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Research article

Taxonomic revision of *Zingiber* (Zingiberaceae) of Taiwan

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Abstract. The genus *Zingiber* contains about 180 species distributed mainly in tropical regions. Several species of *Zingiber* are cultivated globally for their medicinal and culinary value, such as true gingers (*Z. officinale*), bitter gingers (*Z. zerumbet*), and *Z. purpureum*. In Taiwan, two endemic species and one incompletely known taxon were recorded in the last edition of *Flora of Taiwan*, and several taxonomic issues still remain unresolved. Therefore, we revised the Taiwanese *Zingiber* based on morphological, palynological, anatomical, and molecular evidence, as well as their distribution. The results showed that floral characters such as labellum, fertile bracts, and corolla tubes are of great taxonomic value in distinguishing taxa of *Zingiber* of Taiwan. Accordingly, five species are treated in the present study, namely *Z. chengii* Y.H.Tseng, C.M.Wang & Y.C.Lin, *Z. mioga* Thunb., *Z. oligophyllum* K.Schum., *Z. pleiostachyum* K.Schum., and *Z. shuanglongense* C.L.Yeh & S.W.Chung. *Zingiber mioga* might be a newly naturalized species to Taiwan. *Zingiber kawagoii* Hayata and *Z. koshunense* C.T.Moo are treated as synonyms of *Z. pleiostachyum*.

Keywords. *Zingiber*, Zingiberaceae, lectotype, Taiwan.

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Introduction

Zingiber Mill. (Zingiberaceae Martinov, Zingibereae) is the second largest genus of Zingiberaceae with about 180 species (Zingiberaceae Resource Centre 2021). Some members of *Zingiber* are grown globally for their medicinal and culinary value, e.g., true gingers (*Z. officinale* Roscoe), bitter gingers (*Z. zerumbet* (L.) Roscoe ex Sm.), or *Z. purpureum* Roscoe (Mabberley 2017). The genus is distributed throughout tropical and warm-temperate Asia with its center of diversity in SE Asia (Theerakulpisut *et al.* 2012). It is

easily distinguished from related genera among Zingiberaceae by its horn-shaped anther crest embracing the upper part of the style, and the existence of a swollen part of the petiole, known as a pulvinus (Bai *et al.* 2015a). *Zingiber* is classified into four sections based on the habit of its inflorescence, viz. sect. *Zingiber*, sect. *Cryptanthium* Horan., sect. *Dymczewiczia* (Horan.) Benth., and sect. *Pleuranthesis* Benth. (Schumann 1904; Ardiyani *et al.* 2017). Accordingly, all taxa of Taiwan belong to sect. *Cryptanthium*, which has radical and procumbent peduncles (Schumann 1904; Ardiyani *et al.* 2017).

The taxonomy of Zingiberaceae has largely relied on the morphology of floral parts; however, difficulties in the preservation of important floral characters on herbarium specimens through traditional drying methods, as well as the variability of certain morphological characters coupled with hybridization and polyploidy in some genera, make Zingiberaceae taxonomically one of the most challenging plant groups (Leong-Škorničková *et al.* 2010; Bai *et al.* 2015a). There have been many misinterpretations and misapplications of species names of *Zingiber* owing to obscure protologs and poorly preserved or missing type materials.

Taxonomic studies of *Zingiber* in Taiwan date back to more than one hundred years ago, when Henry (1896) recorded two unknown taxa in the Bankensing Mountains. According to Henry's (1896) record, Schumann (1904) described two new species, *Z. oligophyllum* K.Schum. and *Z. pleiostachyum* K.Schum. Later, Hayata (1921) described a new species, *Z. kawagoii* Hayata from the collection of S. Kawagoe from Funkiko, southern Taiwan. Sasaki (1930) proposed a new species, *Z. koshunense*, in the herbarium catalog of TAIF; however, this name is a nomen nudum due to lack of description. After Moo (1978) and Wu *et al.* (2000) provided additional elements, this name was validated by them. More recently, a new species, *Z. shuanglongense* C.L.Yeh & S.W.Chung, was described from central and southern Taiwan (as '*Z. shuanglongensis*'; Yeh *et al.* 2012), and another one, *Z. chengii* Y.H.Tseng, C.M.Wang & Y.C.Lin, was described from Hsinchu County (Wang *et al.* 2020). However, several taxonomic issues with Taiwanese *Zingiber* remain. Some taxa (e.g., *Z. koshunense* and *Z. pleiostachyum*) have unclear taxonomic status and type designation. *Zingiber koshunense*, *Z. pleiostachyum*, and *Z. shuanglongense* have a very similar morphology, all characterized by evergreen habit, oblong leaves, and compact inflorescences leading to taxonomic confusion. Therefore, the aims of the present study are to clarify the taxonomic status of *Zingiber* of Taiwan, and ensure proper taxonomic treatment.

Material and methods

Plant material was obtained from the field, living collections and herbarium collections. Living plants were collected from the field, and cultivated in the greenhouses of the Department of Forestry, National Chung Hsing University. Measurements of morphological characters were made from herbarium specimens and material preserved in 70% EtOH. Terminology of planar shapes follows Exell (1962). Voucher specimens were deposited in the herbarium of National Chung Hsing University; TCF. Acronyms of herbaria follow Index Herbariorum (Thiers continuously updated). Physical or digital specimens from the following herbaria were examined: HAST, IBSC, K, NTNU, PPI, TAI, TAIE, TAIF, TCF, TI, TNM, UPS, US.

Distribution maps were created according to collection information of the authors and herbarium specimens. The range of geographical climatic regions and altitudinal vegetation zones were illustrated according to Su (1984, 1985). Conservation status of *Z. mioga* (Thunb.) Roscoe is evaluated here according to the protocol of Editorial Committee of the Red List of Taiwan Plants (2017). Conservation status of *Z. chengii* Y.H.Tseng, C.M.Wang & Y.C.Lin and all other species adopt the evaluation of Wang *et al.* (2020) and the Editorial Committee of the Red List of Taiwan Plants (2017).

In order to clarify the taxonomic status, we performed a phylogenetic analysis based on three chloroplast DNA (cpDNA) markers. Material for this molecular study are listed in Supp. file 1.Total DNA of *Z. koshunense*, *Z. pleiostachyum*, and *Z. shuanglongense* was extracted by a modified CTAB

method (Doyle & Doyle 1987). Three cpDNA regions were amplified with the following primers: 5'-GCTATGCTTAGTGTGTGACTCGTTA-3' and 5'-CTTCCTCTATGTTGTTTACG-3' for *rpl*16 intron, 5'-CGCGCATGGTGGATTCACAATC-3' and 5'-GTTATGCATGAACGTAATGCTC-3' for *trn*H-*psb*A spacer, and 5'-CGAAATCGGTAGACGCTACG-3' and 5'-ATTTGAACTGGTGACACGAG-3' for *trn*L-F spacer. PCR products were sequenced on an ABI PrismH® 3730XL DNA sequencer (Perkin-Elmer, Foster City, CA, USA) with ExoSAP-IT (Thermo Fisher Scientific Inc., Waltham, MA, USA) and the ABI BigDye 3.1 terminator cycle sequencing kit (Applied Biosystems, Foster City, CA, USA). The cpDNA sequences were aligned and manually checked with BioEdit ver. 7.2 (Hall 1999). The GenBank accession number of these sequences are listed in Supp. file 2.

A haplotype network was reconstructed by using TCS ver. 1.21 (Clement *et al.* 2000) to visualize the genetic relationship of the three species between each haplotype and population. The long-fragment indels in three cpDNA fragments were all treated as single-step mutations by manual recoding. Uncorrelated genetic distances between *Z. koshunense*, *Z. pleiostachyum*, and *Z. shuanglongense* were calculated by MEGA 11 (Tamura *et al.* 2021).

Results

Characters of Zingiber from Taiwan

We examined and compared several characters of species of *Zingiber* from Taiwan, and those that were shown to have taxonomic value are listed in Table 1.

Habit

The Taiwanese taxa of *Zingiber* can be classified into two types, evergreen (*Z. pleiostachyum* and *Z. shuanglongense*) and deciduous (*Z. chengii*, *Z. mioga*, and *Z. oligophyllum*).

Rhizome

The cross sectional color of the rhizome varies from purple in *Z. shuanglongense* to yellow in other taxa (Fig. 1).

Ligule

The ligule is bilobed except in *Z. oligophyllum*, in which it is reduced (Fig. 2).



Fig. 1. Rhizome cross sections. **A**. *Zingiber shuanglongense* C.L.Yeh & S.W.Chung (Aluwan historical trail, *Y.C. Lin 1342* (TCF)). **B**. Other taxa, represented by *Z. pleiostachyum* K.Schum. (Chichidashan, *Y.C. Lin 1290* (TCF)). Photos: L.P. Hsu. Scale bars = 1 cm.

Table 1. Morphological comparisons of species of *Zingiber* Mill. of Taiwan.

	Z. chengii	***Z. shuanglongense***	***Z. pleiostachyum***	***Z. mioga***	***Z. oligophyllum***
Rhizome (internally)	yellow	dark violet	yellow	light yellow	yellow
Leafy shoots	spreading to weakly arching, 11–15 leaves	erect, or slightly inclined, 7–21 leaves	erect, or slightly inclined, 6–21 leaves	erect, or slightly inclined, 11–16 leaves	erect, or slightly inclined, 6–13 leaves
Lamina	linear-lanceolate to lanceolate, 9–15 × 1.5–2.5 cm	narrowly oblong to lanceolate, 12–23 × 2–7 cm	narrowly oblong, 12–29 × 3–8.5 cm	narrowly oblong, 13–29 × 4–7 cm	narrowly obovate, 26–37 × 8–11 cm
Lamina length / width ratio	ca 6	ca 3.7	ca 3.8	ca 4.4	ca 3.8
Corolla tube	creamy-white, ca 3.5 cm	creamy-white, ca 3.0 cm	yellow, ca 3.6 cm	yellow, ca 2.5 cm	yellow, ca 2.7 cm
Labellum	widely obovate, ca 3.0 × 2.5 cm, apex retuse or entire	widely obovate, ca 2.9 ×1.9 cm, apex retuse or cleft	obovate or elliptic, ca 2.8 ×1.1 cm, apex retuse,	widely obovate, ca 2.8 × 2.0 cm, apex retuse or entire	narrowly ovate, ca 1.7 × 0.5 cm, apex incised or entire
Lateral staminodes	narrowly oblong, ca 2.0 × 0.5 cm, connate to labellum at basal ⅓ to ¼	narrowly oblong, ca 2.3 × 0.4 cm, connate to labellum at basal ⅓ to ¼	narrowly oblong, ca 1.6 × 0.5 cm, connate to labellum at basal ½ to ⅔	narrowly oblong, ca 1.6 × 0.5 cm, connate to labellum at basal ca ⅓	narrowly oblong to spathulate, ca 1.1 × 0.3 cm, connate to labellum at basal ca ⅓
Color of labellum and lateral staminodes	violet, scattered with cream-white patches at base	violet, scattered with cream-white patches at base	red or deep violet, yellow patches at base	yellow	yellow
Fruit	ovate	elliptic	elliptic	elliptic	elliptic
Seed enveloped by the aril	⅓	¾	¾	¾	¾

Inflorescence

The number of flowers per inflorescence and the shape of the bract, including the bracteole, are diagnostic characters. *Zingiber chengii* has only one to three loosely arranged flowers in an inflorescence. The other taxa all have more than three flowers that are densely arranged. The fertile bracts are usually narrowly ovate except in *Z. oligophyllum* where they are broadly ovate (Fig. 3).

Flowers

Floral characters are often regarded as diagnostic by several scholars (Wu & Larsen 2000; Yeh *et al.* 2012, 2013; Bai *et al.* 2016; Ohba 2016), and we found that to be true for the classification and identification of Taiwanese *Zingiber*. Each character is listed and described below.

Corolla tube

Two colors of corolla tube are classified here, creamy-white and yellow. *Zingiber chengii* and *Z. shuanglongense* have creamy-white corolla tubes, while *Z. mioga*, *Z. oligophyllum*, and *Z. pleiostachyum* have yellow corolla tubes.

