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中国菊科二新记录属

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摘要：报道了中国菊科 2 新记录属：距格菊属(*Koyamasia* H. Rob.)、婴带菊属(*Struchium* P. Browne)和 2 新记录种：距格菊[*K. curtisii* (Craib & Hutch.) Bunwong, Chantar. & S. C. Keeley]、婴带菊[*S. sparganophorum* (L.) Kuntze]。这 2 属都来自海南，属于菊科(Asteraceae)斑鸠菊族(Vernonieae)。

关键词：中国；海南；菊科；新记录

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Koyamasia and *Struchium* (Asteraceae, Vernonieae), Two Newly Recorded Genera for China

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Abstract: Two suspicious species of Asteraceae tribe Vernonieae were discovered in Hainan Province, China. Detailed morphological investigation suggests that they are *Koyamasia curtisii* and *Struchium sparganophorum.* Molecular data based on nrDNA ITS sequence provide further support of the status of *K. curtisii.* These two species represented two genera that have not been reported from China. Therefore, they are two newly recorded genera for China.

Key words: China; Hainan; Asteraceae; New record

In November 2019, Dr. Bin Chen discovered an unusual population of the Asteraceae from Bawangling, Changjiang County, Hainan Province of China. We took an expedition in December 2019 to the locality again, but unfortunately flowers had withered at that time. In 2020, we took another expedition to Bawangling in November. Fortunately, we successfully collected some flowering specimens (Fig. 1, 2: B). Also we collected a similar specimen from Mt. Xiananshilin, Maogan Town, Baoting County, Hainan Province of China. Because its capitula homogamous, florets all tubular, phyllaries herbaceous, green, 6–7 series, style branches long, slender, subulate, achenes columnar, pappus of many filiform bristles, this plant obviously belongs to Asteraceae tribe Vernonieae. However, the most unique feature of this species is that its involucre bracts are reversed and apex needlelike, which is not consistent with all the species of tribe Vernonieae in China. In order to determine its phylogenetic status, we carried out morphological and molecular phylo-

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genetic studies.

In March 2018, Qinglong Wang discovered an unusual population of the Asteraceae at low altitude wetlands from Danzhou County, Hainan Province (Fig. 2: D, 3). Another population of the same species was found in Wenchang County, Hainan Province. This plant also belongs to Asteraceae tribe Vernonieae, but also not consistent with all the species of tribe Vernonieae in China. In order to better observe this species, Mr. Wang introduced some plants and cultivated them in Danzhou City, Hainan province of China. After flowering, we carried out a detailed morphological study of this species.

