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A NEWLY RECORDED SPECIES *Zingiber densissimum* (sect. *Cryptanthium*) FOR THE FLORA OF VIETNAM

Le Chi Toan[1], Nguyen Thi Lien Thuong[2,*], Nguyen Hoang Tuan[3], Nguyen Van Canh[2], Truong Quang Cuong[4], Nguyen Van Khuong[2], Pham Thi Thanh Dat[2], Nguyen Danh Duc[2]

[1]Hanoi Pedagogical University 2, 32 Nguyen Van Linh, Vinh Phuc province, Vietnam
[2]Institute of Applied Technology, Thu Dau Mot University,
06 Tran Van On, Binh Duong province, Vietnam
[3]Faculty of Pharmacognosy and Traditional Medicine, 13-15 Le Thanh Tong,
Hanoi University of Pharmacy, Hoan Kiem, Ha Noi, Vietnam
[4]Bidoup-Nui Ba National Park, Lam Dong province, Vietnam

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ABSTRACT

During our floristic expedition in South Vietnam, a wild taxon *Zingiber densissimum* (sect. *Cryptanthium*) was recognized as a newly recorded species for the flora of Vietnam. The taxonomic treatment with a description is provided, along with photographs, distribution, ecology, a conservation assessment, and morphological comparison with its alliance species. It is similar to *Zingiber orbiculatum* and *Zingiber mioga* in having whitish flowers and bright yellow anthers but differs in many aspects of vegetative and reproductive characteristics. Moreover, a taxonomic key for all species of sect. *Cryptanthium* in Vietnam is included.

Keywords: *Zingiber densissimum*, Indochina, plant taxonomy, new record, Vietnam.

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[*]*Corresponding author email*: thuongntl@tdmu.edu.vn

INTRODUCTION

Cryptanthium Horan. is the second largest section of the genus *Zingiber* Mill. with 80 of all 208 species of the genus accepted and listed in The International Plant Names Index (Royal Botanic Gardens & Kew, 2023). Traditionally, the genus *Zingiber* is divided into four sections based on the position of inflorescence. Section *Cryptanthium* is similar to the largest sect. *Zingiber* in radical inflorescence, differs from the latter in weakly procumbent peduncle embedded in-ground (vs. stout peduncle). From the two remaining smaller sections, it differs in radical inflorescence (vs. terminal inflorescence in sect. *Dymczewiczia* (Horan.) Bentham & Hooker (Leong-Škorničková et al., 2015) and vs. inflorescence exerting from leaf sheath in sect. *Pleuranthesis* Bentham & Hooker) (Leong-Škorničková et al., 2015). Recently, most phylogeny studies supposed that the genus *Zingiber* should be divided into three sections. *Cryptanthium* is well separated from other sects. but sect. *Dymczewiczia* and *Zingiber* merged in to a large group (Theerakulpisut et al., 2012). Most wild taxa of this section occur in south China, North West India to North Indo-China (Myanmar, North Thailand, Laos and Vietnam). Since the 1990s, comprehensive investigations of international botanists in China and Thailand resulted in 32 and 23 taxa, respectively, and this area became the biodiversity centre of this group. At the same time in Vietnam, this section was poorly recorded. There was only one species recorded, namely *Zingiber rubens* Roxb. (Pham, 2003). However, this species has not been rediscovered again up to now. The existence of this species in Vietnam is unclear and needs further studies to confirm. One more species, namely *Zingiber mioga* Thunb. from the mountainous region of North Vietnam added to the checklist but cultivated (Le et al., 2008).

Recently, Vietnam has become the hot pot of biodiversity of genus *Zingiber*, especially *sect. Cryptanthium*. The number of species presented in this section has risen to more than ten comprising: 5 new species for science described, namely *Zingiber lecongkietii* Škorničk. & H. Đ. Trần (Leong-Škorničková et al., 2015), *Zingiber skornickovae* N.S. Lý (Ly, 2016), *Zingiber vuquangense* N.S.Lý, T.H.Lê, T.H.Trinh, V.H.Nguyen & N.D.Do (Le et al., 2019), *Zingiber tamii* N.S.Lý & Škorničk. *& Zingiber magang* N.S.Lý & Škorničk. (Ly et al., 2021). The four others are the new records for the flora Vietnam, namely *Zingiber thorelii* Gagnep. (Bai et al., 2016), *Zingiber cornubracteatum* Triboun & K.Larsen (Le et al., 2019), *Zingiber mekongense* Gagnep. (Tran et al., 2020) and *Zingiber recurvatum* S. Q. Tong & Y. M. Xia (Nguyen et al., 2020). However, the checklist in Vietnam is being updated and is still far to the end because a number of undefined taxa similar to Chinese ones collected or captured by nature enthusiasts in all parts of Vietnam are being examined.