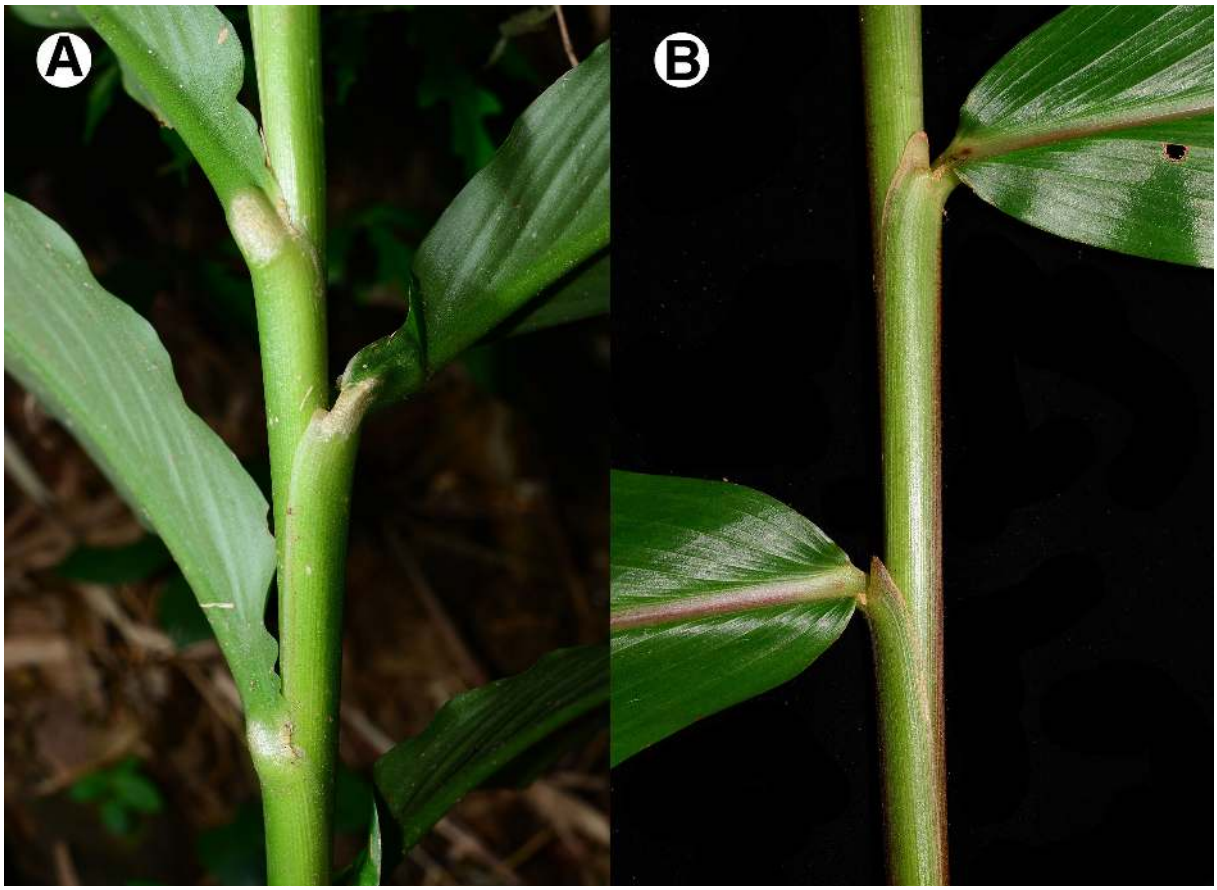


Fig. 2. Ligules. **A**. *Zingiber oligophyllum* K.Schum. (Chading Trail, *Y.C. Lin 1161* (TCF)) **B**. Other taxa, represented by *Z. pleiostachyum* K.Schum. (Mihu Trail, *Y.C. Lin 1151* (TCF)). Photos: L.P. Hsu.

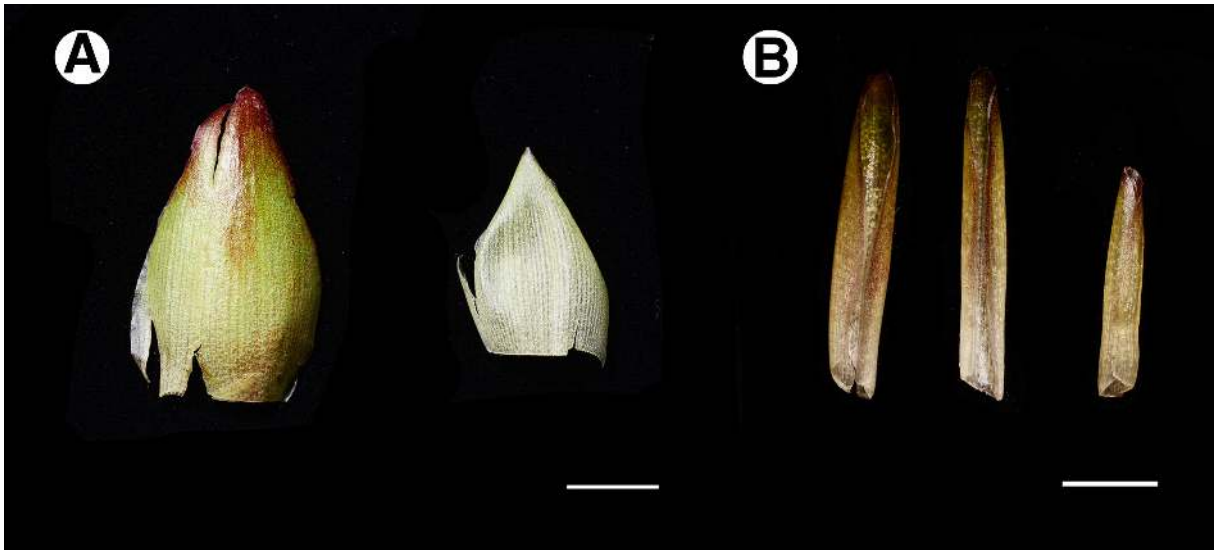


Fig. 3. Bracts and bracteoles. **A**. *Zingiber oligophyllum* K.Schum. (Chading Trail, *Y.C. Lin 1161* (TCF)). **B**. Other taxa, represented by *Z. plaeiostachyum* (Mihu Trail, *Y.C. Lin 1151* (TCF). Photos: L.P. Hsu. Scale bars = 1 cm.

Labellum

The labella can be separated according to color into purple and yellow. *Zingiber chengii* and *Z. shuanglongense* have obovate to widely ovate, bluish-purple labella with creamy-white patches on the basal parts. In contrast, *Z. pleiostachyum* has an obovate to oblong, reddish-purple labellum with yellow patches on the basal parts (Fig. 4). For the yellow type, *Z. mioga* and *Z. oligophyllum* have ovate to widely ovate, yellowish labella without patches.

Lateral staminodes

The morphology of lateral staminodes is similar to the labella; however, the dimensions of the adnate part could be of some taxonomic significance. For *Z. pleiostachyum*, the adnate part is ½ to ⅔ of the size of the staminodes, while all others often have adnate parts that are only ⅓ to ¼ the size of the staminodes.

Anther crest

Stamen morphology also provides taxonomic value for the *Zingiber* of Taiwan. The anther crest can be distinguished by color. The purple variety includes *Z. chengii*, *Z. shuanglongense*, and *Z. pleiostachyum*, while *Z. mioga* and *Z. oligophyllum* represent the yellow color.



Fig. 4. Labellum of *Zingiber* Mill. of Taiwan. **A**. *Z. shuanglongense* C.L.Yeh & S.W.Chung (Shuanglung Logging Trail, *Y.C. Lin 1294* (TCF)). **B**. *Z. pleiostachyum* K.Schum. (Chichidashan, *Y.C. Lin 1290* (TCF)). **C**. *Z. chengii* Y.H.Tseng, C.M.Wang & Y.C.Lin (Jianshih Township, *Y.C. Lin 1148* (TCF)). **D**. *Z. mioga* Thunb. (Ying Ziling roadside, *Y.C. Lin 1366* (TCF)). **E**. *Z. oligophyllum* K.Schum. (Chading Trail, *Y.C. Lin 1161* (TCF). Photos: L.P. Hsu. Scale bars = 1 cm.

Distribution pattern of taxa of Zingiber of Taiwan

Zingiber of Taiwan are often found in shady areas with high humidity, such as beneath the forest canopy, at forest margins, and in deep valleys. In terms of vertical distribution, the highest altitude habitat was found for *Z. shuanglongense*, which grows at heights up to 1600 m in the south (Fig. 5). *Zingiber pleiostachyum* is the most widely distributed species in Taiwan, found across the island and Lanyu Island (Fig. 6); in contrast, *Z. chengii* and *Z. mioga* are restricted to a very narrow area in Hsinchu and Ilan counties, respectively (Figs 5, 7). *Zingiber shuanglongense* and *Z. oligophyllum* are found in the central to southern parts of Taiwan (Fig. 7).

Haplotype network and genetic distance of Zingiber koshunense, Z. pleiostachyum, and Z. shuanglongense

In order to clarify the relationship of taxa with similar morphology, i.e., *Z. koshunense*, *Z. pleiostachyum*, and *Z. shuanglongense*, we reconstructed a haplotype network of these taxa. Two groups emerged from the haplotype network analysis: *Z. pleiostachyum* and *Z. shuanglongense*, with nine and four haplotypes, respectively. No shared haplotypes were found between the two groups. The haplotype of a specimen of *Z. koshunense* from Lanyu Island was identical to that of *Z. pleiostachyum* (Fig. 8).

The genetic distance of *Z. pleiostachyum* vs *Z. shuanglongense* and *Z. koshunense* vs *Z. shuanglongense* was 0.0113, and that of *Z. koshunense* vs *Z. pleiostachyum* was 0.0005. These results revealed that *Z. koshunense* was more close to *Z. pleiostachyum* than to *Z. shuanglongense*, which was similar to the pattern of haplotype network analysis (Table 2).

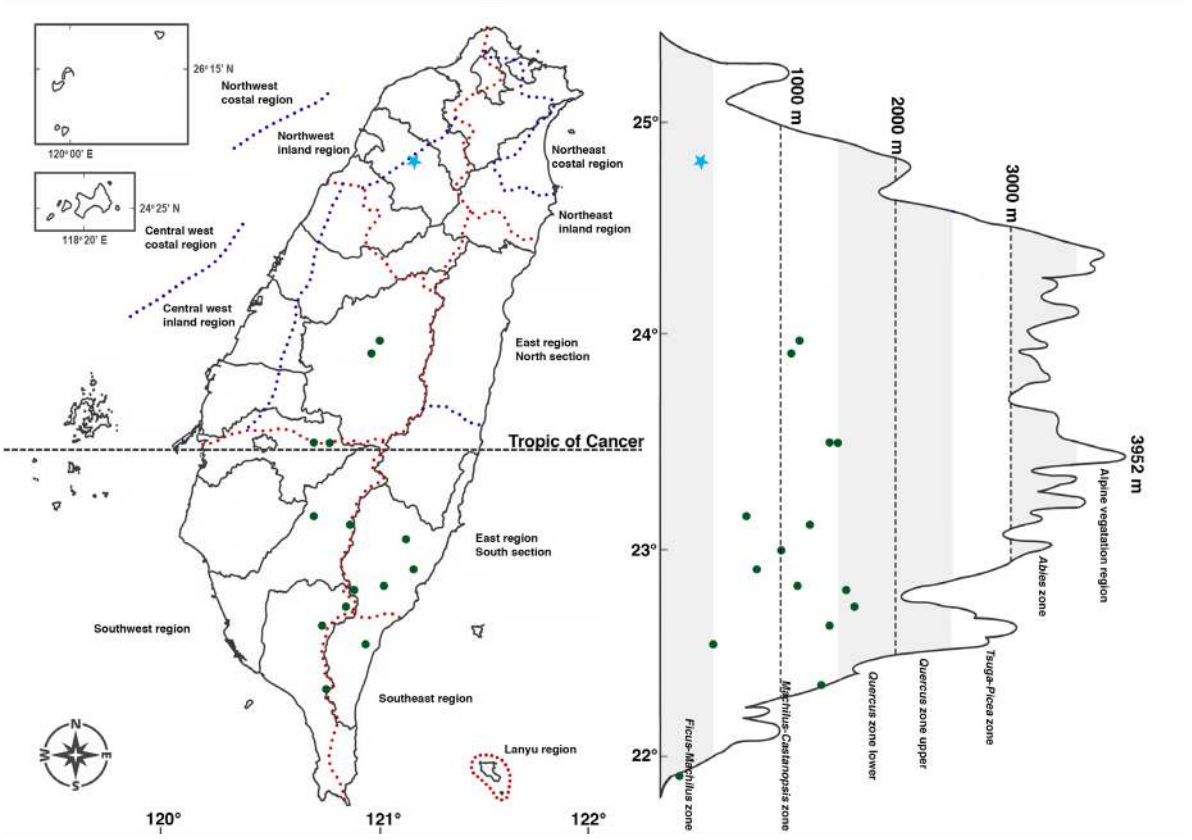


Fig. 5. Distribution map of *Zingiber chengii* Y.H.Tseng, C.M.Wang & Y.C.Lin (star) and *Z. shuanglongense* C.L.Yeh & S.W.Chung (dots) in Taiwan.