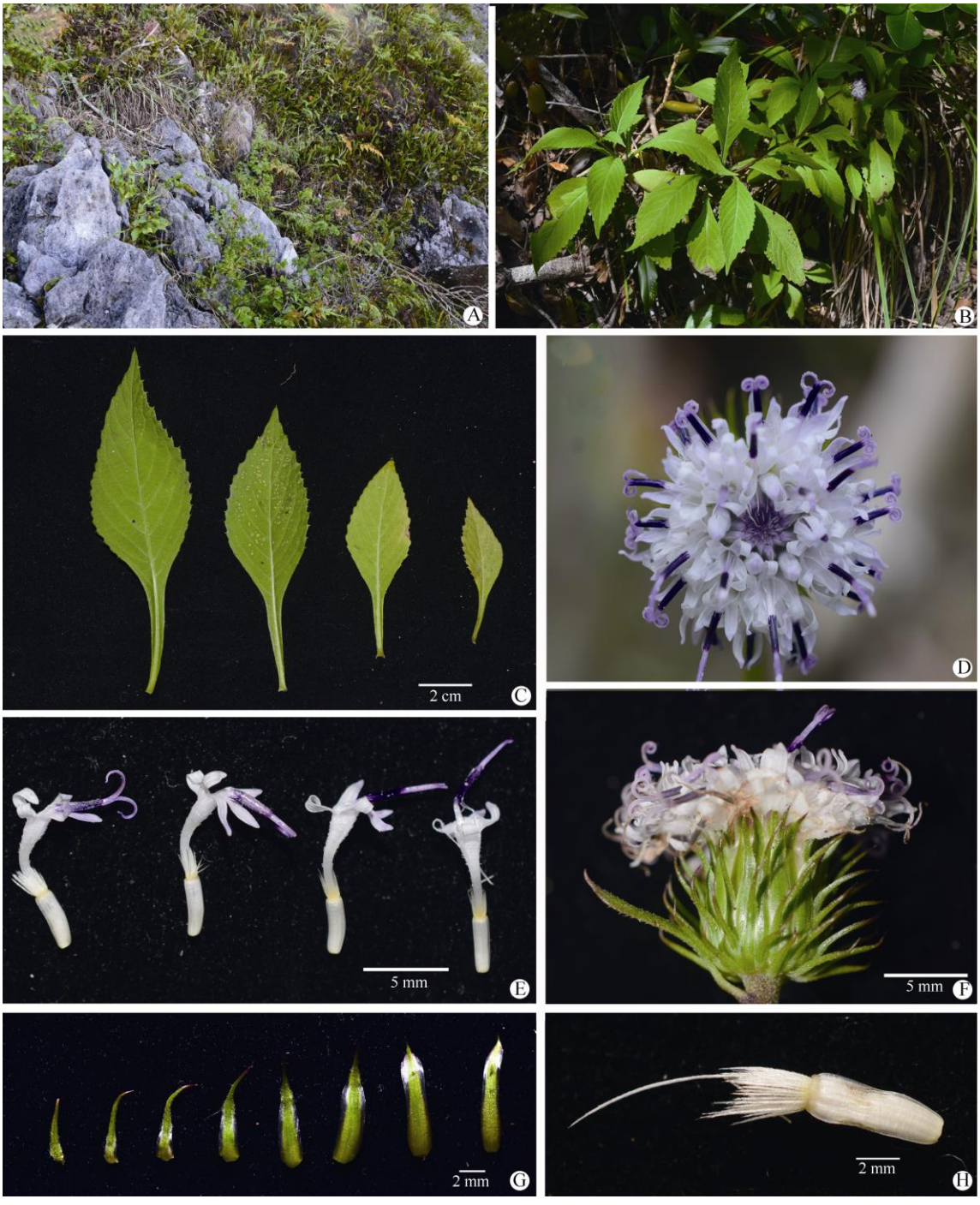

Fig. 1 *Koyamasia curtisii* in the wild (China, Hainan Province, Changjiang County, Bawangling, 18 Nov. 2020, Jun-Jie LIAO et al. LL2020014). A: Habitat; B: Habit; C: Leaves; D: Capitula (top view); E: Disc florets; F: Capitula (side view); G: Abaxial surface of phyllaries from outer series (left) to inner series (right); H: Achene. (Photos taken by Jun-jie LIAO)

Fig. 2 Specimens of *Koyamasia curtisii* and *Struchium sparganophorum.* A: Lectotype of *K. curtisii* (*Curtis 2127*, SING0068747); B: Specimen of *K. curtisii* in China, Jun-jie LIAO LL2020014; C: Epitype of *S. sparganophorum* (G. R. Proctor 20182, BM000576316); D: Specimen of *S. sparganophorum* in China, Qing-Long WANG 18134.

1 Material and methods

1.1 Morphological observation

For the first species from Changjiang and Baoting, we collected three collections with both flowering and fruiting plants, and two plants were cultivated in Guangzhou. For the second species from Danzhou and Wenchang, 5 plants were cultivated in Danzhou

