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## *Citronella suaveolens*, a new generic record for Vietnam, with a key to Vietnamese Cardiopteridaceae

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### Abstract

*Citronella suaveolens* is reported from Quang Nam Province in southern Vietnam, representing the first record of this species and the genus *Citronella* in the country and in mainland Southeast Asia in general. Detailed photographic illustrations of studied specimens are provided. A key to the Vietnamese genera and species of Cardiopteridaceae is presented. Diversity of *Citronella* in the Malesian region is discussed. Floristic affinities of Malesia and Eastern Indochina are highlighted by a list of illustrative examples.

**Keywords:** Aquifoliales, Cardiopteridales, flora, Icacinaceae, plant diversity, Song Thanh Nature Reserve

### Introduction

*Citronella* D.Don (1832: 243) is a genus of about 22 species widely distributed throughout Malesia and Oceania (including Australia) and in Central and South America (summarized by Schori 2016, and a single species described by Munzinger & Levionnois 2016 thereafter). Notably, the genus has been unknown from mainland Southeast Asia, although a population of *C. suaveolens* (Blume 1850: 248) R.A.Howard (1940: 475) in Simeulue Island, off the west coast of northern Sumatra, together with an almost pan-Malesian distribution of the species (Sleumer 1969, 1971) suggest that it might be present in the Malay Peninsula.

*Citronella* has a complicated history of its placement in the taxonomic system of eudicots: although currently assigned to Cardiopteridaceae (Kårehed 2001, Stevens 2001 onwards, Schori 2016), it had long been treated within Icacinaceae (Howard 1940, 1942, Sleumer 1969, 1971, Takhtajan 2009). The family Cardiopteridaceae is commonly placed in the order Aquifoliales (e.g. APG IV 2016). Recent phylogenomic data suggested exclusion of Cardiopteridaceae and its closest relative Stemonuraceae from Aquifoliales (Zhang *et al.* 2020); this view has been adopted by Stevens (2001 onwards) who segregated these two families as the order Cardiopteridales. However, a plastid phylogenomic analysis corroborated the placement of Cardiopteridaceae and Stemonuraceae in Aquifoliales (Li *et al.* 2021).

In its current circumscription, the family Cardiopteridaceae comprises five genera and about 45 species; it has a pantropical distribution with several species extending into the subtropics (Schori 2016, Christenhusz *et al.*

2017). In Vietnam (Nguyen Tien Ban 2003, Pham Hoang Ho 2003), and in the entire mainland Asia except for the Malay Peninsula, the family was known to be represented by a single species of *Gonocaryum* Miquel (1861: 343) (*G. lobbianum* [Miers 1852: 111] Kurz [1870: 72]) and two species of *Cardiopteris* Wall. ex Royle (1834: 136) (*C. platycarpa* Gagnepain [1910: 198] and *C. quinqueloba* [Hasskarl 1843: 142] Hasskarl [1855: 64]); deviations from these figures found in literature sources (e.g. Long 1991, Nguyen Tien Ban 2003, Pham Hoang Ho 2003) reflect different views of generic and species boundaries. Here we report a discovery of *Citronella suaveolens* in Quang Nam Province of Vietnam, within 1–2 km of the border with Laos. We provide detailed illustrations of our collections and a key to the genera and species of Cardiopteridaceae in Vietnam, and briefly discuss the diversity of *Citronella* in the Malesian region. Finally, we illustrate the floristic affinities of Malesia and Eastern Indochina and present a list of taxa, previously assumed endemic to Malesia, recently reported from Cambodia, Laos and Vietnam.

In the course of identification of the Vietnamese specimens of *Citronella*, we employed a morphological approach and compared the herbarium material accompanied by a series of photographs of living plants against the descriptions from the publications cited below and the type herbarium specimens. While there are a few DNA sequences available for *C. suaveolens*, they represent a single voucher and the other Malesian species of *Citronella* have not been sequenced, so molecular data would be of limited value for identifying our material.

## Taxonomic treatment

### *Citronella suaveolens* (Blume 1850: 248) R.A.Howard (1940: 475) (Fig. 1, 2)

**Literature:**—Howard (1942: 82), Backer & Bakhuizen van den Brink (1965: 59), Sleumer (1969: 187, 1971: 6, Fig. 1), Beaman *et al.* (2001: 381), Utteridge & Schori (2011: 109).