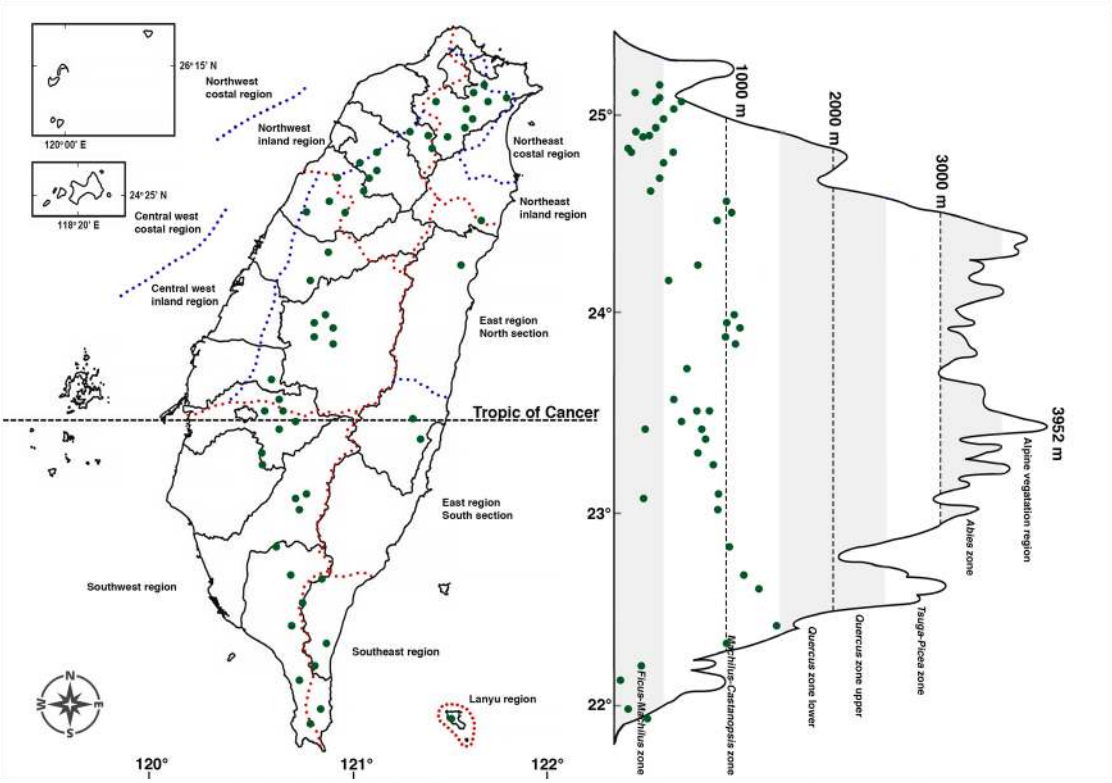


Fig. 6. Distribution map of *Zingiber pleiostachyum* K.Schum. in Taiwan.

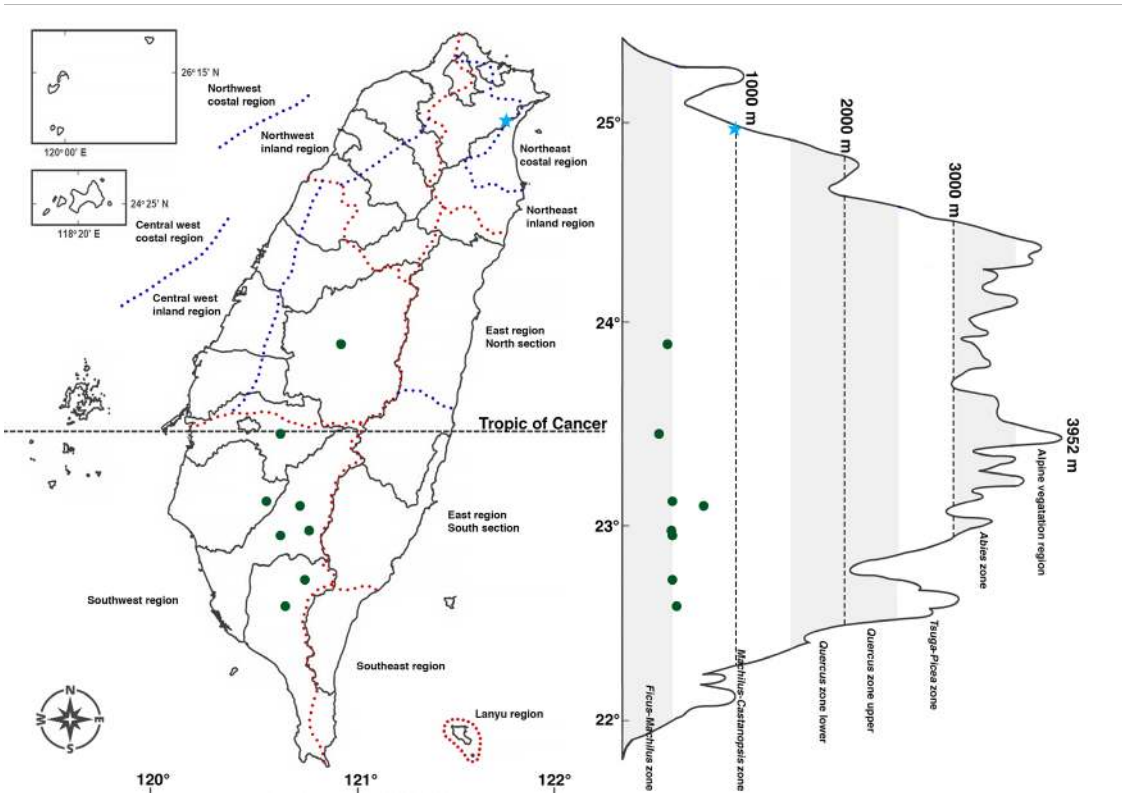


Fig. 7. Distribution map of *Zingiber mioga* Thunb. (star) and *Z. oligophyllum* K.Schum. (dots) in Taiwan.

Table 2. Genetic distance between *Zingiber koshunense* C.T.Moo, *Z. pleiostachyum* K.Schum, and *Z. shuanglongense* C.L.Yeh & S.W.Chung.

Taxa set	Genetic distance (SE)
Z. koshunense vs *Z. pleiostachyum*	0.000458 (0.000286)
Z. koshunense vs *Z. shuanglongense*	0.011299 (0.002247)
Z. pleiostachyum vs *Z. shuanglongense*	0.011311 (0.002246)

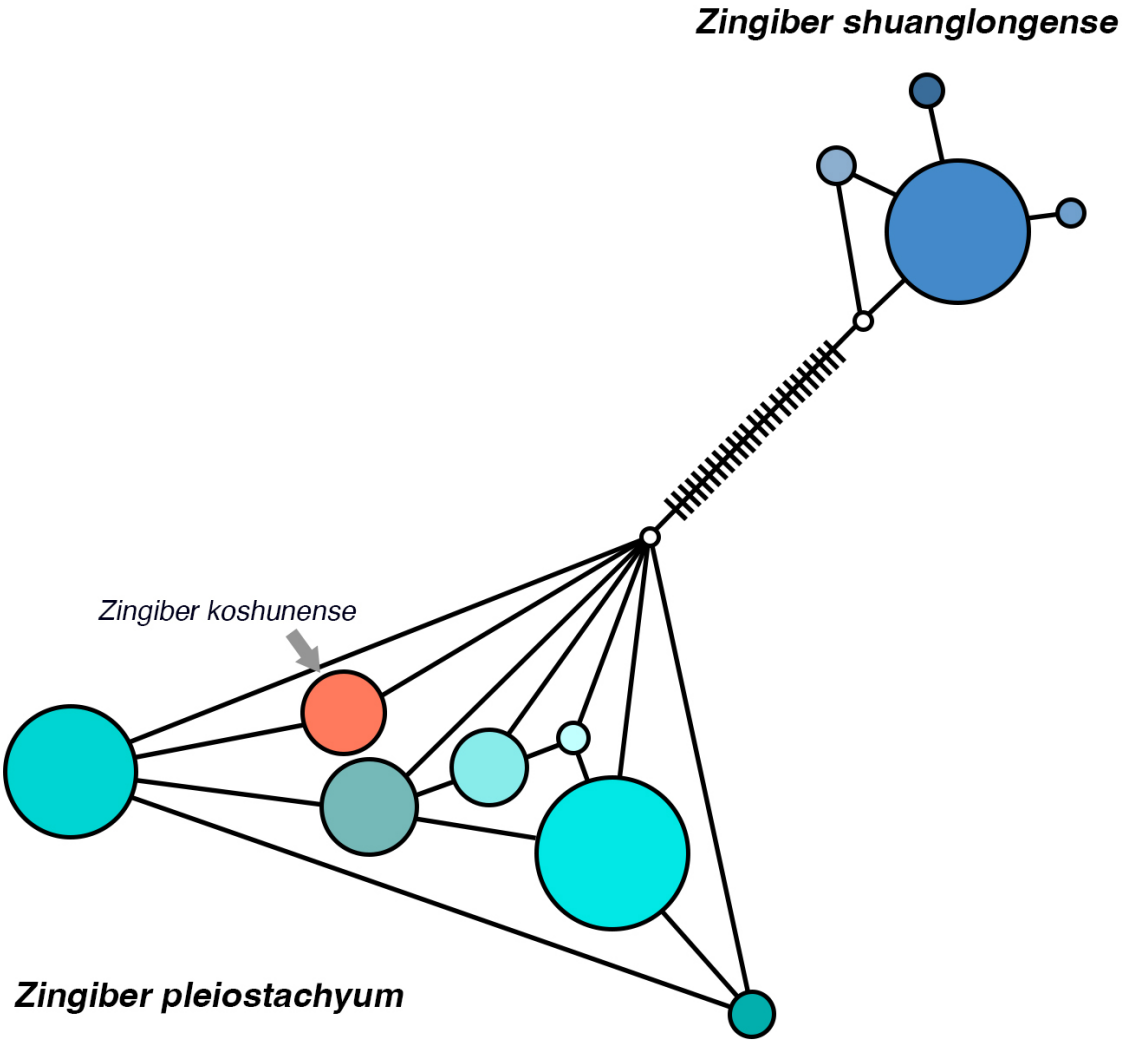


Fig. 8. Haplotype network of *Zingiber koshunense* C.T.Moo, *Z. pleiostachyum* K.Schum., and *Z. shuanglongense* C.L.Yeh & S.W.Chung reconstructed by three cpDNA regions. Each circle represents a haplotype, circle size represents different population sizes of such haplotype. The arrow indicates the haplotype which included samples of *Z. koshunense* C.T.Moo.

Key to the species of Zingiber from Taiwan

1. Labellum yellowish 2
– Labellum violet or reddish 3

2. Ligules reduced, truncate, < 1 mm long; leaf upper surface plicate ..... ***Z. oligophyllum*** K.Schum.
– Ligules bilobed, > 1 mm long; leaf upper surface smooth ..... ***Z. mioga*** (Thunb.) Roscoe

3. Spike with only few sterile bracts; capsule ovoid; ⅓ of seed enveloped by the aril .... ***Z. chengii*** Y.H.Tseng, C.M.Wang & Y.C.Lin
– Spike with several sterile bracts; capsule ellipsoid; ¾ of seed enveloped by the aril 4

4. Corolla tube yellow; ½ to ⅔ of lateral staminodes connate to labellum; capsule longer than the persistent bract ..... ***Z. pleiostachyum*** K.Schum.
– Corolla tube creamy-white; ⅓ to ¼ of lateral staminodes connate to labellum; capsule equal to or shorter than the persistent bract ..... ***Z. shuanglongense*** C.L.Yeh & S.W.Chung

Taxonomic treatment

Class Magnoliopsida Brongn.
Order Zingiberales Griseb
Family Zingiberaceae Martinov
Genus *Zingiber* Mill.
Section *Cryptanthium* Horan.

Zingiber chengii Y.H.Tseng, C.M.Wang & Y.C.Lin
urn:lsid:ipni.org:names:77204420-1
Fig. 9

PhytoKeys 139: 3 (Wang *et al.* 2020). **Type**: TAIWAN – **Hsinchu County** • Jianshih Township; alt. 320 m; 23 May 2014; *Y.H. Tseng 5614*; holotype: TCF!.