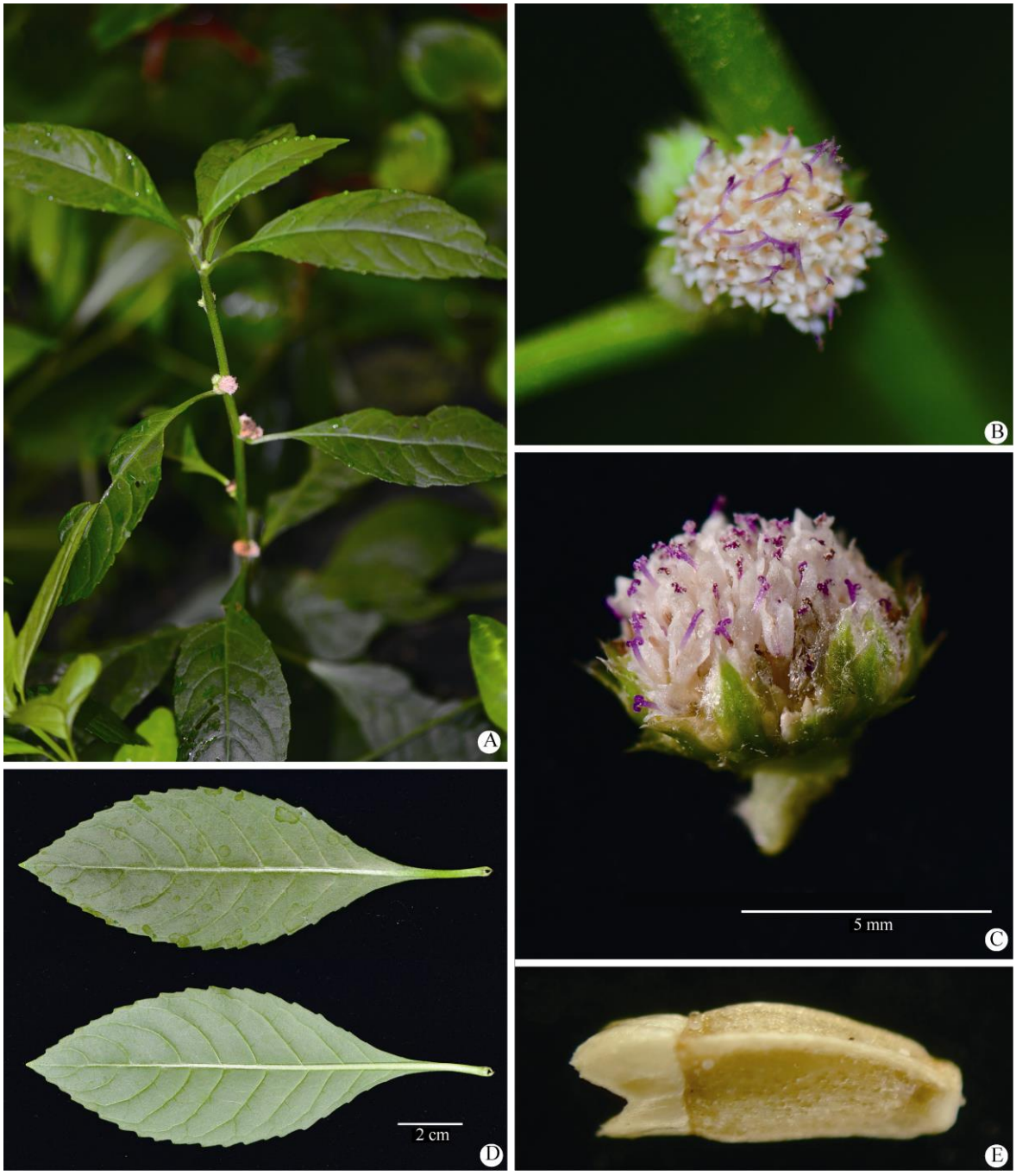

Fig. 3 *Struchium sparganophorum* in the wild (China, Hainan Province, Danzhou County, Zhonghe, Qili, 4 March 2018, Qing-Long WANG 18134). A: Habit; B: Capitula (top view); C: Capitula (side view); D: Leaves; E: Achene. (Photos taken by Qinglong WANG).

City, Hainan Province. Two specimens were pressed after flowering. Specimens are deposited in IBSC. Photos of floral elements were took using a stereoscopic microscope. We carefully examined its morphological characters, searching literatures and comparing with digital specimens from BM, E, K, KYO, L, P, SING, U, WAG (herbaria acronyms following Index Herbariorum).

1.2 Taxonomic sampling, DNA extraction, PCR reaction and ITS sequencing

In order to determine its phylogenetic status of the first doubtful species from Changjiang and Baoting, we selected one sequences of the nuclear ribosomal internal transcribed spacer (nrDNA ITS) regions. 99 collections representing 96 taxa belong to Asteraceae tribe Vernonieae were selected for molecular

studies. The ITS sequences of 10 collections representing 7 taxa are newly sequenced (Table 1), among them three collections of the first doubtful species were selected, and the ITS sequences of 89 taxa are downloaded from NCBI (Table 2), mainly from the research results by Keeley et al.[1].

Total genomic DNA of the nine accessions (Table 1) was isolated from silica geldried leaves using a modified cetyltrimethylammonium bromide procedure[2].

Amplification and sequencing were performed using the primers ITS1 and ITS4 for the ITS region[3]. The PCR mixture contained 1 μL (50–100 ng) of sample DNA, 2 ×2 μL of primer (10 pmol), 5 μL of 10 × PCR buffer, 3 μL of Mg^{2+} (25 mm), 0.8 μL of deoxyribonucleotide triphosphate (each 25 mm), 0.5 μL of *Taq* DNA polymerase (5 U/μL) and sterile water for a final volume of 50 μL. The PCR parameters were as follows: initial denaturation for 4 min at 95 ℃, followed by 30 cycles of denaturation (95 ℃, 1 min), annealing (56 ℃, 40 s) and extension (72 ℃, 1 min), and a final extension of 10 min at 72 ℃[4].

