded or obtuse, membranous, not decaying into fibers at anthesis; *bracteole* 1, oblanceolate, slightly folded, single keeled, 1.1–1.3 × ca. 0.4 cm, chartaceous. *Flower* 1 per bract; *calyx* lanceolate, 2.3–3 × 1.0–1.2 cm, red, densely villous externally, glabrous internally, apex 3-lobed, one of the lobes split to the base, lobes narrowly triangle, 0.7–0.8 × 0.5–0.7 cm, chartaceous, 2 posterior lobes strongly keeled, anterior lobe not keeled, not decaying into fibers at anthesis, margin ciliate; *corolla tube* 1.5–1.8 × 1.5–2.5 cm, deep pink, glabrous on both sides; *corolla lobes* obovate, 3.5–5 × 2–2.2 cm, deep pink, glabrous on both sides, apex mucronate; *labellum* trumpet-shaped, not collapsed in the upper side, 6–8 × 8–9 cm, white, with yellow bands at throat, lip margin crisped, glabrous on both sides; *stamen* petaloid, oblong, bent downwards closing the throat, 4–5 × ca. 1.2 cm, white, abaxially hairy, adaxially glabrous; *anther* at upper half of the stamen, 1–1.3 × 0.3–0.5 cm; *anther appendage* 1–1.1 cm long, yellow, apex slightly incised. *Ovary* 8–12 × 6–10 mm, ellipsoid, densely villous externally. *Fruit* ellipsoid, red, 1.5–2.5 cm long, densely villous externally, apex with persistent calyx; *seeds* angular, ca. 2 × 2 mm, usually with a small white fleshy aril, black.

FIGURE 3. *Hellenia deliniana*. A. Inflorescence. B. Flowers. C. Infructescence. D. Bracts, calyces and fruits. Photos by Y.H. Tan; A–B based on *Pingbian Chinese Medicine Expedition 5325231214*; C–D based on *Pingbian Chinese Medicine Expedition 5325231142.*

Distribution and habitat:—*Hellenia deliniana* is endemic to southern Yunnan, China. It grows in shady, moist places in forests or in ravine at elevations of 920–1700 m.

Phenology:—Flowering in June–September; fruiting in August–November.

Etymology:—The specific epithet is to commemorate Prof. Wu De-Lin (Wu Te-Lin) for his remarkable contribution to the taxonomy of Chinese gingers.

Vernacular names:—Chinese name "莴笋花" [wō sǔn huā].

Additional specimens examined:—CHINA. Yunnan: Hekou City, 1100 m, 23 August 1959, *W.X. Liu 655* (KUN0335067, KUN0335068); Mengtsze [Mengzi City], *Henry 11265* (K, US00340945); Pingbian County, Mawei Village, Wanshao mountain, 950 m, 18 September 2012, *Pingbian Chinese Medicine Expedition 5325231214*

(IMDY0023107); ibid., Sanjiawan, 1250 m, 19 November 1987, *H. Li 112* (KUN0335071); ibid., Shengli Village, 920 m, 12 September 2012, *Pingbian Chinese Medicine Expedition 5325231142* (IMDY); ibid., Mua-mua-tou, 1700 m, 23 October 1939, *C.W. Wang & Y. Liu 82638* (PE00075110); Ping-Pien Hsien [Pingbian County], without precise locality, in ravine, 1200 m, 25 June 1934, *H.T. Tsai 61176* (IBSC0022240, KUN0335076, PE00075114, PE00075108).

Hellenia oblonga (S.Q.Tong) Juan Chen, L.Y.Zeng & N.H.Xia, *comb. nov.* Figs. 1D & 4

Basionym:—*Costus oblongus* Tong (1989: 291).

Type:—CHINA. Yunnan: Yingjiang County, 1200 m, 6 August 1983, *S.Q. Tong & C.J. Liao 24866* (holotype KUN1219295!; isotype KUN1219278!).

Distribution and habitat:—Yunnan and Xizang, China. It grows in shady, moist places along forest edges or in ravine at elevations of 700–1700 m.

Phenology:—Flowering from July–September; fruiting from August–October.