Additional material examined

TAIWAN – **Hsinchu County** • same collection data as for holotype; *Y.H. Tseng 5615*; TCF • ibid.; *Chao 4471*; TAIF • ibid.; *C.M. Wang & C.Y. Li 16051*; TNM • ibid.; *Y.C. Lin 1148*; TCF • Bilin Bridge; *Y.C. Lin 1355*; TCF.

Description

Perennial rhizomatous herbs, 40–70 cm tall. Rhizomes fleshy, weakly aromatic, compacted, densely branched, 0.8–1.4 cm in diameter, brown externally, light yellow internally; root tubers terete, distant from the rhizomes, ca 3.8 × 1.2 cm, brownish green externally. Leafy shoots forming dense clumps, spreading, each shoot comprised of 11–15 well-developed leaves at flowering. Leaves deciduous, simple, distichous; ligules ca 2 mm long, bilobed, membranaceous, pale green, auriculate; petioles 2.0−3.0 mm long, connate a pulvinus; lamina narrowly ovate, 9−15 × 1.5−2.5 cm, length / width ratio 5.1−6.6, adaxially green, glabrous, abaxially pale green, pubescent along the midrib, base cuneate obtuse, apex acuminate, margin entire, undulate, chartaceous. Inflorescences 1–2 per plant, arising from rhizomes; peduncles 2.5–6.2 cm long, ascending, glabrous; spike narrowly oblong, ca 10.5–12.5 × 2.0–3.0 cm, each with 1–3 flowers; fertile bracts yellowish green, usually tinged with red, narrowly ovate, 2.5–3.0 × 0.6–0.8 cm, involute on both sides, apex acute to attenuate, glabrous externally and internally; bracteole narrowly ovate, 1.8–2.8 × 0.6–0.8 cm, translucent green with slight red tinge, apex acute, involute on both sides, glabrous externally and internally. Flowers 7.0–9.0 cm long, much exserted beyond the bracts; calyx

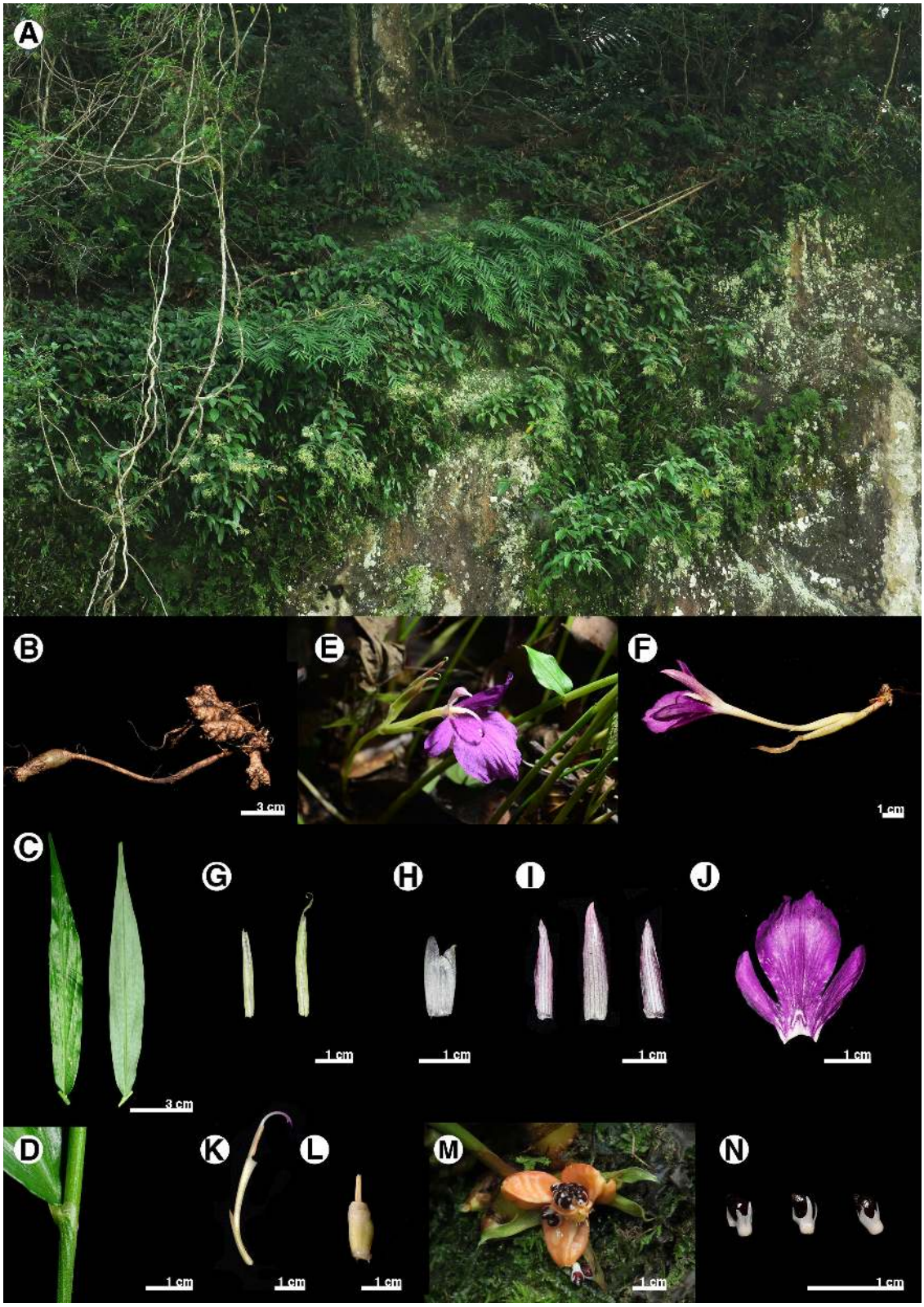


Fig. 9. *Zingiber chengii* Y.H.Tseng, C.M.Wang & Y.C.Lin, Jianshih Township. **A**. Habit. **B**. Rhizome. **C**. Leaf adaxial (left) and abaxial (right) surface. **D**. Ligule. **E**. Inflorescence. **F**. Flower. **G**. Bracts. **H**. Calyx tube. **I**. Corolla lobes. **J**. Labellum. **K**. Stamen and pistil. **L**. Ovary. **M**. Fruit. **N**. Seeds. Photos: L.P. Hsu.

tubular, membranaceous, ca 7 mm long, with unilateral incision, translucent. Corolla tube slender, ca 3.5 cm long, creamy-white, glabrous externally and internally; dorsal corolla lobe narrowly ovate, ca 2.7 × 0.7 cm, purple, apex acuminate, glabrous; lateral corolla lobes narrowly ovate, ca 2.5 × 0.7 cm, purple, apex acuminate, glabrous; labellum widely obovate, ca 3.0 × 2.5 cm, purple, apex retuse or entire, with scattered creamy-white patches at base, glabrous; lateral staminodes narrowly oblong, ca 2.0 × 0.5 cm, connate to labellum at ca basal ⅓ to ¼, purple, apices obtuse, glabrous. Stamen one; filament ca 1 mm, glabrous; anther connective tissue creamy-white, elongate appendage wrapped around style; anther thecae two, ca 1 cm long, longitudinal dehiscence, pollen light yellow; anther crest beak-shaped, ca 1.5 cm long when stretched, purple, apex entire. Style filiform, white, ca 5.5 cm long, extending to the end of anther crest; stigma white, ciliate. Ovary cylindrical, trilocular, ca 6.0 × 3.0 mm, yellowish green, pubescent; epigynous glands two, narrowly conical, ca 6 mm long, pale yellow, apices sharp. Capsule ovate, dehiscence loculicidal, ca 1.5 × 1.3 cm, usually as long as the persistent bract, pericarp yellowish-cream or orange-red inside. Seed ellipsoid, ca 4.0 × 2.0 mm, enveloped by the aril. Aril white, deeply denticulate at apex, enveloping ⅓ of the length of the seeds.

Phenology

Flowering between May and July, and fruiting between July and September.

Distribution

Endemic to Taiwan.

Conservation status

This species was evaluated as Endangered (EN) by Wang *et al.* (2020).

Zingiber mioga (Thunb.) Roscoe
urn:lsid:ipni.org:names:798364-1
Fig. 10

Transactions of the Linnean Society of London 8: 348 (Roscoe 1807).

Basionym

Amomum mioga Thunberg, *Systema Vegetabilium: secundum classes ordines genera species cum characteribus et differentiis. Editio decima quarta*: 51 (Thunberg 1784).

Material examined

TAIWAN – **Ilan County** • Yingzi Ling roadside; *Y.C. Lin 1339*; TCF • ibid.; *Y.C. Lin 1366*; TCF • Mt. Yingtzuting; *T.C. Hsu 9667*; TAIF • Yingtzuling; *C.T. Chao 4644*; TAIF.

Description

Perennial rhizomatous herb, 60–80 cm tall. Rhizomes fleshy, weakly aromatic, compacted, branched, 0.9–2.9 cm in diameter, brown externally, light yellow internally; root tubers terete, distant from the rhizomes, ca 3.0× 1.5 cm, brownish externally. Leafy shoots forming dense clumps, spreading, each shoot comprising13–16 well-developed leaves at flowering. Leaves deciduous, simple, distichous; ligules ca 3 mm long, bilobed, membranaceous, pale green, auriculate; petiole 8–11 mm long, connate a pulvinus; lamina elliptic, 13–29 × 4–7 cm, length/width ratio 3.3–5.6, adaxially green, glabrous, abaxially pale green, pubescent along the midrib, base cuneate, apex acuminate, margin entire, conspicuously undulate, chartaceous. Inflorescences 2–4 per plant, arising from rhizomes; peduncles 1.5–2.4 cm long, ascending, glabrous; spike ellipsoid, ca 4.2–8.2 × 1.6–3.7 cm, each with 3–7 flowers; fertile bracts greenish-yellow,

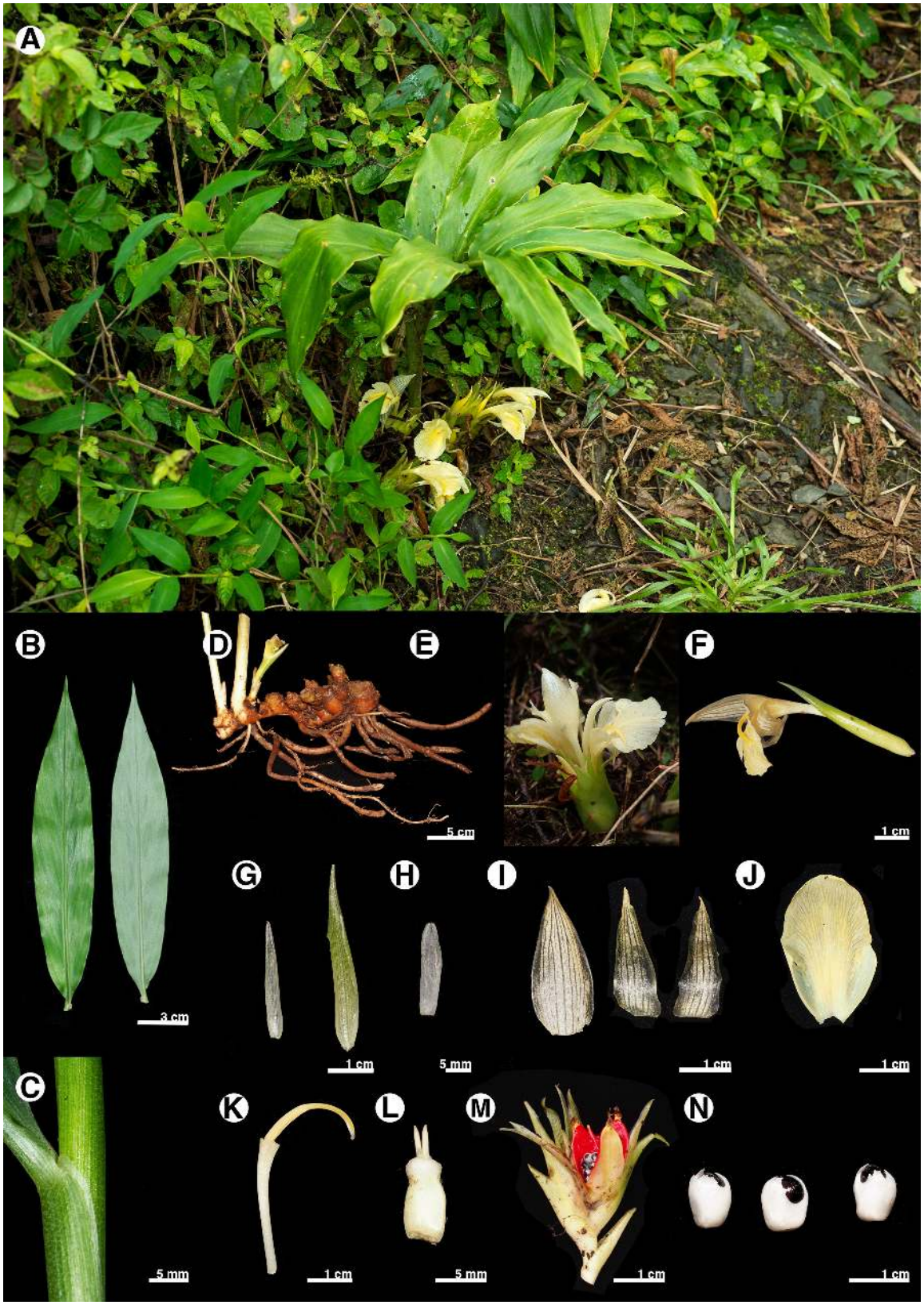


Fig. 10. *Zingiber mioga* Thunb., Yingzi Ling roadside. **A**. Habit. **B**. Leaf adaxial (left) and abaxial (right) surface. **C**. Ligule. **D**. Rhizome. **E**. Inflorescence. **F**. Flower. **G**. Bracts. **H**. Calyx tube. **I**. Corolla lobes. **J**. Labellum. **K**. Stamen and pistil. **L**. Ovary. **M**. Fruit. **N**. Seeds. Photos: A = C.T. Chao; B–N = L.P. Hsu.