PhyloSuite[5] was used to conduct, manage and streamline the analyses with the help of several plug-in programs: 1 sequence was aligned with MAFFT[6] using 'FFT-NS-1 (fast)' strategy and normal alignment mode. ModelFinder[7] was used to select the best-fit model using BIC criterion. Maximum likelihood phylogenies were inferred using IQ-TREE[8] under the model automatically selected by IQ-TREE ('Auto' option in IQ-TREE) for 20 000 ultrafast bootstraps[9], as well as the Shimodaira-Hasegawa-like approximate likelihood-ratio test[10]. Bayesian Inference phylogenies were inferred using MrBayes 3.2.6[11] under SYM+G model (2 parallel runs, 5 000 000 generations), in which the initial 25% of sampled data were discarded as burn-in.

2 Results and discussion

The ITS region has a total length of 637 bp, the best fit model for ITS was SYM+I+G. Character state changes were equally weighted and gaps were treated as missing data. All analyses produced similar topology and only the Maximum Likelihood tree is presented in Fig. 4 with ML bootstrap (LP), and PP values for each clade.

The molecular evidence showed that the three samples of Baoting and Changjiang populations in Hainan province were grouped together with strong support (LP=100%, PP=1.00 in Fig. 4) and nested within the genus *Koyamasia* clade (LP=100%, PP=1.00 in Fig. 4). *Koyamasia* H. Rob. is a genus with only two species distributed in India, Laos, Malaysia, Myanmar, Thailand and Vietnam[11]. It belongs to subtribe Erlangeinae under tribe Vernonieae and is characterized by oblong achenes, reflexed phyllaries, 3-porate pollens, short and caduceus pappus[12–13]. This genus has not been documented to occur in China[14]. We studied the specimens from Hainan, and found the plants also have the characters of oblong achenes, reflexed phyllaries, short and caduceus pappus. So the above plants from Baoting and Changjiang are most possibly belong to genus *Koyamasia*. Hainan is a natural extension of the genus *Koyamasia*

Table 1 Newly sequenced taxa, localities and accession number of ITS

Taxon	Specimen	Locality	Accession No.
Distephanus henryi	Y. S. Chen et al. WS0825 (IBSC)	Xihua Park, Wenshan, Yunnan	MW628534
Koyamasia curtisii 1	J. J. Liao CJ1912002 (IBSC)	Mt. Exianling, Bawangling Town, Changjiang County, Hainan, 940 m	MW628535
K. curtisii 2	J. J. Liao et al. CJ1912003 (IBSC)	Mt. Exianling, Bawangling Town, Changjiang County, Hainan, 940 m	MW628536
K. curtisii 3	J. J. Liao et al. LL2020002 (IBSC)	Xianrendong, Mt. Xianansilin, Maogan Town, Baoting County, Hainan, 676 m	MW628537
Vernonia solanifolia	J. J. Liao LYD202001001 (IBSC)	Longyandong Park, Guangzhou, Guangdong	MW628538
V. cumingiana	J. J. Liao LYD202001002 (IBSC)	Longyandong Park, Guangzhou, Guangdong	MW628539
V. volkameriifolia	Y. S. Chen et al. PB0556 (IBSC)	Zhoudou, Xinxian Town, Pingbian County, Yunnan	MW628540
V. esculenta	Y. S. Chen et al. PB0563 (IBSC)	Zhoudou, Xinxian Town, Pingbian County, Yunnan	MW628541
V. spirei	Y. S. Chen et al. WS0829 (IBSC)	Baigeshangzhai, Xigu Town, Wenshan, Yunnan	MW628542