Lam Dong province is located in South Vietnam with ecosystems representing for South Annamite Range. Its northern part is a high-altitude mountain area composed of the Langbiang plateau (average altitude of 1,500 m) and the Di Linh plateau (average altitude of 1,000 m). This region may be the Far South of the distribution range of the sect. *Cryptanthium*. Some wide-distributing species are found here such as *Z. thorelii* and *Z. mekongense*. Our recent botanical exploration focused on the Langbiang plateau, during which a common species of this section was found. A careful study of specimens collected from the field and detailed comparison with herbarium specimens and relevant literature confirm that our collection is *Zingiber densissimum* S. Q. Tong & Y. M. Xia, which has added to the Vietnamese *Zingiber* key (Ly et al., 2021) without formal description and photographic illustration. Therefore, we present in the present article the taxonomic treatment with a description provided, along with photographs, distribution, ecology, a conservation assessment, and morphological comparison to its alliance species.

MATERIALS AND METHODS

The morphological characteristics of our specimens were compared with those of

relative species in Vietnam and neighbour countries based on their protologue and relative document (Tong & Xia, 1987; Theilade, 1999; Triboun et al., 2014; Bai et al., 2015, 2016, 2018a,b; Ding et al., 2020; Lin et al., 2022) as well as their herbarium specimen from the traditional herbaria (E, P, K, SING, YNTBI and VNM) and high-resolution images of specimen digitized on Chinese Virtual Herbarium (http://www.cvh.org.cn/), Jstor Global Plant (https://plants.jstor.org/), Muséum National d'Histoire Naturelle (https://science.mnhn.fr/). The general terminology used follows (Beentje, 2012) and the previous work of (Ly et al., 2021). Conservation status was assessed using the IUCN Red List Categories and Criteria version 15 (IUCN, 2022).

RESULTS AND DISCUSSION

Zingiber densissimum S.Q. Tong & Y.M. Xia, Acta Phytotax. Sin. 25(6): 467 (1987) (Fig. 1).

TYPE:—Type: CHINA, China, Yunnan, Menghai, 1400 m, October 7 1986, S.Q. Tong & Y.M. Xia 24998 (holo. HITBC 081604(photo!); iso. YNTBI).