**TYPE:**—INDONESIA. W Java: s.loc., s.d., *C.L. Blume s.n.* (lectotype, designated by Sleumer [1969: 187]: L: L0014727 photo!; isolectotype: U: U.1169894 photo!).

Images of lectotype and isolectotype available at:

<https://data.biodiversitydata.nl/naturalis/specimen/L%20%200014727>

<https://data.biodiversitydata.nl/naturalis/specimen/U.1169894>

#### Heterotypic synonym:

*Citronella brassii* R.A.Howard (1942: 81).

**TYPE:**—INDONESIA. Papua Province: Idenburg [Taritat] River, 2 km SW of Bernhard Camp, primary rainforest, on slope of ridge, 850 m, 18 March 1939, *L.J. Brass*, *C. Versteegh* 13173 (holotype: A: 00050211 photo!; isotypes: BM: BM000839490 photo!, BRI: BRI-AQ0340320 photo!, L: L0014728 photo!).

**Additional specimens examined:**—VIETNAM. Quang Nam Province: Nam Giang District, Song Thanh Nature Reserve, forest, river bank, 15°34'12"N 107°22'39"E, elev. 1050 m, 30 April 2019, *M.S. Nuraliev* 2448 (MW: MW0757764, MW0757765; photo LE: LE01093242 <http://en.herbariumle.ru/?t=occ&id=108748>); Quang Nam Province: Nam Giang District, Song Thanh Nature Reserve, forest, river bank, 15°32'08"N 107°23'10"E, elev. 1070 m, 01 May 2019, *M.S. Nuraliev* NUR 2451a (photo LE: LE01093243 <http://en.herbariumle.ru/?t=occ&id=108749>).

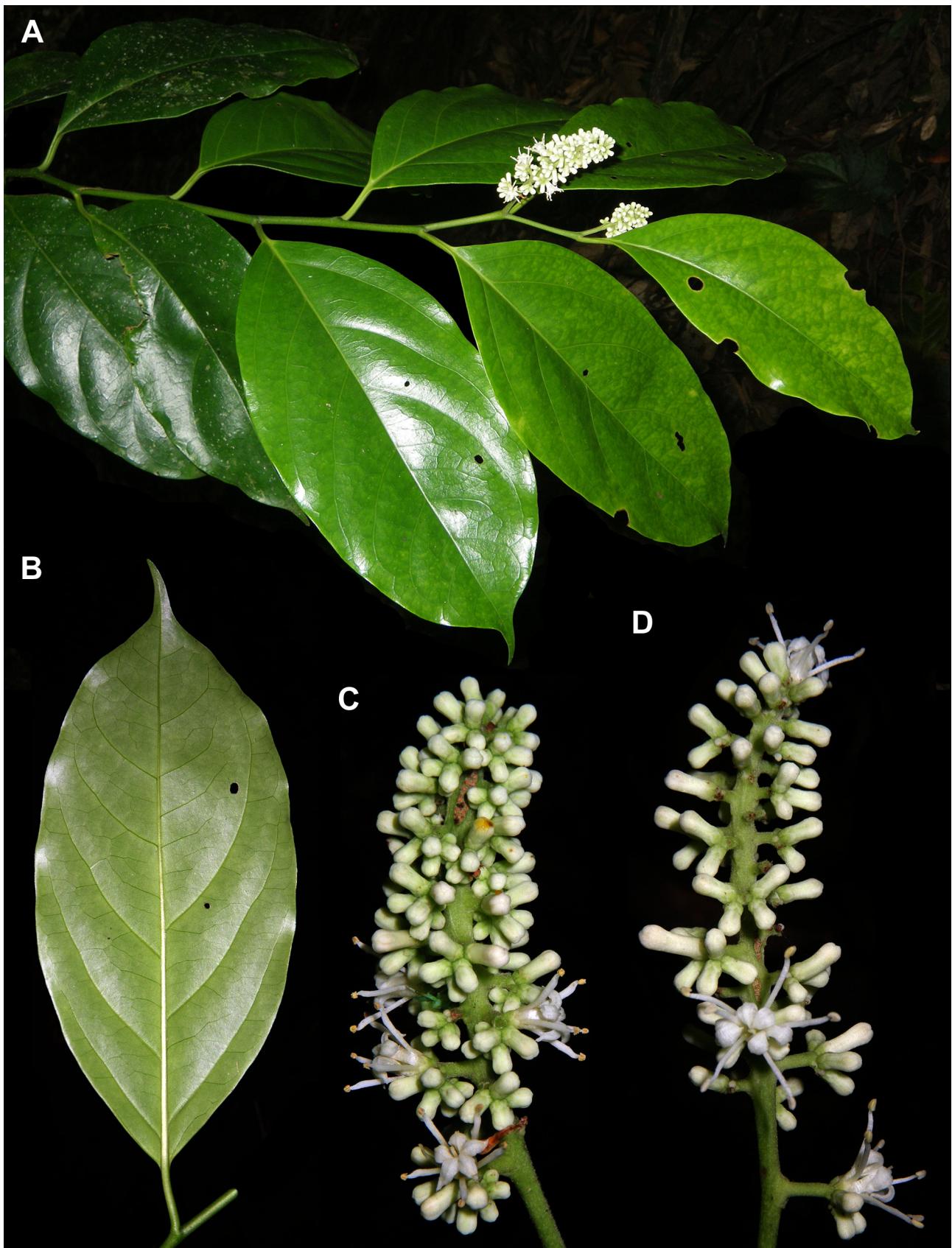
**Distribution:**—Vietnam (Quang Nam Province: Song Thanh Nature Reserve), Sumatra (Simeulue Island), Java, Borneo, Sulawesi, the Maluku Islands, New Guinea.