Table 2 Taxa sampled, reference and GenBank accessions

Taxon	Reference	Accession No.	Taxon	Reference	Accession No.
Albertinia brasiliensis	[1]	EF155744	*Leiboldia guerreroana*	[1]	EF155820
Baccharoides adoensis	[1]	EF155745	*Lepidaploa arborescens*	[1]	EF155783
B. lasiopus	[1]	EF155796	*L. balansae*	[1]	EF155784
Bothriocline laxa	[1]	EF155746	*L. borinquensis*	[1]	EF155785
B. ugandensis	[1]	EF155747	*L. canescens*	[1]	EF155786
Brachythrix brevipapposa	[1]	EF155748	*L. tortuosa*	[1]	EF155787
Cabobanthus polysphaera	[1]	EF155749	*L. jonesii*	[1]	EF155788
Camchaya gracilis	[1]	HQ158383	*Lessingianthus buddleiifolius*	[1]	EF155789
C. loloana	[1]	HQ158385	*Linzia accommodata*	[1]	EF177478
C. loloana var. *mukdahanensis*	[1]	HQ158387	*L. gerberiformis*	[1]	EF155791
C. pentagona	[1]	HQ158388	*L. melleri* 1	[1]	EF155790
C. spinulifera	[1]	HQ158391	*L. melleri* 2	[1]	EF155792
C. tenuiflora	[1]	HQ158393	*Munnozia giganteum*	[1]	AY504697
Centauropsis decaryi	[1]	EF155750	*Muschleria* sp.	[1]	EF155793
C. pauciXorus	[1]	EF155751	*Orbivestus cinarescens*	[1]	EF155794
C. punctatum	[1]	EF155754	*Parapolydora fastigiata*	[1]	EF155817
Chresta sphaerocephala	[1]	EF155755	*Polydora poskeana*	[1]	JN837108
Chrysolaena flexuosa	[1]	EF155756	*Pseudelephantopus spicatus*	[1]	HQ158410
C. platensis	[1]	EF155757	*Sipolesia lanuginosa*	[1]	EF155798
Critoniopsis huairacajana	[1]	EF155821	*Stokesia laevis*	[1]	EF155799
C. sodiroi	[1]	EF155760	*Stramentopappus pooleae*	[1]	EF155801
Cyanthillium patulum	[1]	EF155812	*Strobocalyx arborea*	[1]	EF155774
Distephanus polygalaefolia	[1]	EF155762	*Tephrothamnus paradoxa*	[1]	EF155759
Eirmocephala brachiata	[1]	EF155763	*Vernonanthura patens*	[1]	EF155803
Elephantopus carolinianus	[1]	EF155764	*Vernonia abyssinica*	[1]	EF155805
E. elatus	[1]	EF155765	*V. alamanii*	[1]	EF155802
E. mollis 1	[1]	EF155766	*V. altissima*	[1]	EF155806
E. mollis 2	[1]	EF155767	*V. angustifolia*	[1]	EF155807
E. nudatus	[1]	EF155768	*V. baldwinii*	[1]	EF155808
E. scaber	[1]	HQ158402	*V. brachycalyx*	[1]	EF155809
Eremanthus erythropappus	[1]	EF155770	*V. brasiliana*	[1]	EF155827
Eremosis shannoni	[1]	EF155758	*V. bullata*	[1]	EF155810
Ethulia conyzoides	[1]	EF155772	*V. capensis*	[1]	EF155811
Gorceixia decumbens	[1]	EF155773	*V. elliptica*	[1]	EF155813
Gymnanthemum amygdalinum	[1]	AY504695	*V. fasciculata*	[1]	EF155815
G. mesipifolium	[1]	EF155775	*V. gigantea*	[1]	EF155818
Hesperomannia arborescens	[1]	AY504696	*V. humbloti*	[1]	EF155819
H. arbuscula	[1]	EF155776	*V. lindheimerii*	[1]	EF155822
H. lydgatei	[1]	EF155777	*V. madagascariensis*	[1]	EF155761
Hesperomannia sp. nov.	[1]	EF155778	*V. noveboracensis*	[1]	EF155825
Heterocypsela andersonii	[1]	EF155779	*V. profuga*	[1]	EF155826
Hilliardiella aristata	[1]	EF155780	*Vernonia* sp.	[1]	EF155828
H. leopoldii	[1]	EF155781	*V. subplumosa*	[1]	EF155830
H. oligocephala	[1]	EF155782	*V. texana*	[1]	EF155831
Koyamasia calcarea	[1]	HQ158406			

in Southeast Asia. Thus, our identification of this species based on morphological and geographical distribution is further corroborated by molecular data. Since its involucres campanulate, 7–10 mm long, 8–15 mm in diameter, florets ca. 60, the plant should be *K. curtisii* (Craib & Hutch.) Bunwong, Chantar. & S. C. Keeley. In fact, this plant (Fig. 1) perfectly match the type specimen of *K. curtisii* (Fig. 3: A).