Description: Rhizomatous herb 0.4–0.8 m tall, forming small clumps, 1–2 (up to 6) leaf shoots per each clump. **Rhizome** branched 1–2.3 cm diam., 1–3 cm between neiboring leafy shoots, externally whitish (young rhizomes) to brown (older rhizomes), internally cream, aromatic, covered with light brown triangular scales, 2.5 –3.2 cm long, glabrous, soon decaying. **Leafy shoots** 0.5–0.7 m apart, slightly arching, with up to 9 leaves, approximately basal ¼ to 1/3 of pseudostem leafless; **bladeless sheaths** 2–3, 3–10 cm long, reddish brown, sparsely pubescent. **Leaf sheaths** green to pale green, white hairy, margin ciliate; **ligules** reduced, bi-lobed ca. 5–10 mm long, densely white pubescent; **petiole** 1–5 cm long, comprising a pulvinus, pubescent; pulvinus ca. 1 cm long, pale green, pubescent; **lamina** lanceolate, 22–45 × 4–9 cm, plicate, adaxially mid green and glabrous, abaxially pale green and pubescent, hairs appressed, base obliquely attenuate, apex acuminate to slightly caudate. **Inflorescences** radical, arising 1–2 from young rhizome parts; **peduncles** procumbent, 6–13 cm long, 0.6–0.7 cm in diam.; **sheathing bracts** lanceolate ovate, 1–5 cm long (shortest basally, progressively longer distally), involute, 0.7–1.5 cm wide when flattened, cream-white, apex tinged brownish red, glabrous; **spike** ovoid, 4–5 × 3–5 cm, comprising 6–9 tightly arranged bracts, each subtending a single flower (lower ca. 1–3 bracts usually sterile); **fertile bracts** narrowly ovate to broadly ovate, 35–40 mm long, involute, 20–30 mm wide when flattened (smaller towards apical part of the inflorescence), cream white tinged brownish red toward apex, lightly pubescent abaxially (appressed hairs), glabrous adaxially, apex sub-acute; **bracteoles** narrowly oblong, ca. 30–35 × 3–4 mm, involute, ca. 10 mm wide when flattened, cream-white with brownish red dots mottling on apex, densely pubescent abaxially (appressed hair), glabrous adaxially, apex sub-acute to truncate. **Flowers** ca. 8 cm long, much exerted beyond the bracts; **calyx** tubular, 11–19 mm long, ca. 2.0 mm in diam. at base, turning broader at apex up to 3 mm in diam., membranaceous, semi-translucent cream-white, glabrous externally and glabrous internally, apex truncate with minutely 3-toothed, with unilateral incision to 6 mm deep; **floral tube** 4–5 cm long, shallowly curved, cylindrical from base (ca. 2 mm in diam.) turning funal shaped at the apex (3–5 mm in diam.), yellowish white, glabrous externally, sparsely puberulous near the throat internally; **dorsal corolla lobe** narrowly ovate, ca. 32–33× 9–10 mm, cream white, glabrous both sides, apex mucronate and curved to front; **lateral corolla lobes** narrowly triangular, ca. 25–27 × 4.5–5 mm, cream white, deflexed, glabrous; **labellum** broadly obovate, ca. 25–30 × 20 mm, pure white, glabrous, apex rounded or emarginate; **lateral staminodes** narrowly oblong, 20–24 × 6–7 mm, connate to labellum in the basal 2/3, pure white, glabrous, apices rounded. **Stamen** 19–21 mm long (25–27 mm long with anther crest stretched); **filament** 1–2 mm; **anther** ca. 12 mm long (excluding anther crest),

connective tissue cream white, glabrous; **anther thecae** ca. 12 mm long, dehiscing throughout entire length, pollen pale yellow; **anther crest** hook-shaped, 11–13 mm long when stretched, cream white tinged pale yellow turning apex, apex entire. **Style** filiform, white, glabrous; **stigma** extending to the tip of anther crest, funnel-shaped, slightly thicker than the style, 1–2 mm long, white, ostiole ciliate. **Ovary** cylindrical, slightly swollen in middle, trilocular, ca. 5–7 × 2.8–3 mm, cream-white, densely rusty villous (hair appressed); **epigynous glands** two, narrowly conical, 6–7 mm long, 0.5 mm in diam. at base, pale yellow, apex sharp. **Capsules** oblong, triangular, dehiscent loculicidally, pericarp fleshy, orange-red inside. Seeds black or dark brown, aril white, sac-like.