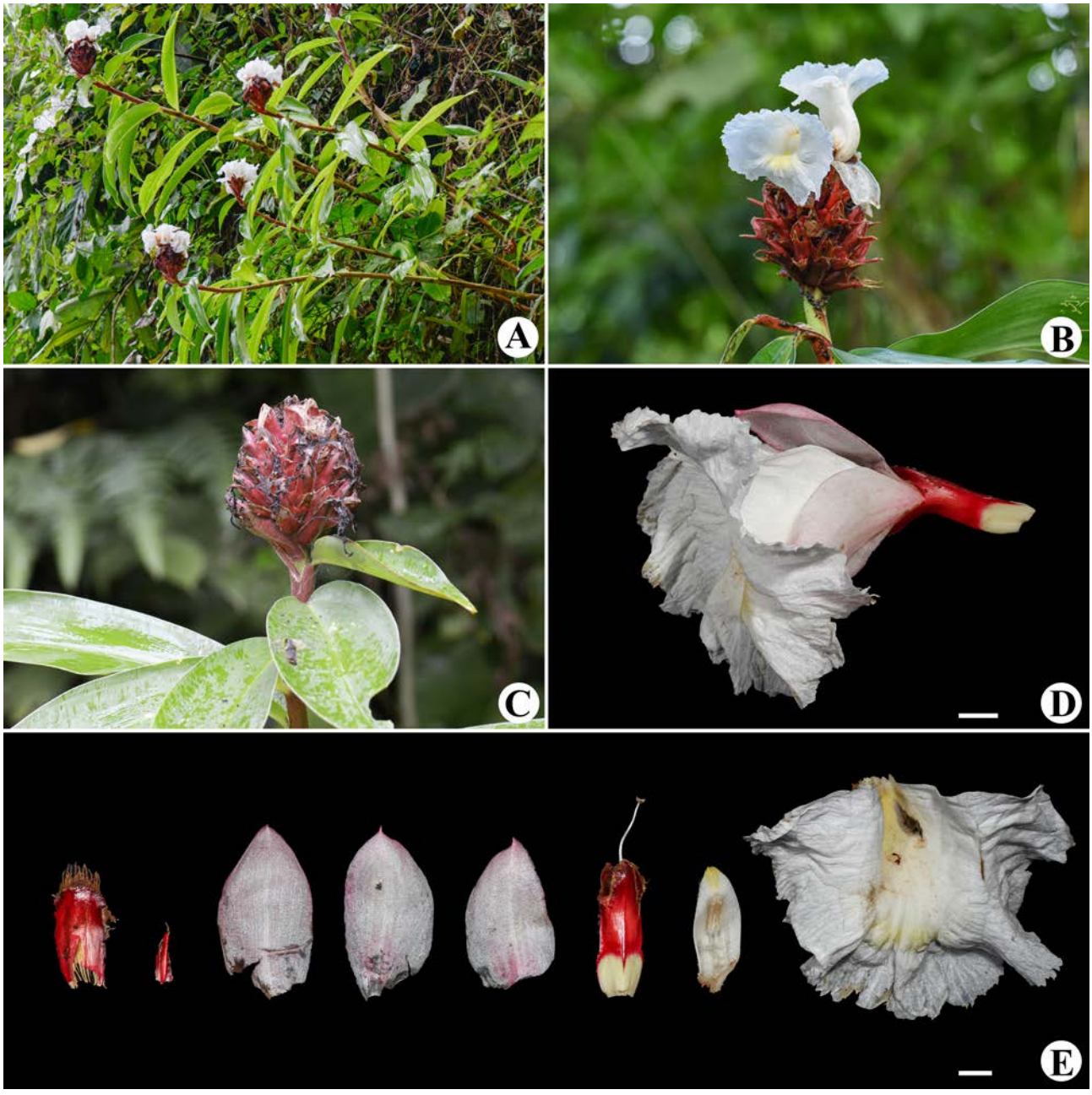

FIGURE 4. *Hellenia oblonga*. A. Habit. B. Inflorescence. C. Infructescence. D. Flower. E. Flower dissection, from left to right: bract, bracteole, corolla lobes, ovary with calyx at the top, petaloid stamen and labellum. Photos by L.Y. Zeng, A from Ruili City, B–C from Yingjiang County, Yunnan. D–E based on *L.Y. Zeng 20082601*. Scale bars = 1 cm.

Additional specimens examined:—CHINA. Yunnan: Lianghe County, 1300 m, 4 August 1984, *Q.G. Wu & X.X. Huang 110* (IBSC); Longchuan County, *S.Q. Tong & C.J. Liao 24840* (KUN1268307); Longling County, Nongxian Village, 1500 m, 29 August 2020, *LY. Zeng & S.J. Zeng 20082901* (IBSC); Tengchong County, 1300–1510 m, 17 September 1960, *W.Q. Yin 60-1042* (KUN0335069, KUN0335074); ibid., Nanjingli Village, 1700 m, 21 July 1987, *S.Y. Bao et al. 889* (KUN0335072); Yingjiang County, Tongbiguan Nature Reserves, 840 m, 24 August 2020, *L.Y. Zeng & S.J. Zeng 20082401* (IBSC); ibid., 1000–1500 m, 26 August 2020, *L.Y. Zeng & S.J. Zeng 20082601*, *20082605*, *20082606*, *20082607* (IBSC). Xizang: Mêdog County, 800–850 m, *Qinghai-Xizang Expidition 74-4583* (KUN0335084, KUN0335085, PE00075172); ibid., outskirts of Mêdog Town, 26 August 1990, *K. Yao 3465* (NAS0006341, NAS0006440); ibid., Mêdog to Beibeng, 700 m, 3 September 2009, *Southeast Tibet Expedition Team SET-ET 1148* (PE02010602); ibid., Beibeng, 810 m, 11 August 1974, *Qinghai-Xizang Expidition 74-1916* (KUN0335086, PE00075171); ibid., 1000 m, 10 October 1992, *H. Sun, Z.K. Zhou & H.Y. Yu 0311* (KUN0335087, KUN0335088); ibid., Beibeng to Hanmi, 716 m, 5 September 2009, *Southeast Tibet Expedition Team SET-ET 1233* (PE02010603).