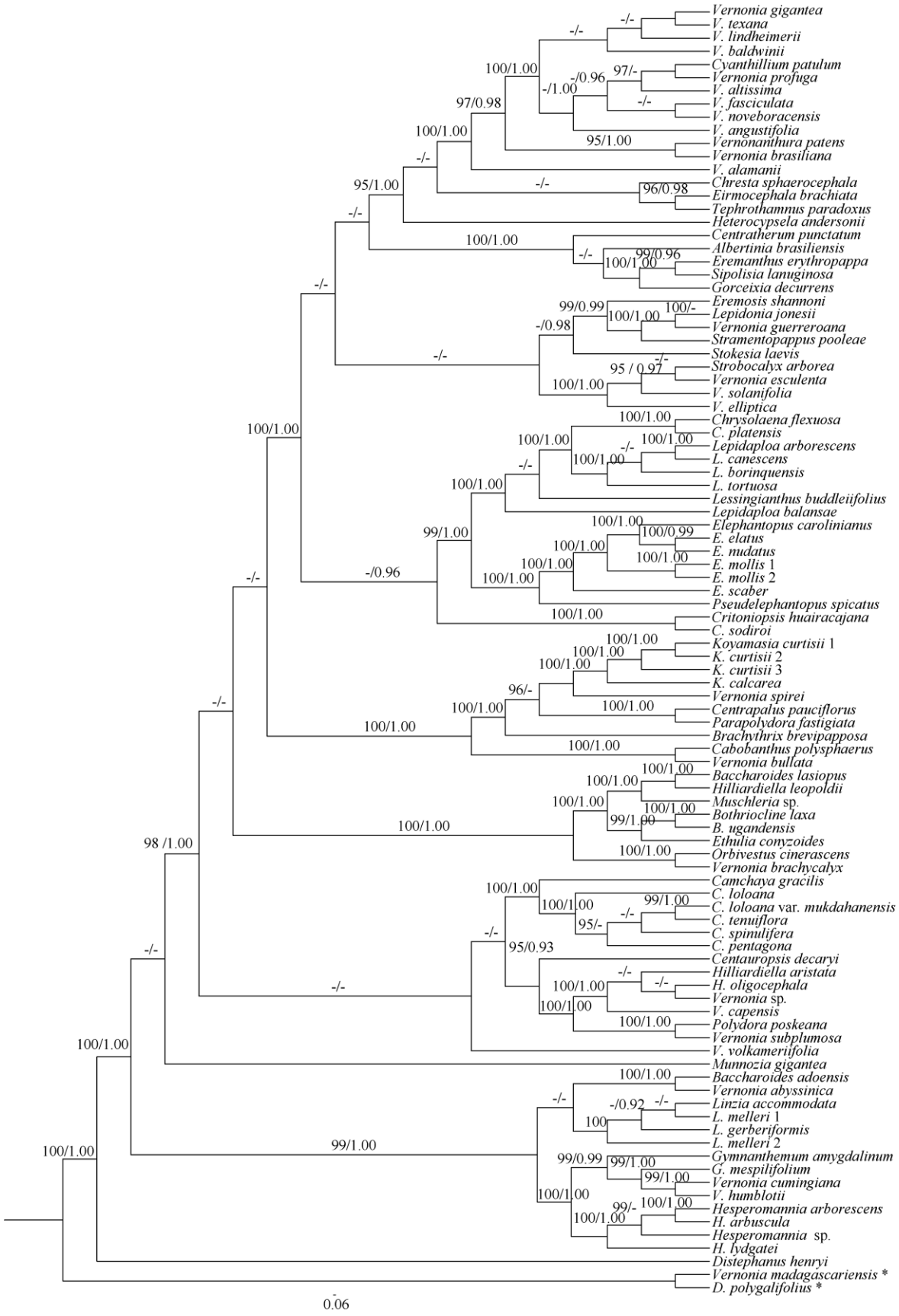

Fig. 4 Cladogram of the maximum likelihood (ML) tree from ITS showing the position of *Koyamasia curtisii.* Data above branch represent bootstrap values (LP) for maximum likelihood and Bayesian posterior probabilities (PP), respectively; the dash (–) indicates LP < 95% or PP < 0.90; *: Outgroup taxa.

Koyamasia calcarea (Kitam.) H. Rob., another species with larger capitulum in this genus, is closed related to the three populations of *K. curtisii* in Hainan Province (LP = 100%, PP = 1.00 in Fig. 4).

Genus *Koyamasia* is poorly known to science, with very few specimens has been collected. Bunwong et al.[12] reported *K. curtisii* to be a perennial herb. After our examination in the wild, we found it is in fact a shrub with woody stems (The detailed morphological characteristics are shown on the Fig. 1, 2). After examining specimens from Thailand, we found some collectors also recorded it is a shrub. *Koyamasia curtisii* grows on limestone hills in Hainan province. The discovery of *K. curtisii* in Hainan represents the first generic record of *Koyamasia* in China.