narrowly ovate, 3.5–4.1 ×0.6–0.8 cm, involute on both sides, apex acute to attenuate, glabrous externally and internally; bracteole narrowly ovate, 1.7–2.5 × 0.6–1.5 cm, translucent greenish, apex acute, involute on both sides, glabrous externally and internally. Flowers 6–8 cm long, much exserted beyond the bracts; calyx tubular, membranaceous, ca 6 mm long, with unilateral incision, translucent. Corolla tube slender, ca 2.5 cm long, yellowish-white, glabrous externally and internally; dorsal corolla lobe narrowly ovate, ca 2.7 × 1.1 cm, yellow, translucent, apex acuminate, glabrous; lateral corolla lobes narrowly ovate, ca 2.2 × 0.7 cm, yellowish, translucent, apex acuminate, glabrous; labellum widely obovate, ca 2.8 × 2.0 cm, yellowish, apex retuse or entire, glabrous; lateral staminodes narrowly oblong, ca 1.6 × 0.5 cm, connate to labellum at ca basal ⅓, yellow, apices obtuse, glabrous. Stamen one; filament ca 2 mm, glabrous; anther connective tissue yellow, elongate appendage wrapped around style; anther thecae two, ca 1.1 cm long, longitudinal dehiscence, pollen light yellow; anther crest beak-shaped, ca 10 mm long when stretched, yellow, apex entire. Style filiform, white, ca 5.6 cm long, extending to the end of anther crest; stigma, white, ciliate. Ovary cylindrical, trilocular, ca 0.6 × 0.3 cm, yellow, pubescent; epigynous glands two, narrowly conical, ca 6 mm long, pale yellow, apices sharp. Capsule ovate, dehiscence loculicidal, ca 2.9 × 1.5 cm, usually shorter than persistent bract, pericarp yellow and orange-red inside. Seed ellipsoid, ca 0.4 × 0.3 cm, enveloped by the aril. Aril white, enveloping ¾ of the length of the seeds.

Phenology

Flowering from July to September. Fruiting from September to October.

Distribution

Distributed in China, Japan, and Korea. In Taiwan, this species was naturalized in Ilan County (see Discussion).

Conservation Status

This species is evaluated as data-deficient (DD) here, due to its uncertain taxonomic status.

Zingiber oligophyllum K.Schum.
urn:lsid:ipni.org:names:798373-1
Fig. 11

Das Pflanzenreich Heft 20: 185 (Schumann 1904). **Type**: TAIWAN – **Pingtung County** • Bankensing mountains; lectotype: *A. Henry 1605*; K[K-00815678]; isolectotype: US[US-00092878]; syntype: *A. Henry 1605A*; K[K-000815679] (designated by Bai *et al.* 2016).

Zingiber mioga sensu acut. Wu & Larsen, *Flora of China Vol. 24*: 332 (Wu & Larsen 2000). – Ohba, *Flora of Japan. IVb*: 187 (Ohba 2016), non Roscoe.

Additional material examined

TAIWAN – **Nantou County** • 131 County Rd. 37K bamboo grove; *Y.C. Lin 1089*; TCF. – **Chiayi County** • Yunshuihsi; *Y. Shimada s.n.*; TAI. – **Kaohsiung City** • Liugui; *L.H. Yang 246*; TAIE • Mt. Paiyun; *S.W. Chung 11189*; TAIF • Mt. Shihbaluohan; *Y.C. Lin 1088*; TCF • Chading Trail; *Y.C. Lin 1161*; TCF. – **Pingtung County** • Lidingshan; *C.I. Huang et al. 2851*; HAST • Lidingshan Hiking Trail; *S.C. Liu & C.K. Yang 2492*; TNU • Lidingshan; *S.L. Huang 009*; TNU • ibid.; *H.T. Hung 463*; TNU • Lilungshan (Lidingshan); *T.C. Huang 16142*; TAI.

Description

Perennial rhizomatous herb, 30–90 cm tall. Rhizomes fleshy, aromatic, compacted, branched, 1.8–2.0 cm in diameter, brown externally, yellow internally; root tubers terete, distantly from the rhizomes, ca 2.3 ×



Fig. 11. *Zingiber oligophyllum* K.Schum., Chading Trail. **A**. Habit. **B**. Leaf adaxial (left) and abaxial (right) surface. **C**. Ligule. **D**. Rhizome. **E**. Inflorescence. **F**. Flower. **G**. Bracts. **H**. Calyx tube. **I**. Corolla lobes. **J**. Labellum. **K**. Stamen and pistil. **L**. Ovary. **M**. Fruit. **N**. Seeds. Photos: L.P. Hsu.

1.2 cm, brownish externally. Leafy shoots forming dense clumps, spreading, each shoot comprising 6–13 well-developed leaves at flowering. Leaves deciduous, simple, distichous; ligules ca 1 mm long, reduced, membranaceous, pale green; petiole 2.4–2.8 cm long, connate a pulvinus; lamina narrowly obovate, 26–37 × 8–11 cm, length/width ratio 3.0–4.4, adaxially green, plicate, sparsely pubescent, abaxially pale green, densely pubescent, base attenuate, apex acuminate, margin entire, conspicuously undulate, chartaceous. Inflorescences 1–4 per plant, arising from rhizomes; peduncles 4–18 cm long, ascending, glabrous; spike fusiform-ovoid to narrowly ovoid, ca 8–12 × 2–3 cm, each with 3–5 flowers; fertile bracts greenish-yellow, usually red tinged at base and apex, broadly ovate, 2.3–3.7 × 1.6–2.5 cm, involute on both sides, apex acute to attenuate, glabrous externally and internally; bracteole broadly ovate, 2.2–3 × 0.8–1.3 cm, translucent greenish, apex acute, involute on both sides, glabrous externally and internally. Flowers 3–5 cm long, exserted beyond the bracts; calyx tubular, membranaceous, 6–9 mm long, with unilateral incision, translucent. Corolla tube slender, 2.2–3.3 cm long, yellowish-white, glabrous externally and internally; dorsal corolla lobe narrowly ovate, ca 1.9 × 0.7 cm, yellow, apex acuminate, glabrous; lateral corolla lobes narrowly ovate, ca 1.5 × 0.5 cm, yellowish, apex acuminate, much deflexed, glabrous; labellum narrowly ovate, ca 1.7 × 0.5 cm, yellowish, apex incised or entire, glabrous; lateral staminodes narrowly oblong to spatulate, ca 1.1 × 0.3 cm, connate to labellum at ca basal ⅓, yellow, apices rounded, glabrous. Stamens one; filaments ca 2 mm, glabrous; anther connective tissue yellow, elongate appendage wrapped around style; anther thecae two, ca 0.8 cm long, longitudinal dehiscence, pollen light yellow; anther crest beak-shaped, ca 5 mm long when stretched, yellow, apex entire. Style filiform, white, ca 3.6 cm long, extending to the end of anther crest; stigma, white, ciliate. Ovary cylindrical, trilocular, ca 0.6 ×0.3 cm, yellow, pubescent; epigynous glands two, narrowly conical, ca 4 mm long, pale yellow, apices sharp. Capsule ovate, dehiscence loculicidal, ca 3.1 × 1.5 cm, usually shorter than persistent bract, pericarp yellow and orange-red inside. Seed ellipsoid, ca 0.6 × 0.4 cm, enveloped by the aril. Aril white, enveloping ¾ of the length of the seeds.

Phenology

Flowering from July to September and fruiting from August to December.

Distribution

In Taiwan, *Z. oligophyllum* grows in shaded, moist undergrowth of disturbed secondary forest (orchards and bamboo mixed forest), at elevation 300–800 m. Recently, this species was also recorded from China (Bai *et al.* 2016).

Conservation status

This species was evaluated as Endangered (EN) by the Editorial Committee of the Red List of Taiwan Plants (2017).

Zingiber pleiostachyum K.Schum.
urn:lsid:ipni.org:names:798378-1
Fig. 12

Das Pflanzenreich Heft 20: 185 (Schumann 1904). **Type**: TAIWAN – **Pingtung County** • Mt. Bankengsing; *Henry 1659*; lectotype: K[K-000815680] photo!, **here designated**; syntypes: *Henry 147*; K[K-000815681] photo!, US[US-00092879] photo!.

Synonym

Zingiber kawagoii Hayata **syn. nov.**, *Icones Plantarum Formosanarum Vol. X*: 35–36 (Hayata 1921). **Type**: TAIWAN – **New Taipei City** • Urai; *S. Kawagoe s.n.*; lectotype: TI[TI-00010376]!, **here designated**; isolectotype: TAIF[TAIF-6460]!.

Zingiber koshunense Moo, *Flora of Taiwan Vol. 5*: 850 (Moo 1978). **Type**: TAIWAN – **Taitung County** • 5000 feet of Abei Line; 2 Jan. 1911; *T. Kawakami & S. Sasaki s.n.*; lectotype: TAIF!, designated by Wu *et al.* 2000.