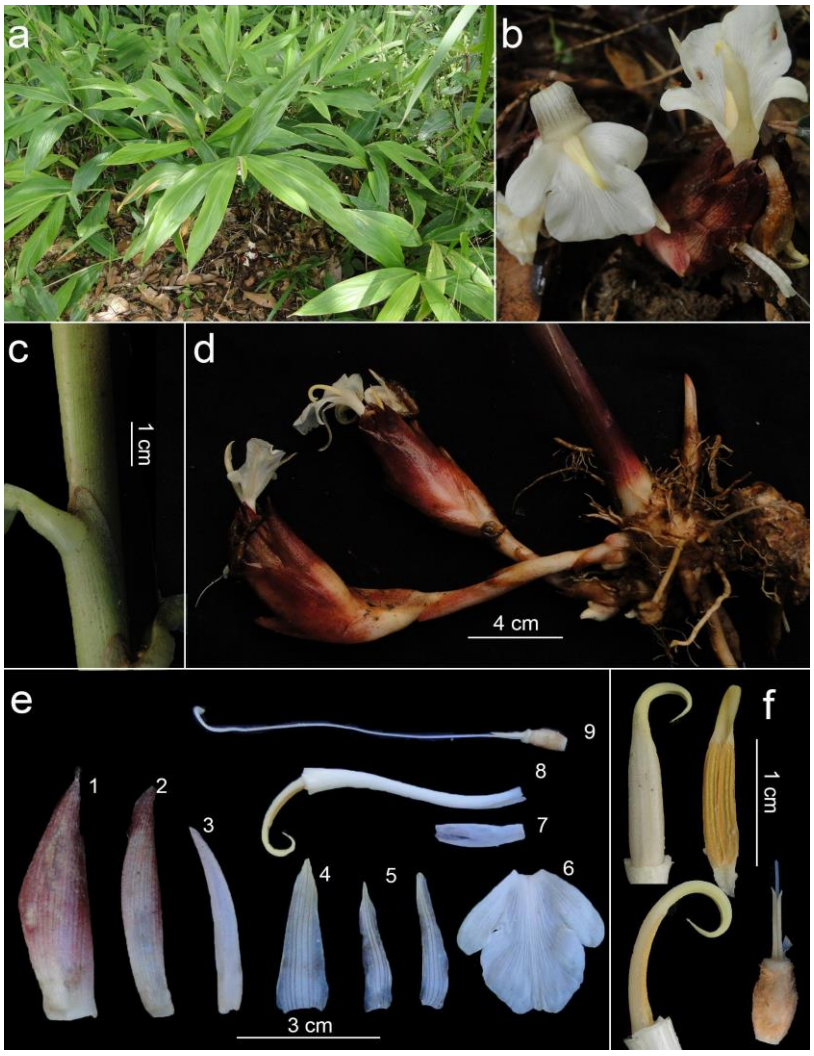

Figure 1. Zingiber densisimum S.Q. Tong & Y.M. Xia. a. Habit; b. inflorescent in-situ with flowers blooming; c. Ligule; d. Rhizome with the basal part of the leafy shoot and inflorescent with opening flower; e. Flower dissection; showing 1. bract in the basal part of inflorescence, 2. Bract in the apical part of inflorescence, 3. Bracteoles, 4. Dorsal corolla lobe, 5. Lateral corolla lobes, 6. Lateral staminodes and labellum, 7. Calyx, 8. Floral tube and stamen, 9. Ovary with epigynous glands and style; f. Stamen in back view, front view, side view and ovary with epigynous glands. [*Photo by:* Danh Duc Nguyen from specimen *NDD-267* (HNU)]

Ecology and phenology: Open area under the canopy of pine (*Pinus kesiya* Royle ex Gordon) forest and plantation, and occasionally in evergreen forest, above 1200 m to 1800m altitude. Flowering from August to September and fruiting extends to December.

Distribution: Known only from Lam Dong province in Vietnam by this study and also in China, Thailand (Triboun et al., 2014), Laos (Souvannakhoummane & Leong-Škorničková, 2018), and Myanmar (Aung & Tanaka, 2019). This species, originally described from southern China by Tong & Xia (1987), has also been reported from Thailand. In Vietnam, locally common in open areas under the canopy of pine forest forests and plantations, and occasionally in evergreen forests, around Da Lat City with no imminent threat, above 1200 m to 1800 m altitude. The herbarium specimen tagged as Zingiber rubens of Newman 847 kept at Herbarium (K) of Kew, during the survey in 1994 in Langbian plateau, Lam dong province shows vegetative parts similar to *Z. densissimum* (small habit, rhizome compact, short bi-lobed ligule and lanceolate lamina) and the description about colour and shape of flower note in herbarium sheet also match with others of the flower of *Z. densissimum*.