The plants from Danzhou and Wenchang are annual herbs, leaves simple, alternate, capitula axiallary and sessile, phyllaries imbricate and nearly subequal, florets white, pappus coroniform. After a survey of literature and herbarium specimens, we found that these plants (Fig. 3, 2: D) perfectly match the morphological characteristics of *Struchium sparganophorum* (L.) Kuntze (Fig. 3: C). *Struchium* P. Browne is a monotypic genus distributed widely in the pantropical area[12,15–19], and *Struchium* belongs to subtribe Verno- niinae under tribe Vernonieae and is characterized by sessile and axillary capitulum, subequal phyllaries, 3–4-lobed corolla, and thick and coroniform pappus. Since this genus is well distinguished from other genera in tribe Vernonieae, there is no need to carry out molecular systematics to determine the status of this species. *Struchium* also has not been documented to occur in China[13]. The discovery of *Struchium* in Hainan represents a new generic record for China.

3 Newly recorded species and genera

3.1 *Koyamasia curtisii* (Craib & Hutch.) Bunwong, Chantar. & S. C. Keeley 距格菊 (Fig. 1, 2: A, B)

In PhytoKeys **37**: 82, 2014. = *Vernonia curtisii* Craib & Hutch. Bull. Misc. Inform. Kew 1910: 22. 1910. —— Type: Malay Peninsula, Kedah, Trutow, November 1889, Curtis 2127 (SING–lectotype, K–isolectotype).

Shurbs 20–60 cm tall. Stems erect, conspicuously ribbed, puberulous with stipitate glands. Leaves 5–15 cm long, 2–7 cm wide, ovate or elliptic, margin serrate, apex acute to acuminate, base attenuate, chartaceous; both surfaces puberulous with whip-shaped hairs and capitate glands; lateral veins 7–12-paired; petioles up to 4 cm long. Capitulescences terminal, solitary or loosely paniculate. Capitula campanulate, 15–20 mm long, pedunculate. Receptacle flat, glabrous. Involucres campanulate, 7–10 mm long, 8–15 mm in diam. Phyllaries imbricate, in 6–7 series, light green or purple apex, margin entire, outer surface puberulous; the outer and the middle ones ovate to lanceolate, apex acuminate with reflexed, the inner ones lanceolate to oblong, apex caudate. Florets ca. 60; corollas funnelform, purple, pubescent with soft hairs and capitate glands; corolla tubes 7–10 mm long; corolla lobes 2–3 mm long. Anthers 2.8–3 mm long, apical appendage acute, base obtuse. Styles purple. Achenes clavate, 3–3.5 mm long, 10-ribbed, sparsely glandular. Pappus in one series of bristles, 2–8 mm long, deciduous.

Phenology: Flowering in November in Hainan (possibly also in October).

Habitat: Growing on limestone slopes at 660–950 m elevation.

Distribution: China (Hainan), India, Laos, Malaysia, Myanmar, Thailand and Vietnam.

Specimens examined: CHINA. Hainan, Changjiang County, Bawangling Town, Mt. Exianling, 940 m, 25 December 2019, J.J. Liao CJ1912002 (IBSC); Hainan, Changjiang County, Bawangling Town, Mt. Exianling, 940 m, 25 December 2019, J.J. Liao CJ1912003 (IBSC); Hainan, Changjiang County, Bawangling Town, Mt. Exianling, 940 m, 11 Novermber 2020, J.J. Liao CJ2020014 (IBSC); Hainan, Baoting County, Maogan Town, Mt. Xianansilin, Xianrendong, 676 m, 16 Novermber 2020, J.J. Liao et al. LL2020002 (IBSC). **MALAY PENINSULA**. Langkawi, Palau Chupa, 19 November 1941, E.J.H. Corner 37834 (L, SING); Langkawi, September 1901, Curtis 3690 (K).

THAILAND. Banggrajon, Samut Prakan, 2 January 1970, J. F. Maxwell 70-19 (L); Thamphathai Forest Park, Ngao District, 400 m, 3 October 1982, F. Konta et al. T29668 (KYO, L); Chiang Mai, Doi Chiang Dao, 600–1 300 m, 25 September 1971, G. Murata et al. T14893 (L); Lampang, Muang Ngao, 17 January 1931, Put 4019 (BM, K, P); Lampang, Muak Lek, 4 September 1928, Put 1879 (BM, E, K, P); Saraburi, Khao Sawng Phi Nawng, 4 October 1963, T. Smitinand & H. Sleumer 1372 (K, L).

Conservation status: *Koyamasia curtisii* is sparsely distributed in China (Hainan), India, Laos, Myanmar, Thailand, Vietnam, Malay Peninsula, and Malay islands. But in China, it is only found from two limestone areas in Hainan, with about 60 plants in total. These two populations are severely fragmented, so maybe easily threaten by habitat lose. Since it is small size of population, this species should be considered Vulnerable (VU: B1, 2a; C2a) based on the IUCN Red List Categories and Criteria[20].