Additional material examined

TAIWAN – **New Taipei City** • Wulai; *C.W. Lin 003*; TAIF • ibid.; *C.L. Huang et al. 78*; TAIF • ibid.; *S.L. Huang 10*; TNU • Hutung; *Y.H. Chang 4873*; TAIF • Mt. Pataoerh; *W.F. Ho 2366*; TAIF • Wantan; *P.F. Lu 7330*; TAIF • AYuXi; *S. Sasaki s.n.*; TAIF • Urai; *S. Kawagoi s.n.*; TAIF • Leikungpo, Hsiaoketou; *C.I. Peng 12277*; HAST • Hsiao-I to Tung-Hou; *Y.K. Chen 295*; HAST • Paichi, on the way from the abandoned Yufeng coal mine to Paichishan; *S.M. Liu 597*; HAST, TNU • Mt. Huang-ti-tien; *J.C. Wang et al. 10216*; TNU, HAST • Tatungshan, Vicinity of Chungchi mountain-hiking entrance; *Y.C. Kao 71*; HAST • Huangdidian; *S.C. Liu et al. 975*; TNU, HAST, TAIF • en route from China University of Science and Technology to NanKangShan; *C.I. Huang 5442*; HAST • PaoZiLun; *C.I. Huang 5501*; HAST • Mt.Tungshihtoushan; *H.M. Chang 4561*; TNU, PPI • Arou village; *T.W. Hsu 15602*; TAIE • Shihting; *H.W. Lin et al. 104*; TNU • Shihting, Hsiaoketou; *S.C. Liu et al. 2490*; TNU, TNM • Wulai, Mt. Bar-Dau-Eel; *Y.C. Lu 397*; TNU • ibid.; *C.L. Huang et al.* 78; TNU • Hsiaoketou; *S.L. Huang 17*; TNU • ibid.; *S.L. Huang 11*; TNU • ibid.; *C.T. Moo 86*; TAI • Wulai, Fushan Botanical garden; *Y.C. Chen et al. 60*; TNU • Huang-ti-tien; *S.L. Huang 18*; TNU • Huangdidian; *S.C. Liu et al. 975*; TNU • Kuanghsing; *S.C. Liu 2354*; TNU, TAIF • Hsiungkunghsi; *T.Y.A. Yang 16008*; TNM • Erhkeshan; *C.H. Chen 6201*; TNM, TNU • ibid.; *H.L. Chiang s.n.*; TAIF • ibid.; *Y.C. Lin 1066*; TCF • Lepeishan; *S.T. Chiu 1515*; TNM • Nuannuan, Dandan (Dandangai); *S. Sasaki s.n.*; TAI • Nanshihhsi; *T. Suzuki 15825*; TAI • Mt. Pataoerh; *C.Y. Chiang 985*; TAI • Pichiashan; *K.C. Yang 2171*; TAI • Chihnankung; *T. Suzuki 13865*; TAI • Fushan-Happen; *S.F. Huang 1270*; TAI. – **Taoyuan County** • Mt. Nanchatien; *P.F. Lu 14561*; HAST • Dongman Trail; *K.Y. Liao 84*; TAIE • Luoma Road; *Y.C. Lin 1064*; TCF. – **Hsinchu County** • Mt. Wuchih; *C.I. Peng et al. 12940*; HAST • ibid.; *K.H. Lai 1023*; TAIE • Mt. Ekungchi; *C.M. Wang 12712*; TNM • ibid.; *C. Chang et al. 38*; TNM • Shihtoushan; *T.Y.A. Yang et al. 11720*; TNM • Mt. Wuchih; *W.P. Leu s.n.*; TNM • ibid.; *T.C. Hsu 4772*; TAIF • Wuchihshan; *Y.P. Cheng 2841*; TAIF • Chingchuan; *S. Sasaki s.n.*; TAI. – **Miaoli County** • Ssumahsien Forest Road, between Hsinhsing and Erhpensung; *C.I. Huang 2375*; HAST • Mt. Baguali; *T.W. Hsu 10483*; TAIE • Mt. Taping; *T.C. Hsu 3440*; TAIF • Shenhsien Valley; *S.W. Chung 10178*; TAIF • Mt. Ekungchi; *P.F. Lu 21320*; TAIF • Mingte Reservoir to Mt. Fantzuliao; *P.F. Lu 20918*; TAIF • Dahu Township; *Y.C. Lin 1299*; TCF. – **Taichung County** • Beikengxi Trail; *Y.C. Lin 985*; TCF • 200 Forest Road 14 km; *Y.C. Lin 1105*; TCF. – **Nantou County** • Hsitou, National Taiwan University Experimental Forest; *W.P. Leu 385*; HAST • ibid.; *C.I. Peng et al. 15847*; HAST • ibid.; *S.Y. Hwang 1414*; TAIE • ibid.; *S.M. Kuo et al. 68*; TNU • ibid.; *S.L. Huang 008*; TNU • ibid.; *R.Y. Tsou 14*; TNM • ibid.; *T.Y.A. Yang 11686*; TNM • ibid.; *C.T. Moo 76*; TAI • ibid.; *T. Kiang s.n.*; TAI • Hsitou to Shenmu; *C.C. Hsu 6131*; TAI • Shanlinhsi Chinese Zodiacal sign Ox-Tiger; *T.Y.A. Yang 20828*; TNM • Hui-Sun Experimental Forest; *C.I. Huang 220*; TNM • Yashanping Forest Road; *C.H. Chen 8536*; TNM • Jenlun Forest Road; *C.H. Chen 8428*; TNM • Sanpitin Logging Trail; *S.W. Chung 10580*; TAIF • Lienhuachih; *S.W. Chung 10278*; TAIF • Jeichu; *S.W. Chung 10276*; TAIF • Nengkao Waterfall; *S.W. Chung 10275*; TAIF • Mt. Mukuatan; *S.W. Chung 10272*; TAIF • Mt. Shuishe; *P.F. Lu 18913*; TAIF • Luantashan; *T. Kawakami & U. Mor 7074*; TAI • Lienhuachi Rengechi; *S. Sasaki s.n.*; TAI • Maolan; *Kudo & Sasaki 15065*; TAI • Fenghuangshan–Hsiankuliao; *C.S. Kuoh 3611*; TAI • Chichidashan; *Y.C. Lin 1290*; TCF. – **Yunlin County** • Kukeng Township; *C.H. Chen 10700*; TNM • Caoling Road; *S.W. Chung 10581*; TAIF. – **Chiayi County** • Alishan Highway 68–70 km; *Chung 10463*; TAIF • Fushan Tribe; *T.C. Hsu 4737*; TAIF • Shihcho to Shihtzulu; *S.W. Chung 6877*; TAIF • Hsinmei Village; *S.M. Liu et al. 674*; TAIF • AliShan Highway 55 km, FuShan Stop; *B.J. Wang 10108*; HAST • Fengshan; *C.H. Chen 2493*; TAIE • Fengshan to Ta-tien-yu waterfall; *J.C. Wang et al. 9491*; TNU • Alishan Highway 53 km; *C.S. Kouh 15229*; NCKU, TNM • Fenchihu; *Y.H. Hwang et al. 61*; TNM • ibid.; *H.M. Lin & Y.H. Tsai 102*; TNM • Fenchihu, 169 county highway 18.5 km; *T.Y.A. Yang et al. 19706*; TNM • Shiheho–Fenchihu; *C.M. Wang et al. 7671*; TNM • Juili–Chiaoliping; *C.M. Wang et al. 7694*; TNM •

AliShan–Fengshan; *C.M. Wang 316*; TNM • Yunshuihsi; *Y. Shimada s.n.*; TAI • Alishan; *C.T. Moo 71*; TAI • Lungtou; *Y.C. Lin 1278*; TCF • Mihu Trail; *Y.C. Lin 1151*; TCF • Dingshizhao; *Y.C. Lin 1346*; TCF. – **Tainan County** • Tatungshan; *H.F. Yen 9*; HAST • Hsienkung temple, Kantoushan, en route from entrance to the summit of the mountain; *C.C. Liao 1745*; HAST, TNM • Kantoushan; *L.H. Lee 359*; TAIE. – **Kaohsiung County** • Shanping Station, along the trail to Nanfengshan; *C.C. Wang 821*; HAST • Along Fengkang Forest Road; *C.I. Huang 3464*; HAST • Tsaitie Valley; *W.C. Leong* 2156; HAST • Shanping; *C.C. Chen 597*; TNU • ibid.; *T.C. Huang 4886*; TAI • ibid.; *Y.C. Lin 985*; TCF • Shyr-Shan logging tract; *J.C. Wang et al.7596*; TNU • Mt. Senshan (Mt. Yuyushan); *C.K. Yang 888*; TNM • Liukuei; *E. Matuda 1165*; TAI. – **Pingtung County** • Mt. Hutou; *T.C. Hsu 4737*; TAIF • Shouchia; *T.C. Hsu 6094*; TAIF • Shouka Logging Trail; *C.F. Chen 4977*; TAIF • Shouka; *S.W. Chung 10474*; TAIF • Wuweishan; *K.C. Yang 4542*; TAIF • ibid.; *K.C. Yang 4582*; TAIF • ibid.; *S. Sasaki s.n.*; TAI • ibid.; *E. Matuda 327*; TAI • ibid.; *K.C. Yang 4547*; TAIF, HAST • Mt. Lilung; *S.W. Chung 6927*; TAIF • ibid.; *T.C. Huang et al. 16287*; TAI • ibid.; *H.C. Sun 11*; PPI • ibid.; *C.C. Wu 273*; TNM • ibid.; *Y.Y. Huang et al. 210*; HAST; Liangshan; *M.J. Jung 1779*; TAIF • Chinshuiying natural reserve; *S.Y. Lu 20691*; TAIF • ibid.; *S.F. Huang 360*; TAI • ibid.; *T. Suzuki 8033*; TAI • ibid.; *C.I. Huang et al. 2808*; HAST • ibid.; *S.Z. Yang 42702*; PPI, TNM • ibid.; *S.Z.Yang 23971*; PPI • ibid.; *T.W. Hsu 6053*; TAIE • ibid.; *T.W. Hsu 4700*; TAIE • ibid.; *T.T. Chen et al. 5228*; TAIF • Kantou–Lili; *N. Fukuyama 3829*; TAI • Machia; *T.C. Huang 7519*; TAI • Nanjenshan-Nanjenkeng; *H. Ohashi et al. 13998*; TAI • Nanjenshan Nature Reserve; *S.Y. Lu 18229*; TAIF • ibid.; *H. Ohashi et al. 13833*; TAI • ibid.; *S.L. Huang 12*; TNU • ibid.; *T.Y.A. Yang 7875*; TNM, HAST, TAIF • ibid.; *S.M. Chaw 824*; TNM, TNU, TAIF, HAST • ibid.; *T.C. Hsu 3356*; TAIF • Taiwu; *E. Matuda s.n.*; TAI • Wangkcingtsun; *U. Faurie 929*; TAI • Mt. Kaoshih; *H. Ohashi et al. 13574*; TAI • along Fengkang Forest Road; *C.I. Huang et al. 3464*; HAST • Peitawushan; *T. Soma 308*; TAI • entrance of Peitawushan; *Y.K. Chen 695*; HAST • ibid.; *S.H. Liu et al. 122*; TNU • ibid.; *C.K. Liao 171*; PPI • en route from hiking entrance to Laofoshan; *C.H. Liu et al. 362*; HAST, TNM • Weiliaoshan; *P.U. Su et al. 14*; PPI • Kutzulurshan; *G.P. Hsieh 2344*; PPI • south of Dahanshan; *C.F. Chen 896*; PPI • Chachayalaishan; *C.F. Chen 992*; PPI • Majia Village to Mt. Xueyegen; *T.W. Hsu 10397*; TAIE • Tahanshan to *Amentotaxus* nature preservation; *J.C. Wang et al. 8806*; TNU • South Link Highway 471.5 km; *C.S. Kouh 15495*; NCKU, TNM • Mt. Yitingshan; *C.K. Yang 843*; TNM • Shuangliu Forest Recreation Area; *Y.C. Lin* 1303; TCF. – **Ilan County** • Fu-Shan Station, Taiwan Forestry Research Institute, en route from the Station to Chukenghsi (a stream); *S.C. Hsiao 1150*; HAST • Fu-Shan industrial road; *Y.C. Lin 1351*; TCF. – **Hualien County** • Yuli Logging Trail; *S.C. Wu 1020*; TAIF • Antung; *S.Y. Li 288*; TAI • Dali-Datong Trail; *Y.C. Lin 1350*; TCF • Yuli Logging Trail; *Y.C. Lin 1352*; TCF. – **Taitung County** • Lanyu; *C.T. Moo 2340* • Lanyu Tianchi; *B.J. Wang 14317*; HAST • Lanyu Mt. Hungtou; *S.W. Chung 8412*; TAIF • ibid.; *Y.L. Jone 1144*; PPI • Tajen Farm; *W.C. Leong 2080*; HAST, TNU • Kueitien; *S.Y. Lu 17907*; TAIF, TAI • Lutao Is.; *S. Sasaki s.n.*; TAI.