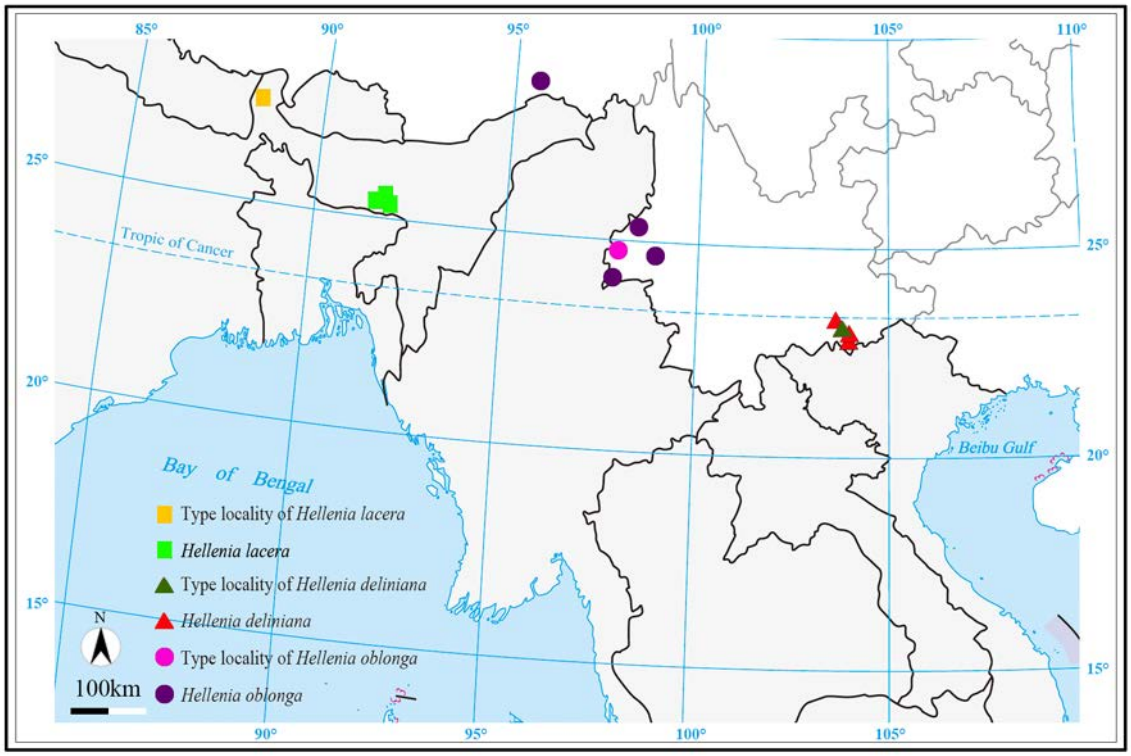

FIGURE 5. Distribution map of *Hellenia lacera*, *H. deliniana* and *H. oblonga*.

Hellenia viridis (S.Q.Tong) Juan Chen, L.Y.Zeng & N.H.Xia, *comb. nov.*

Basionym:—*Costus viridis* Tong (1989: 289).

Type:—CHINA. Yunnan: Ruili City, Wanting Town, 1050 m, 22 June 1983, *S.Q. Tong & W.D. Liao 24822* (holotype KUN1219281!).

Distribution and habitat:—Yunnan, China. It grows in moist places along forest edges or at roadside in disturbed evergreen forest with fertile soil at elevations of 900–1050 m.

Phenology:—Flowering June to September; fruiting in August to December.

Vernacular names:—Chinese name “绿苞茛笋花” [lǜ bāo wō sǔn huā].

Additional specimens examined:—CHINA. Yunnan: Ruili City, Wanting Town, 960 m, 25 August 2020, *L.Y. Zeng & S.J. Zeng 20082501*, *20082503*, *20082504* (IBSC); Ruili City, Daluo Village, 900 m, 22 August 2017, *J. Chen et al. 17082211* (IBSC).

Additional specimens of *Hellenia lacera* examined:—INDIA. Meghalaya: Cherrapunjee, Khasi Hills, 1220 m, 7 June 1952, *W.N. Koelz 30249* (MICH1492715); ibid., 1220 m, 29 July 1952, *W.N. Koelz 30908* (MICH1492715); ibid., *J.D. Hooker s.n.* (P02198208, P02198209); ibid., 1220 m, 18 August 1949, *T.R. Chand 2020* (MICH1492715).

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