3.2 *Struchium sparganophorum* (L.) Kuntze 婴带菊

(Fig. 2: C, D; Fig. 3)

In Revis. Gen. Pl. **1**: 366. 1891 = *Ethulia sparganophora* L., Sp. Pl.: 1171. 1763. Type: [Guadeloupe], near Grand Etang, 400–425 m, 27 November 1959, G. R. Proctor 20182 (BM000576316–epitype designated by Hind)[21].

Annual herbs, 20–50 cm tall. Stems erect, inconspicuously ribbed, puberulous. Leaves 8–15 cm long, 4–5 cm wide, elliptic, pubescent, margin serrate, apex acute, base attenuate, chartaceous; both surfaces puberulous with cylindrical hairs and capitate glands; lateral veins 7–11-paired; petioles up to 12 mm long. Capitulescences axillary, solitary or clustered. Capitula hemispherical, sessile, 4–6 mm in diam. Receptacle convex, 2–2.5 mm in diameter, glabrous. Involucres 3–4 series, 3–4 mm long, imbricate, hemispherical. Phyllaries light green, margin piliferous, outer surface puberulous without glands; the outer ovate to lanceolate, apex acute to acuminate; the inner ones obovate-lanceolate, apex acuminate. Florets 50–70; corollas funnelform, white, glandular; corolla tubes 1–1.5 mm long; corolla lobes 3–4, 0.5–1 mm long. Anthers ca. 1 mm long, apical appendage acute, base acute. Styles purple, ca. 2 mm long, branches 1–1.5 mm long, inner surface covered with stigmatic papillae. Achenes turbinate, 3–4-angular, 1–1.5 mm long, 3–5-ribbed, glandular. Pappus of 3–4 parts, coroniform, ca. 1 mm long, whitish.

Phenology: Flowering all year round in Hainan (According the cultivation observation in Danzhou City by Qinglong Wang).

Habitat: Growing in wetlands at low elevations.

Distribution: China (Hainan), India, Indonesia, Malaysia, Philippines, Singapore, Sri Lanka, Thailand, Vietnam, also tropical Africa, Madagascar, tropical South America, Central America, Mexico, and West Indies[11,14–18].

Specimens examined: **CHINA**. Hainan, Danzhou County, Zhonghe, Qili, 4 March 2018, Qing-Long Wang 18134 (IBSC). **GABON**. Mabounie, 24 m, 15 November 2013, O. Lachenaud et al. 1380 (WAG). **GUINEA**. Nzerekore, 456 m, 26 April 2011, C.C.H. Jongkind 10371 (WAG). **INDONESIA**. Kalimantan Timur, northern part of Samarinda, 1 January 1979, G. Murata et al. B-96 (KYO, L); North Sumatra, Gunung Leuser Nature Reserves, Alas River Valley, 50 m, 5 July 1979, W.J.J.O. de Wilde & B.E.E. de Wilde-Duyfjes 18533 (L); Sulawesi Tenggara, 20–250 m, 26 November 1978, S. Prawiroatmodjo & S. Soewoko 1978 (L3706203). **MALAYSIA**. Sabah, Beluran, Sapi, 25 June 2007, G. Pius et al. SAN148860 (L); Sarawak, Belarga, 26 August 1954, W.M.A. Brooke 9093 (L1588310); Sarawak, Bau, 15 September 1955, J.W. Purseglove 4446 (L1588311). **SURINAM**. Sipaliwini, Tapanahoni, 2 July 2013, T.R. van Andel, C. Toika, T.E.Vossen 6142 (U). **THAILAND**. Lamphun, Muang District, 20 December 1994, P. Palee 265 (L); Bangkok, Klong San, 20 Febuary 1971, J. F. Maxwell 71-107 (L); Ka Pur, 7 December 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham 26302 (L); Ranong, 10 April 1969, C. Chermsirivathana 1266 (L1588636); Trang, Khao Chong, 13 August 1975, J.F. Maxwell 75-824 (L); Trang, Khao Pap Pa, 150 m, 13 March 1974, K. Larsen & S. Larsen 33266

(L1588635); Songkhla, Rattaphume, 3 August 1986, J.F. Maxwell 86-636 (L).

Conservation status: *Struchium sparganophorum* is a weed widely distributed in the pan-tropical area. It is a weed in wetland areas in Hainan, but usually overlooked by previous plant collectors. According to Qinlong Wang, it is also found in Wenchang County in Hainan Province.

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