Description

Perennial rhizomatous herbs, 25–135 cm tall. Rhizomes fleshy, weakly aromatic, compacted, densely branched, 1.0–2.7 cm in diameter, brown externally, yellow internally; root tubers terete, distantly from the rhizomes, ca 5 × 1.2 cm, brownish externally. Leafy shoots forming dense clumps, spreading, each shoot comprising 6–21 well-developed leaves at flowering. Leaves evergreen, simple, distichous; ligules ca 6 mm long, bilobed, membranaceous, pale green, auriculate; petiole 3−8 mm long, connate a pulvinus; lamina elliptic to narrowly ovate, 12−29 × 3−8.5 cm, lengt / width ratio 2.4−5.6, adaxially green, glabrous or pubescent, abaxially pale green sometimes flush, pubescent, base cuneate or obtuse, apex acuminate, margin entire, undulate, chartaceous. Inflorescences 1–5 per plant, arising from rhizomes; peduncles 11–12.7 cm long, ascending, glabrous; spike narrowly cylindrical or obovate, ca 7–9 × 2.0–3.1 cm, each with 3–11 flowers; fertile bracts greenish-red, narrowly ovate, 2.3–4.3 × 0.5–1.5 cm, usually red tinged, involute on both sides, apex acute to attenuate, glabrous externally and internally; bracteole narrowly ovate, 1.5–2.6 × 0.4–1.0 cm, translucent reddish with slight red tinge, apex acute, involute on both sides, glabrous externally and internally. Flowers 6–8 cm long, much exserted beyond the bracts; calyx tubular,

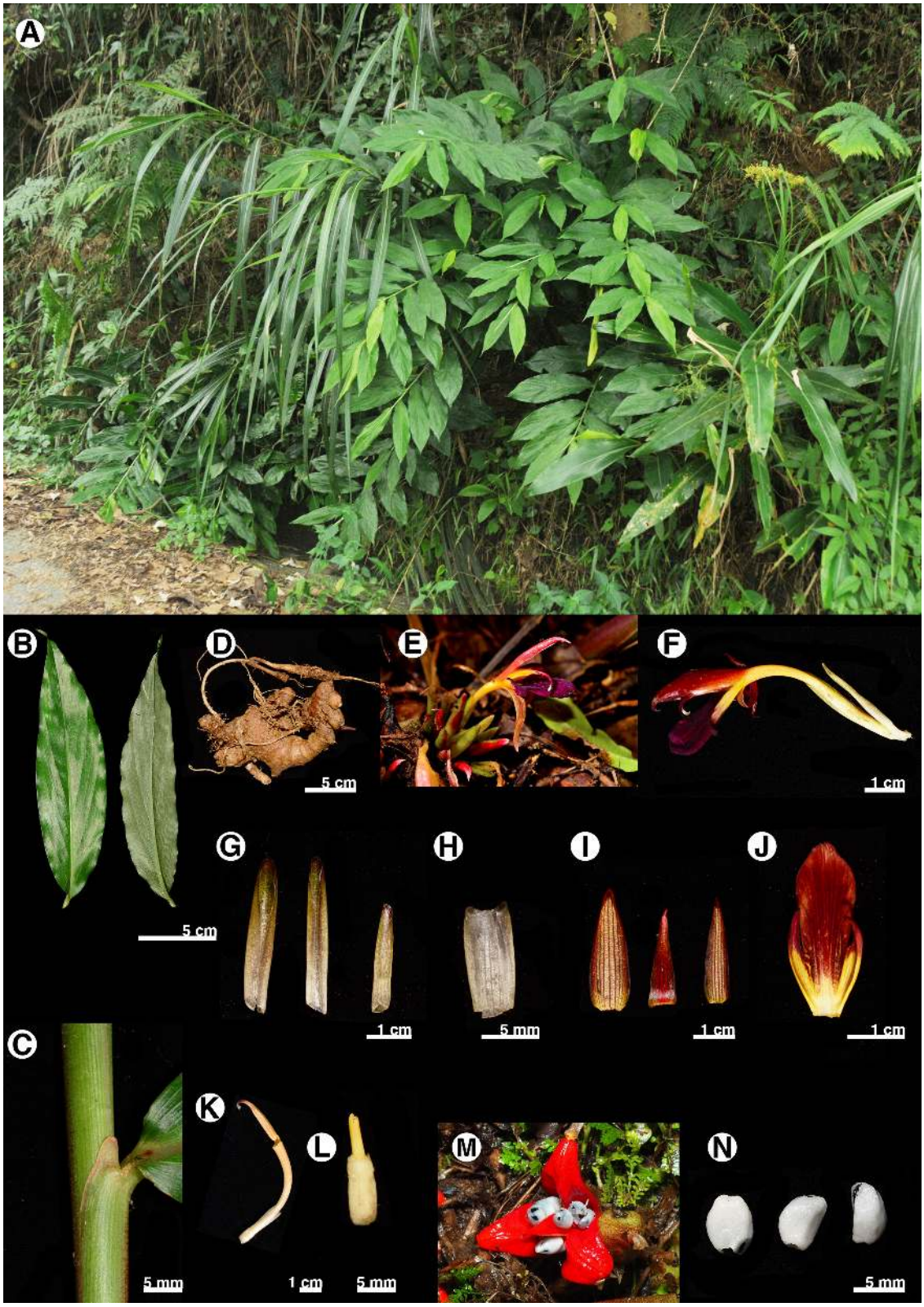


Fig. 12. *Zingiber pleiostachyum* K.Schum., Chichidashan. **A**. Habit. **B**. Leaf adaxial (left) and abaxial (right) surface. **C**. Ligule. **D**. Rhizome. **E**. Inflorescence. **F**. Flower. **G**. Bracts. **H**. Calyx tube. **I**. Corolla lobes. **J**. Labellum. **K**. Stamen and pistil. **L**. Ovary. **M**. Fruit. **N**. Seeds. Photos: A = C.T. Chao; B–N = L.P. Hsu.

membranaceous, 5–15 mm long, with unilateral incision, translucent. Corolla tube slender, 2.6–4.7 cm long, yellow, glabrous externally and internally; dorsal corolla lobe narrowly ovate, ca 2.8 × 0.9 cm, red, apex acuminate, glabrous; lateral corolla lobes narrowly ovate, ca 2.4 × 0.6 cm, red, apex acuminate, glabrous; labellum obovate or elliptic, ca 2.8 ×1.1 cm, red or purple, apex retuse, yellow patches at base, glabrous; lateral staminodes narrowly oblong, ca 1.6 × 0.5 cm, connate to labellum at basal ½ to ⅔, red or purple, yellow patches at base, apices obtuse, glabrous. Stamen one; filament ca 2mm, glabrous; anther connective tissue yellow, elongate appendage wrapped around style; anther thecae two, ca 1.2 cm long, longitudinal dehiscence, pollen light yellow; anther crest beak-shaped, ca 1.1 cm long when stretched, purple, apex entire. Style filiform, white, ca 5.1 cm long, extending to the end of anther crest; stigma white, ciliate. Ovary cylindrical, trilocular, ca 6.0 × 2.8 mm, yellowish, pubescent; epigynous glands two, narrowly conical, ca 4 mm long, yellow, apices sharp. Capsule elliptic, dehiscence loculicidal, ca 3.2 × 1.5 cm, usually longer than the persistent bract, pericarp yellowish-red and red inside. Seed ellipsoid, ca 6.2 × 4.6 mm, enveloped by the aril. Aril white, enveloping ¾ of the length of the seeds.

Phenology

Flowering from August to November and fruiting from October to March.

Distribution

Endemic to Taiwan.

Conservation status

This species was evaluated as Least Concerned (LC) by the Editorial Committee of the Red List of Taiwan Plants (2017) (as *Z. kawagoii*).

Zingiber shuanglongense C.L.Yeh & S.W.Chung
urn:lsid:ipni.org:names:77133995-1
Fig. 13

Journal of Systematics and Evolution 50: 168 (Yeh *et al.* 2012), as '*shuanglongensis*'. **Type**: TAIWAN – **Nantou County** • Shuanglung; 12 Apr. 2008; *C.R. Yeh s.n.*; holotype: TAIF[TAIF-156518]!.

Additional material examined

TAIWAN – **Nantou County** • Shuanglung Logging Trail; *T.W. Hsu 3301*; TAIF • ibid.; *Y.C. Lin 1294*; TCF • Jenlun logging road; *Y.C. Lin 1306*; TCF. – **Chiayi County** • Shihcho to Shihtzulu; *T.W. Hsu 5546*; TAIF • Dadungshan backbend (huitouwan); *Y.C. Lin 1292*; TCF • Dingshizhao; *Y.C. Lin 1347*; TCF. – **Kaohsiung County** • Tengchih Forest resort area; *C.I. Peng 11225*; HAST • Terng-Jr; *J.C. Wang et al.7528*; TNU • ibid.; *S.Z. Yang 7202, 7203, 7185, 9804*; PPI • Tengchih; *T.W. Hsu 9861*; TAIE • ibid.; *S.W. Wu 5084*; TAIF • ibid.; *S.W. Wu 5084*; TAIF • ibid.; *Y.C. Lin 1256*; TCF • Tengchih National Forest recreation area; *T.W. Hsu 14360*; TAIE • Mt. Paiyun; *Y.C. Lin 1319*; TCF; Hsiaokuangshan logging road; *Y.C. Lin 1316*; TCF. – **Pingtung County** • Along Tahan forest road; *C.I. Huang et al. 2828*; HAST • Forest trail from Ali to Hsiaokueihu; *C.C. Liao et al. 636*; HAST, TNU • Xiaoguihu; *C.S. Kouh 16039*; NCKU, TNM • Tahan forest road; *Y.C. Lin 1329*; TCF • Aluwan historical trail; *Y.C. Lin 1342*; TCF. – **Taitung County** • Hungshih Logging Trail; *Y.P. Cheng 4381*; TAIF • Yanping forest road 11 km; *C.H. Chen 6006*; TAIE • Lichia Logging Trail; *Y.C. Lin 1338*; TCF.

Description

Perennial rhizomatous herbs, 40–70 cm tall. Rhizomes fleshy, weakly aromatic, compacted, densely branched, 0.8–2.7 cm in diameter, brown externally, purplish internally; root tubers terete, distant from

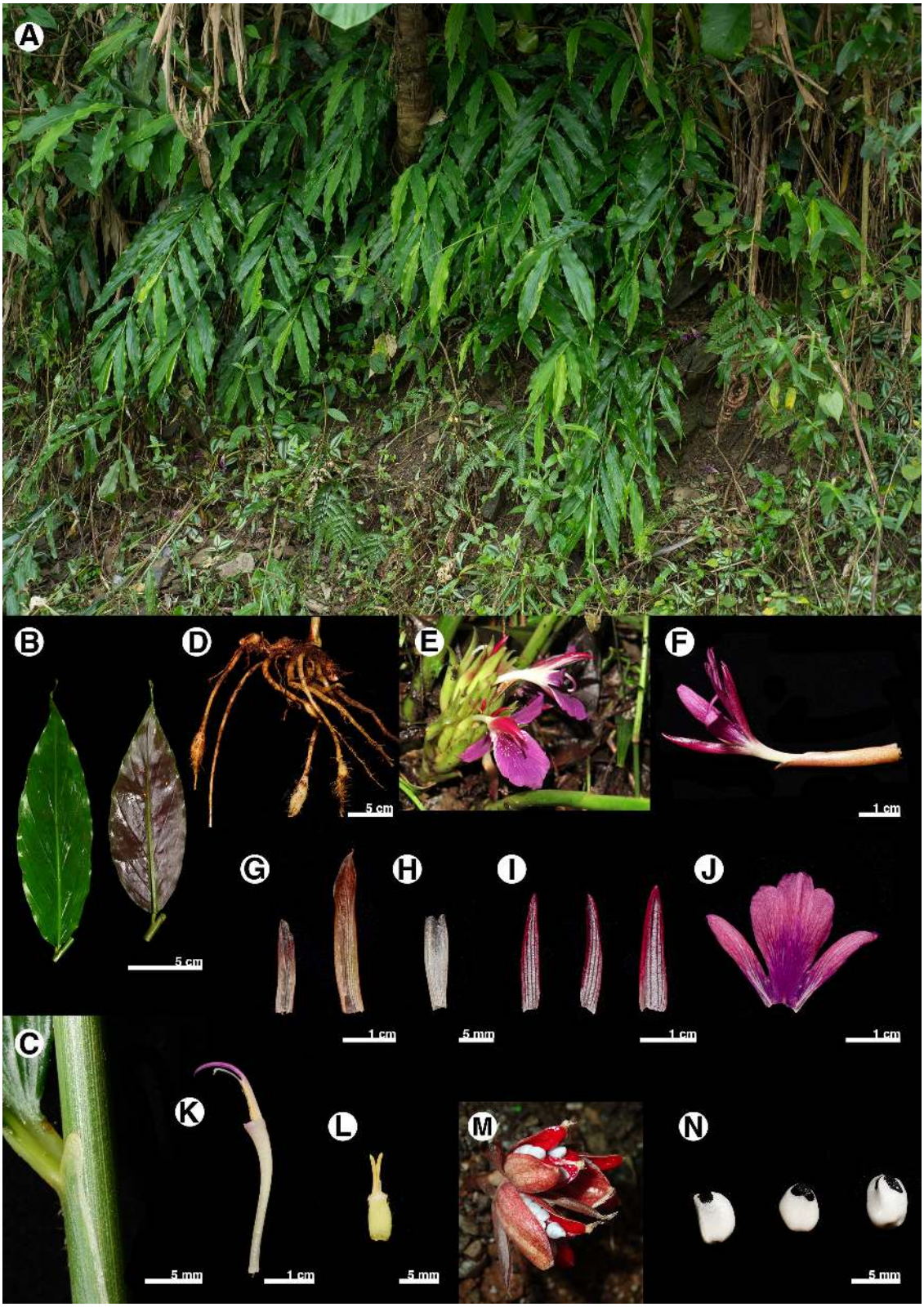


Fig. 13. *Zingiber shuanglongense* C.L.Yeh & S.W.Chung, Shuanglung Logging Trail. **A**. Habit. **B**. Leaf adaxial (left) and abaxial (right) surface. **C**. Ligule. **D**. Rhizome. **E**. Inflorescence. **F**. Flower. **G**. Bracts. **H**. Calyx tube. **I**. Corolla lobes. **J**. Labellum. **K**. Stamen and pistil. **L**. Ovary. **M**. Fruit. **N**. Seeds. Photos: L.P. Hsu.