**Notes:**—The Vietnamese population of *Citronella suaveolens* reported here (Fig. 3) is more than 1400 km distant from the known locations of the species in Sumatra and Borneo. The finding represents a significant range extension of the genus *Citronella* and its first known occurrence from mainland Southeast Asia.

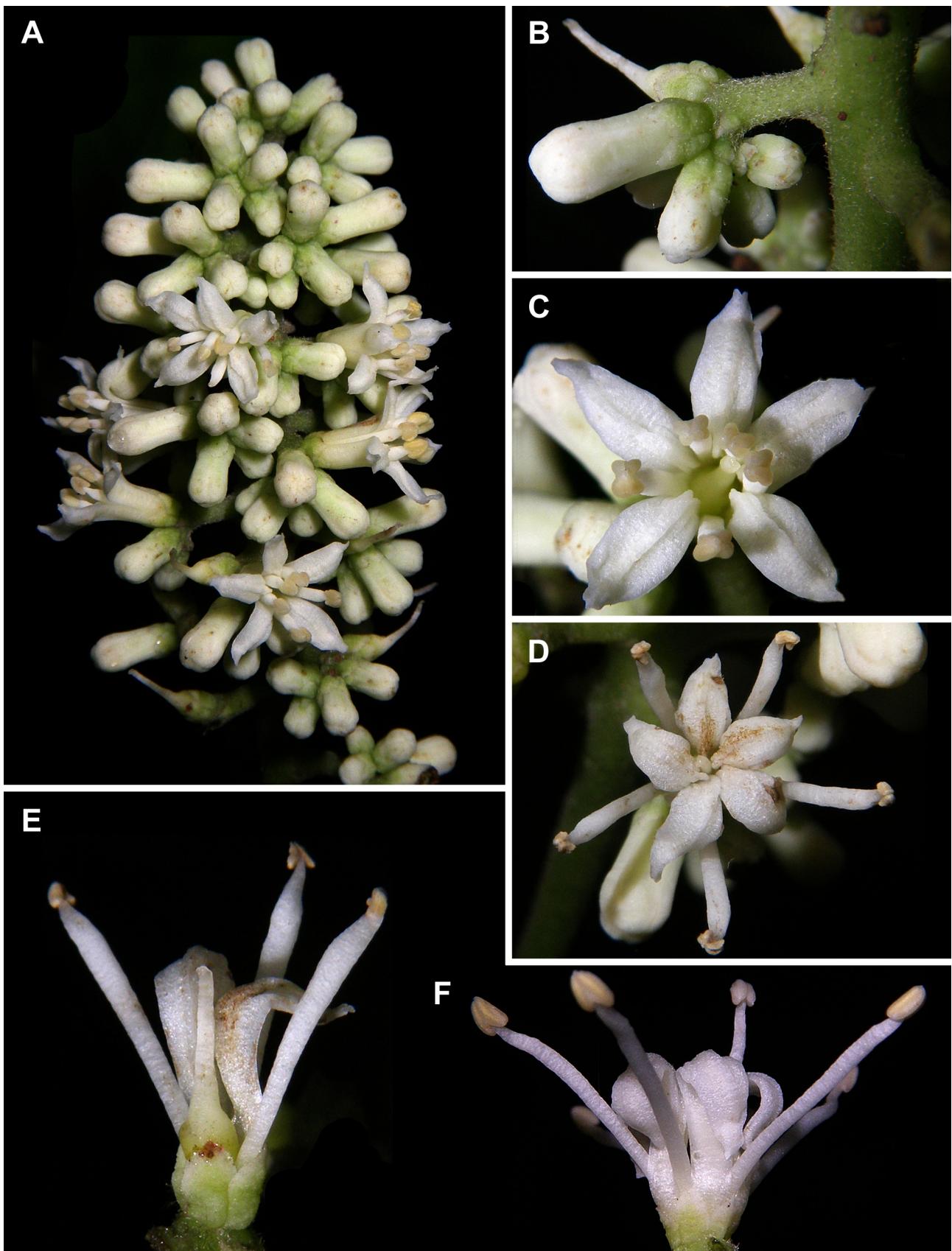
This disjunct population of *Citronella* provides another example of the taxa recently discovered in Eastern Indochina and previously known only (or mostly) from Malesia and further south; see Appendix 1 for a list. The considerable overlap of floristic elements between Eastern Indochina and such Malesian regions as Peninsular Malaysia, Borneo, Sumatra and Java presumably reflects connection of these regions as parts of Sundaland during glacial periods.