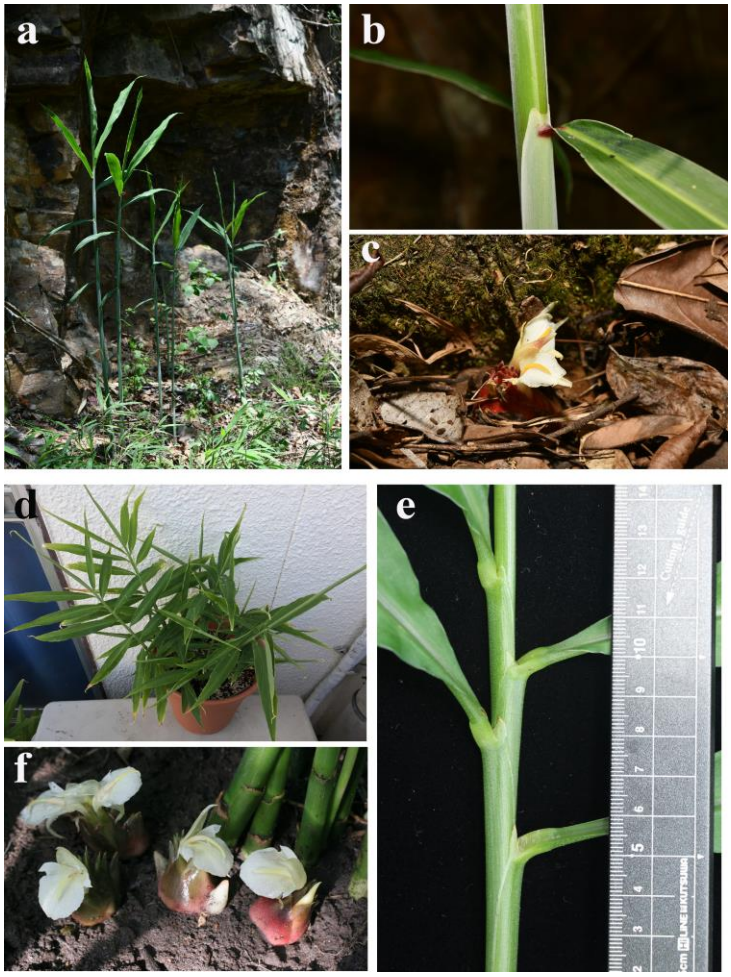

Figure 2. Zingiber orbiculatum: a. Habit, b. Ligule, c. Inflorescence with opening flowers; *Zingiber mioga*: d. Habit, e. Ligule, f. Inflorescence with opening flowers
[*Photo by:* Ding Hong Bo & Hidenobu Funakoshi]

Conservation status: The extent of its occurrence (EOO) is estimated at about 4.397,93 km², around Da Lat city with no imminent threat. Therefore, based on currently available data, we provisionally assess this species as Least Concern (LC) according to the IUCN Red List criteria (IUCN, 2022).

Additional specimens examined: Vietnam. Lam Dong province: Lang Bian, 12°03'N-108°27'E, October 12 1994, *Newman 847* (K); Lac Duong district, Da Chais commune, 12°09'37.3"N-108°39'53.7"E, c.1400 m altitude, September 1 2016, *Nguyen Danh Duc NDD-267* (HNU); Lac Duong district, Lac Duong commune, 12°02'04.3"N-108°25'00.7"E, c.1800 m altitude, May 2015, *Nguyen Danh Duc NDD-488* (HNU); Lac Duong district, Lat commune, 12°05'32.1"N-108°22'43.2"E, 1800 m altitude, September 2022, *Nguyen Danh Duc NDD-22303* (HNU).

Table 1. Morphological comparison of *Zingiber densissimum* with *Zingiber orbiculatum* and *Zingiber mioga*

Characteristics	*Zingiber densissimum*	*Zingiber orbiculatum*	*Zingiber mioga*
Pseudostem	0.4–0.8 m tall	1.5–2 m tall	60–80 cm tall
Leaf sheath	white hairy and not covered	glabrous and covered	glabrous and not covered
Pulvinus	pale green	reddish brown	pale green
Ligule	5–10 mm, bilobed, apex acute, white pubescent	13–15 mm, apex subtruncate, glabrous	ca. 3 mm, bilobed, ear-shaped, glabrous
Petiole	1–50 mm long	reduced	8–11 mm long
Lamina	lanceolate or obovate, 22–45 × 4–9 cm	lanceolate 45–60 × 7–9 cm,	elliptic, 13–29 × 4–7 cm
Fertile bracts	red at apex, elliptic, 3.5–4.0 cm	reddish, ovate or broadly ovate, 3–5 × 2–2.5 cm	greenish-yellow, narrowly ovate, 3.5–4.1 × 0.6–0.8 cm
Bracteoles	30–35 × 3–4 mm, cream-white with brownish red dots mottling on apex	4 cm long and ca. 8 cm, red distally	1.7–2.5 × 0.6–1.5 cm, translucent greenish
Floral tube	4–5 cm long	unknown	2.5 cm long
Calyx length	11– 19 mm	30 mm	6 mm
Labellum	25–30 × 20 mm	25 × 12 mm,	2.8 × 2.0 mm
Lateral staminodes	20–24 × 6–7 mm	1.7 × 7 mm	16 × 5 mm