the rhizomes, ca 5 × 1.5 cm, brownish externally. Leafy shoots forming dense clumps, spreading, each shoot comprising 7–21 well-developed leaves at flowering. Leaves evergreen, simple, distichous; ligules ca 5 mm long, bilobed, membranaceous, pale green, auriculate; petiole 3−7 mm long, connate a pulvinus; lamina elliptic to narrowly ovate, 12−23 × 2−7 cm, length / width ratio 2.8−6.7, adaxially green, glabrous, abaxially pale green sometimes flush, pubescent, base cuneate or obtuse, apex acuminate, margin entire, undulate, chartaceous. Inflorescences 1–4 per plant, arising from rhizomes; peduncles 2–8.3 cm long, ascending, glabrous; spike narrowly cylindrical, ca 8–9.3 × 2.0–2.5 cm, each with 3–8 flowers; fertile bracts greenish-red, lanceolate, 2.3–3.3 × 0.5–1.0 cm, usually red tinged, involute on both sides, apex acute to attenuate, glabrous externally and internally; bracteole lanceolate, 1.7–2.2 × 0.4–0.6 cm, translucent reddish with slight red tinge, apex acute, involute on both sides, glabrous externally and internally. Flowers 6.2–7.3 cm long, much exserted beyond the bracts; calyx tubular, membranaceous, 5–10 mm long, with unilateral incision, translucent. Corolla tube slender, 2.6–3.4 cm long, creamy-white, glabrous externally and internally; dorsal corolla lobe lanceolate, ca 2.5 × 0.7 cm, red, apex acuminate, glabrous; lateral corolla lobes lanceolate, ca 2.3 × 0.6 cm, red, apex acuminate, glabrous; labellum widely obovate, ca 2.9 ×1.9 cm, purple, apex retuse, with scattered cream-white patches at base, glabrous; lateral staminodes narrowly oblong, ca 2.3 × 0.4 cm, connate to labellum at basal ⅓ to ¼, purple, apices obtuse, glabrous. Stamen one; filament ca 2 mm, glabrous; anther connective tissue creamy-white, elongate appendage wrapped around style; anther thecae two, ca 1.1 cm long, longitudinal dehiscence, pollen light yellow; anther crest beak-shaped, ca 1.3 cm long when stretched, purple, apex entire. Style filiform, white, ca 5.6 cm long, extending to the end of anther crest; stigma white, ciliate. Ovary cylindrical, trilocular, ca 5.0 × 2.8 mm, yellowish green, pubescent; epigynous glands two, narrowly conical, ca 5 mm long, pale yellow, apices sharp. Capsule elliptic, dehiscence loculicidal, ca 3.3 × 1.4 cm, usually shorter or as long as the persistent bract, pericarp yellowish-red and red inside. Seed ellipsoid, ca 6.5 × 4.5 mm, enveloped by the aril. Aril white, enveloping ¾ of the length of the seeds.

Phenology

Flowering from August to November and fruiting from October to February.

Distribution

Endemic to Taiwan.

Conservation status

This species was evaluated as Least Concerned (LC) by the Editorial Committee of the Red List of Taiwan Plants (2017).

Notes

According to ICN art. 23.5 (Turland *et al.* 2018), the adjective form of the species epithet must agree with the gender of the generic name, and must be corrected when not conforming to this article. Therefore, the gender of the original spelling of '*shuanglongensis*' by Yeh *et al.* (2013) did not conform to the neuter gender of '*Zingiber*', thus needed to be corrected to '*shuanglongense*'. Bai *et al.* (2015b) also made the same correction for this specific epithet.

Discussion

Morphological comparison of taxa of *Zingiber* from Taiwan

The floral parts are often regarded as the most important diagnostic characteristic for the delimitation of species of *Zingiber* (Wu & Larsen 2000; Yeh *et al.* 2012, 2013; Bai *et al.* 2016; Ohba 2016); however, flowers of *Zingiber* wither on herbarium specimens and fine distinctions become difficult to interpret. To add to the problem of species delimitation and identification, the flowers of Taiwanese taxa of *Zingiber*

often hide under leaves near the ground. This fact together with the plant's preference for shady habitats and its diurnal habit makes field work difficult.

In the second edition of *Flora of Taiwan* (Wang 2000), all species with bilobed ligules and purplish labella were lumped into *Z. kawagoii*. Our study revealed that at least three species from this group could be distinguished by the corolla tube color and labellum morphology. *Zingiber chengii* differs from *Z. shuanglongense* and *Z. pleiostachyum* in its deciduous habit, lanceolate leaves and inflorescence with loosely arranged flowers, together with a creamy-white corolla tube and violet labellum with creamy-white patches. In addition, *Z. shuanglongense* resembles *Z. pleiostachyum* in the pseudostem and leaf morphology, and their distribution range overlaps in central and southern areas. However, the creamy-white corolla tubes and violet labellum with creamy-white patches of *Z. shuanglongense* could easily be distinguished from the yellow corolla tubes and purplish labellum with yellow patches of *Z. pleiostachyum*, even in sympatric populations.

Zingiber pleiostachyum was described by Schumann (1904). This species was characterized by its narrow bracts and by the flowers that have pubescent pedicels. He cited two gatherings (*Henry 147* and *1659*; both in K) collected from the Bankensing Mountains. Both Schumann's description of these specimens and the label (*Henry 1659*) describe this species as having red flowers similar to those of *Z. kawagoii*. We compared the protologue and references of Taiwanese taxa, and confirm that this species is identical to *Z. kawagoii*. According to ICN art. 11.3 (Turland *et al.* 2018), *Z. pleiostachyum* has priority over *Z. kawagoii*; therefore, we treat *Z. kawagoii* as a synonym of *Z. pleiostachyum*.

Zingiber oligophyllum was historically misidentified as *Z. mioga* (Wu & Chen 1981; Wu & Larsen 2000; Ohba 2016). Both species show some similarities in terms of deciduous habit and yellow corolla tubes and labellum. However, *Z. oligophyllum* can be distinguished from *Z. mioga* by having an entire rather than bilobed ligule, plicate lateral veins instead of smooth lateral veins, and widely ovate bracts and bracteoles (vs lanceolate). These differences between the two species were supported by Yeh *et al.* (2013) and Bai *et al.* (2016). Considering the differences between them, *Z. oligophyllum* is treated as an independent species rather than a synonym of *Z. mioga* in this study.

Taxonomic status of *Zingiber mioga* in Taiwan

Zingiber mioga was recorded as a cultivated species by Matsumura & Hayata (1906). They stated that the specimen was collected at Pachina in 1896 by Makino. The supposed provenance of this specimen suggests that this species might have been introduced before the twentieth century. Later studies by Kawakami (1910), Sasaki (1928) and Masamune (1936) also regarded this species as a cultivated one, and that there might not have been a naturalized population at that time. Recently, one wild population of *Z. mioga* was recorded in Ilan County, northeastern Taiwan. This population located on a mountain ridge at an altitude of about 900 m. The habitat was in forest margin with the following companion species commonly found in nearby locations: *Ficus erecta* Thunb. var. *beecheyana* (Hook. & Arn.) King (Moraceae Gaudich.), *Miscanthus sinensis* Andersson (Poaceae Barnhart), *Euscaphis japonica* (Thunb.) Kanitz (Staphyleaceae Martinov), *Machilus thunbergii* Siebold & Zucc. (Lauraceae Juss.), and *Melastoma candidum* D.Don (Melastomataceae Juss.). We also found fertile seeds and seedlings in this population, demonstrating good regeneration. The habitat of this population was similar to that of other species of *Zingiber* of Taiwan.

Zingiber mioga was cultivated in China for its medicinal rhizomes and in Japan for its edible young inflorescences (Wu *et al.* 2000; Ohba 2016). Recently, this species was also cultivated for edible inflorescences near Fengchihu, southern Taiwan. Therefore, it was not surprising that the population of *Z. mioga* introduced in the northeastern section had naturalized into the surrounding areas. In fact, *Z. mioga* had been reported as a naturalized plant in Korea (Kim & Ou 2010; Ikeda *et al.* 2021). However,

considering the habitat and its global distribution, *Z. mioga* is also possibly a native species of Taiwan. From these observations and revisions to the literature, *Z. mioga* might be a naturalized species of *Zingiber* in Taiwan.

Typification of *Zingiber kawagoii* and *Z. pleiostachyum*

Zingiber kawagoii was described by Hayata (1921) based on the specimen collected by Kawagoe from Funkiko (*Kawagoe s.n.*; TI, TAIF). The specimen cited by Hayata would likely have been deposited in TI or TAIF, or other herbaria in Japan or Taiwan, but it could not be found in these herbaria. Therefore, the type specimen of *Z. kawagoii* was considered to be lost and a lectotype or neotype had to be designated (ICN Art. 9.3) (Turland *et al.* 2018). However, Hayata (1921) did not cite the other specimen in the protologue of *Z. kawagoii*; therefore, the other original material studied by the author were candidates for the lectotype specimen (ICN Art. 9.4) (Turland *et al.* 2018). We found other specimens in TI and TAIF identified as *Z. kawagoii* and also collected by Kawagoe, but the locality of these specimens was the Urai instead of the type locality, Funkiko. One specimen was identified as being collected by Hayata based on his handwriting, and we believe this specimen could be regarded as part of the original material collected and examined by Hayata (ICN Art. 9.4) (Turland *et al.* 2018). Therefore, this specimen is here designated as the lectotype of *Z. kawagoii* (Fig. 14).

Schumann (1904) cited *Henry 147* (K) and *1659* (K) in the protologue of *Z. pleiostachyum*, however, none of them was designated as the type specimen. *Zingiber kawagoii* is treated as a synonym of *Z. pleiostachyum* here, but according to ICN Art. 9.3 (Turland *et al.* 2018), a lectotype specimen should still be designated. Among those cited by Schumann, *Henry 1659* was an intact, related specimen and thus, is here designated as the lectotype (Fig. 15).

Taxonomic status of *Zingiber koshunense*

This name was first published by Sasaki (1930) in the herbarium list as *Zingiber koshunense* [sic] Hayata, based on a collection of T. Kawakami and S. Sasaki at an altitude of 5000 feet of Abei Line, 2 Jan. 1911. This collection was the first one of this species. Moo (1978) described *Z. koshunense* as a new species. He provided detailed descriptions and two specimens were cited, one which was collected by T. Kawakami and S. Sasaki, and the other one from Lanyu, which was collected by him (*Moo 2340*; TAI). Neither of them was designated as the type specimen. Therefore, Moo's name was still invalid because no single specimen or illustration was designated as the type specimen as required by ICN articles 8.1 and 9.1 (Turland *et al.* 2018). Wu *et al.* (2000) designated a holotype (which actually was a lectotype) for this species, and ascribed its name to Moo due to his providing the morphological description of this species, and *Z. koshunense* Moo has been valid since then.

However, *Z. koshunense* was still a poorly known species in Taiwan. Because of the lack of the floral parts, the morphology could only be judged by Moo's description (1978). Fortunately, Moo (1978) provided a detailed description of the labellum of *Z. koshunense*, reddish-purple and lanceolate, which was identical to that of *Z. pleiostachyum*. As we have stated before, the labellum characters are crucial for settling *Zingiber* taxonomy, and based on this description, we treated *Z. koshunense* as a synonym of *Z. pleiostachyum*. The result of the haplotype network of cpDNA also supported such treatment of *Z. koshunense* (Fig. 8).



Fig. 14. Lectotype of *Zingiber kawagoii* Hayata (TI-00010378).



Fig. 15. Lectotype of *Zingiber pleiostachyum* K.Schum. (K-000815680).

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Supplementary files

Supp. file 1. Collection information of *Zingiber* species materials for molecular analysis.
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Supp. file 2. Accession number of cpDNA sequences applied in molecular analysis.
https://doi.org/10.5852/ejt.2022.839.1933.7773