**Ecology and phenology:**—*Citronella suaveolens* inhabits various types of primary forests at elevations of 0–1600 m a.s.l. In the Song Thanh Nature Reserve, Vietnam, it is common in a primary, mid-mountain, weakly disturbed forest along rivers. A description of vegetation in this forest complex is provided by Vislobokov *et al.* (2019).

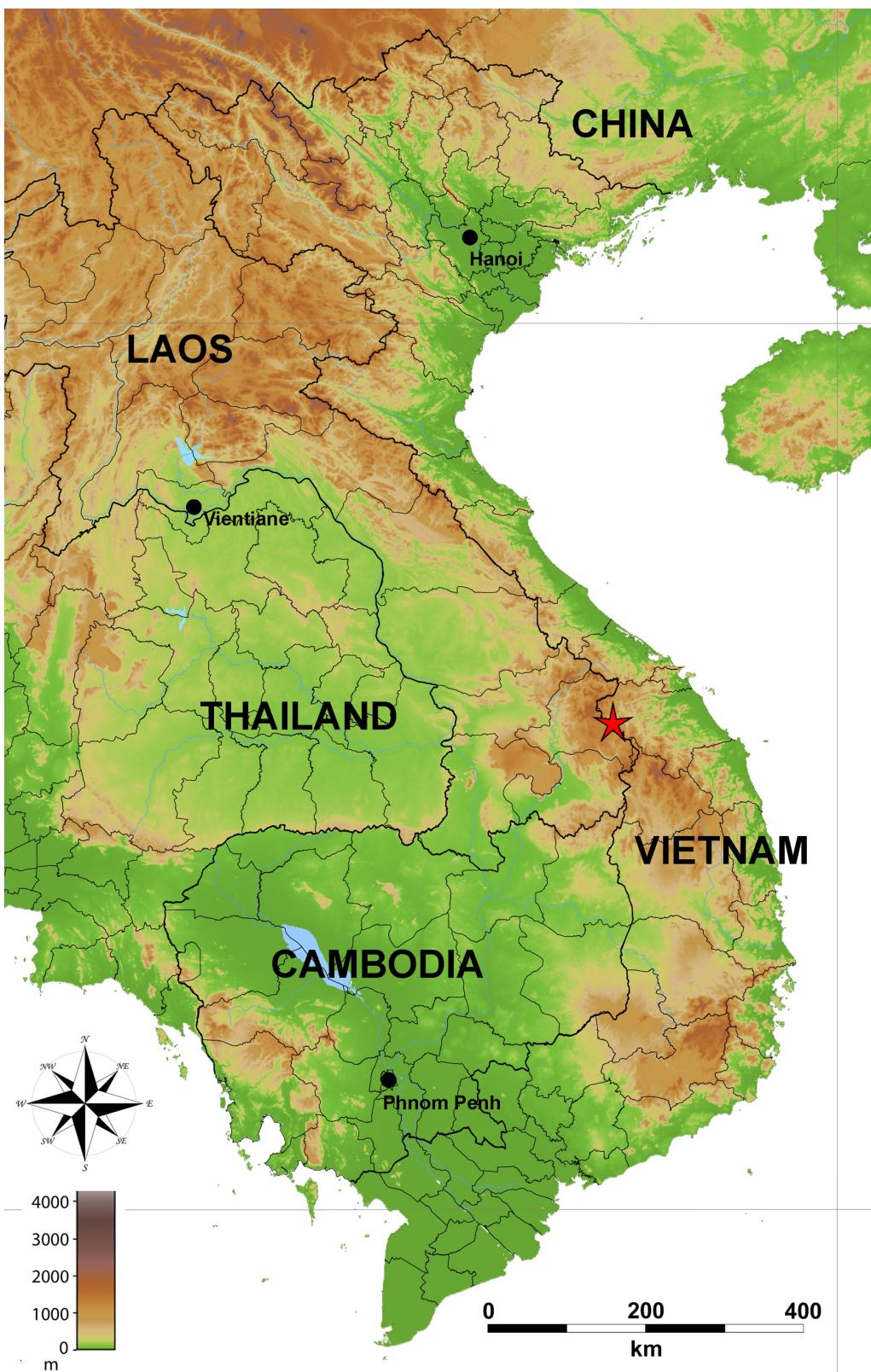
Flowering in Vietnam: April–May.



**FIGURE 1.** *Citronella suaveolens*. **A.** Branch with inflorescences. **B.** Leaf, abaxial surface. **C, D.** Inflorescences. Nuraliev 2448 (A–C) and Nuraliev NUR 2451a (D). Photos and design by M. Nuraliev.



**FIGURE 2.** *Citronella suaveolens*, floral structure and phenology. **A.** Inflorescence at nighttime, showing opening flowers. **B.** Inflorescence branch (a cincinnus). **C.** Flower at early anthesis, top view (around 23:30). **D.** Flower at late anthesis, top view (around 16:30). **E, F.** Flowers at late anthesis, side view; three petals and two stamens removed to show pistil in E. *Nuraliev 2448* (A–E) and *Nuraliev NUR 2451a* (F). Photos and design by M. Nuraliev.



**FIGURE 3.** Distribution map of *Citronella suaveolens* in Vietnam.

Brief field observations made by the first author suggest predominantly nocturnal flowering, or at least flower opening, in *C. suaveolens*. During the daytime (including morning hours, Fig. 1D, 2F, and evening hours, Fig. 1C, 2D, E), the inflorescences bear flowers at late anthesis, showing petals with signs of withering and strongly reflexed apices, and strongly exerted stamen filaments reflexed outwards between the free petals. Anther thecae present pollen in the morning (Fig. 2F) and are dried and empty in the evening (Fig. 2D, E). In cut branches awaiting herbarium preparation, simultaneous flower opening (one flower in each cincinnus) occurred around 23:00 (Fig. 2A, C). The freshly opened

flowers had erect stamen filaments not reflexed outwards from the corolla, filaments not fully elongated (distinctly shorter than petals), and undehisced or just dehisced anthers.

## Key to the genera and species of Cardiopteridaceae in the flora of Vietnam

Distinction of genera is based on Schori (2016); key to the species of *Cardiopteris* follows Gagnepain (1911).