Taxonomic note: *Z. densissimum* was originally described from South China, however, recently it was also recorded from Laos and Myanmar. The Vietnam plant differs from the others from those countries by the clumping habit up to 6 leaf shoots (vs. solitary, 1 or rarely 2–3 leafy shoots) per clump, and calyx glabrous externally and internally (vs. silvery villous), apex truncate with minutely 2-toothed (vs. unequally 3-toothed). but it matches very well the original protologue by Tong and Xia (1987) and the illustration by Ding et al. (2020). The species *Z. densissimum* is similar to *Z. orbiculatum* S. Q. Tong and *Z. mioga* Thunb. in having whitish flowers and bright yellow anthers. It can be distinguished from the second by its smaller leafy shoot 0.4–0.8 m tall (vs. 1.5–2 m tall) with leaves arranged 1/4 to 1/3 in the upper part of the pseudostem (vs. 3/4 in the

upper part of pseudostem), pulvinus pale green (vs. reddish brown); leaf sheath white hairy and not prominently plicate leaves with white villous indumentum on the lower side of the lamina (vs. smooth and glabrous both sides), and hairy and bilobed ligules (vs. glabrous and apex sub-truncate) (Fig. 2). From the third, it can be recognized by longer flower tube 4–5 (vs. 2.5) cm long; longer calyx 11– 19 (vs. 6) mm long; densely white hairy on the leaf sheath, ligule and lower side of the lamina (vs. glabrous habit); prominently plicate (vs. smooth) lamina; cream white (vs. pale yellow) labellum and lateral staminodes (Fig. 2). The detail of morphological comparison is given in Table 1. The morphological characteristics of *Z. orbiculatum* and *Z. mioga* are referred from descriptions of Aung et al. (2015) and Lin et al. (2022), respectively.

A taxonomic key for all species of sect. *Cryptanthium* in Vietnam

1a. Ligule more than 8 mm long……..2

2a. Leaves with prominent petioles…..……...*Z. vuquangense*

2b. Leaves with laminae sessile…….…….....3

3a. Ligule > 22 mm long, lamina narrowly obovate……..……*Z. mekongense*

3b. Ligule up to 11 mm long, broadly elliptic to elliptic–ovate……..…..4

4a. Ligule glabrous, lamina pubescent abaxially, the length of lateral staminodes less than 1/4 length of labellum……..…*Z. rubens*

4b. Ligule densely pale brown pubescent, lamina puberulent abaxially, the length of lateral staminodes more than 1/3 length of labellum……..*Z. recurvatum*

1b. Ligule up to 5 mm long……..5

5a. Spike narrowly ovoid to oblong, covered by loose bracts……...….6

6a. Lamina broadly elliptic, prominent petiole 3–7.7(–10.5) cm long……..*Z. magang*

6b. Lamina narrowly obovate, petiole reduced up to 3.5 cm long……7

7a. Labellum cream yellow often with pale red-pinkish spots…….….*Z. thorelii*

7b. Labellum dark red-purple to purple-violet with pale yellow to whitish Blotches……Z. *skornickovae*

5b. Spike broadly ovoid to ovoid, covered by tightly imbricate bracts……8

8a. Labellum white or pale yellow……9

9a. Glabrous leaf sheath, ligule and lower side of the lamina; smooth lamina……...……*Z. mioga*

9b. Densely white indumentum on the leaf sheath, ligule and lower side of the lamina; prominently plicate lamina……..……*Z. densissimum*

8b. Labellum red, dark purple or violet with yellow or white spots or blotches…….……10

10a. Plant >1.8m tall, leaves sessile…….*Z. cornubracteatum*

10b. Plant up to 1 m tall, leaves with petiole……...……11

11a. Petiole 30–60 mm long, lamina broadly elliptic and plicate…….……..*Z. tamii*

11b. Petiole to 12 mm long, lamina narrowly ovate and smooth……...……*Z. lecongkietii*

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