1. Liana with whitish latex; leaf blade entire or lobed, truncate to cordate at base, palmatinerved; corolla gamopetalous; stamens epipetalous; fruit a samara with a fleshy terminal appendage..... 2 (*Cardiopteris*)  
- Trees or shrubs without latex; leaf blade entire, acute to obtuse at base (never cordate), penninerved; corolla choripetalous or gamopetalous; stamens free or epipetalous; fruit a drupe ..... 3
2. Inflorescence with 2–6 cincinni; fruit stipe not or shortly exceeding calyx, ca. 2 mm long; fruit distinctly longer than wide, obcordate ..... *Cardiopteris quinqueloba*  
- Inflorescence with 15 or more cincinni; fruit stipe greatly exceeding calyx, 7–8 mm long; fruit oval to nearly circular in outline... *Cardiopteris platycarpa*
3. Flowers unisexual; corolla gamopetalous, tube often longer than lobes; stamens epipetalous, included in corolla..... *Gonocaryum (G. lobbianum)*  
- Flowers bisexual or unisexual; corolla choripetalous; stamens free, exserted from corolla (in female flowers, staminodes included)..... *Citronella (C. suaveolens)*

## Discussion: species delimitation in Malesian *Citronella*

Three species of *Citronella* are recorded from Malesia: *C. latifolia* (Merrill 1919: 415) R.A.Howard (1940: 472), *C. philippinensis* (Merrill 1919: 414) R.A.Howard (1940: 474), and *C. suaveolens* (Sleumer 1969, 1971, Utteridge & Schori 2011). The first two are endemic to the Philippines, whereas the last species has a wide distribution in Southeast Asia extending to New Guinea (see above). Sleumer (1969, 1971) used fruit shape and size to distinguish *C. suaveolens* from the two other species. However, for identification of flowering material, including the specimens from Vietnam reported here, other taxonomically important characters must be evaluated.

As follows from Sleumer (1971), leaf characters separate *C. philippinensis*, which has relatively long petioles and small leaves (2–3) cm, 6–12 × (2)4–6.5 cm), from *C. latifolia* (1.0–1.5(2.5) cm, (12)14–18 × (6)8–11 cm) and *C. suaveolens* (0.6–1.5 cm, (6)10–24(30) × (3)5–13(17) cm). Flowers have not been recorded for *C. latifolia*, but its infructescences differ from those observed in *C. suaveolens* in tending to have closely crowded (vs. more distant) lateral branches that are 1–5 cm (vs. 0.5–2 cm) long and with longer cincinni when secondary branching is present (based on Sleumer 1971 and the type specimens listed above and in Appendix 2).

In addition, Sleumer (1969, 1971) stated that *C. latifolia* and *C. philippinensis* are distinguished by the leaf apex shape; however, in the type specimens of *C. latifolia*, the only material available to Sleumer, most of the leaves lack an intact or visible apex.

The Vietnamese specimens of *Citronella* studied here are characterized by petioles 1.3–2.3 cm, leaf blades 13.5–18.5 × 6–8 cm and inflorescences with short lateral branches. Thus, both morphological and geographical evidence agree with assignment of these specimens to *C. suaveolens*.

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**APPENDIX 1.** Genera and species of vascular plants newly recorded from Eastern Indochina (Cambodia, Laos and Vietnam) since 2001 and earlier known to occur only (or predominantly) in Malesia and further south.

**Lycopodiaceae**

*Phlegmariurus tetrastichus* (Kunze) A.R.Field & Bostock (Lu *et al.* 2020)

**Polypodiaceae**

*Chrysogrammitis musgraviana* (Baker) Parris (Chen *et al.* 2020)

*Ctenopterella khaoluangensis* (Tagawa & K.Iwats.) Parris (Chen *et al.* 2020)

*Dasygrammitis brevivenosa* (Alderw.) Parris (Parris *et al.* 2015)

*Scleroglossum pyxidatum* Alderw. (Parris *et al.* 2015)

*Themelium halconense* (Copel.) Parris (Parris *et al.* 2015)

**Pteridaceae**

*Pteris argyraea* T.Moore (Wu *et al.* 2012)

**Annonaceae**

*Neo-uvaria* Airy Shaw (Tagane *et al.* 2018b)

**Petrosaviaceae**

*Petrosavia stellaris* Becc. (Remizowa *et al.* 2017)

**Burmanniaceae**

*Burmannia lutescens* Becc. (Nuraliev *et al.* 2018)

**Triuridaceae**

*Sciaphila densiflora* Schltr. (Nuraliev *et al.* 2020)

**Orchidaceae**

*Bogoria* J.J.Sm. (Averyanov *et al.* 2018a)

*Bulbophyllum flavescens* (Blume) Lindl. (Averyanov *et al.* 2018c)

*Bulbophyllum leysianum* Burb. (Truong *et al.* 2020a)

*Bulbophyllum nematocaulon* Ridl. (Averyanov 2010)

*Cephalantheropsis laciniata* Ormerod (Averyanov *et al.* 2016)

*Corybas geminigibus* J.J.Sm. (Truong *et al.* 2020b)

*Dendrobium hendersonii* A.D.Hawkes & A.H.Heller (Averyanov *et al.* 2015)

*Didymoplexiella ornata* (Ridl.) Garay (Averyanov 2012a)

*Eria lancifolia* Hook.f. (Averyanov *et al.* 2018b)

*Goodyera reticulata* (Blume) Blume (Hsu *et al.* 2020)

*Hymenorchis* Schltr. (Averyanov *et al.* 2012)

*Liparis compressa* (Blume) Lindl. (Averyanov 2012b)

*Liparis rhodochila* Rolfe (Averyanov *et al.* 2019)

*Mycarantes latifolia* Blume (Dang *et al.* 2021)

*Octarrhena* Thwaites (Averyanov *et al.* 2015, 2020)

*Pennilabium struthio* Carr (Averyanov *et al.* 2018a)

*Plocoglottis quadrifolia* J.J.Sm. (Nuraliev *et al.* 2015)

*Silvorchis* J.J.Sm. (Averyanov *et al.* 2018d)

*Taeniophyllum javanicum* (J.J.Sm.) Kocyan & Schuit. (Averyanov *et al.* 2016)

*Thecopus secunda* (Ridl.) Seidenf. (Averyanov *et al.* 2016)

**Polygalaceae**

*Xanthophyllum ellipticum* Korth. ex Miq. (Tagane *et al.* 2016a)

*Xanthophyllum obscurum* A.W.Benn. (Tagane *et al.* 2016a)

**Euphorbiaceae**

*Koilodepas longifolium* Hook.f. (Tagane *et al.* 2018a)

**Melastomataceae**

*Memecylon paniculatum* Jack (Tagane *et al.* 2015)

**Rubiaceae**

*Gaertnera junghuhniana* Miq. (Tagane *et al.* 2016b)

*Lasianthus clementis* Merr. (Naiki *et al.* 2015)

*Lasianthus latifolius* (Blume ex DC.) Blume ex Miq. (Naiki *et al.* 2015)

**APPENDIX 2.** Additional Malesian specimens of *Citronella* examined.

***Citronella latifolia* (Merr.) R.A.Howard**

PHILIPPINES. Northern Samar Province: Catubig River, February–March 1916, *M. Ramos*, *Bureau of Science* 24557 (lectotype, designated by Sleumer [1969: 188]: PNH, destroyed; isolectotypes: A: 00050213 photo!, BM: BM000839491 photo!, BM000839492 photo!, GH: 00050212 photo!, K: K000700075 photo!, K000700076 photo!, KAG: 016622 photo!, L: L0014721 photo!, NY: 00337670 photo!).

***Citronella philippinensis* (Merr.) R.A.Howard**

PHILIPPINES. Ilocos Norte Province: Mt. Palimlim, 1000 m, August 1918, *M. Ramos*, *Bureau of Science* 33267 (lectotype, designated by Sleumer [1969: 188]: PNH, destroyed; isolectotypes: A: 00050214 photo!, K: K000700074 photo!, L: L0014725 photo!, P: P00834221 photo!, US: 00094932 photo!), same location and date, *M. Ramos*, *Bureau of Science* 33308 (paratypes: K: K000700073 photo!, P: P00834222 photo!, US: 03359823 photo!).