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Alpinia arachniformis (Zingiberaceae): a new species from New Ireland, Papua New Guinea

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Abstract. During explorations of the ginger flora of the Bismarck Archipelago in 2013 and 2023, we made collections of the ginger genus *Alpinia* sensu lato, some of which had unusually elongated cincinni composed of distichously arranged bracteoles and in the present paper we conclude that these collections document a distinct species new to science, *Alpinia arachniformis* A.D.Poulsen. The choice of epithet refers to the spider-like appearance of the inflorescence. Similar morphology of the cincinni is found in other lineages of *Alpinia*, but our molecular analysis using the Internal Transcribed Spacer (ITS) marker established a close relationship with *A. oceanica* from which the new species differs by having cincinni with more flowers and linear labellum. An ink drawing and colour plates, information on distribution and habitat, and provisional conservation status are provided for the new species as well as a key to species of *Alpinia* in the Bismarck Archipelago.

Keywords: *Alpinia oceanica, Alpinia vittata,* Bismarck Archipelago, ITS, Zingiberaceae.

INTRODUCTION

The knowledge of the family Zingiberaceae in Papua New Guinea has been gradually updated in the past few decades as a few species were recently discovered (Poulsen and Bau 2017; Lofthus et al. 2020), rediscovered (Poulsen et al. 2022) or re-evaluated (Poulsen et al. 2024a). Papua New Guinea, along with its offshore islands, is home to around 130 species within 10 genera of gingers. The largest genus is *Riedelia* Oliv. with 47 species, followed by *Alpinia* Roxb. with 29 species, and *Pleuranthodium* (K.Schum.) R.M.Sm. with 20 species (Newman et al. 2005 onwards), all of which await confirmation being monophyletic and revision based on the latest high-quality collections including pickled reproductive parts and silica-dried leaves for DNA extraction.

One of the biogeographically interesting areas of the region is the Bismarck Archipelago comprising approximately 76 islands off the north-eastern coast of mainland New Guinea. Major islands include New Britain, New Ireland, New Hanover, the St. Matthias Group, the Admiralty Islands (also called Manus), and others in the far west (Loffler and Fairbridge 1975). Together with the Solomon Islands and Vanuatu, they form the East Melanesian Islands, which is one of the most interesting areas on Earth for geologists because of its islands of varying ages and geology (Hall 2002). This has led to the isolation and adaptive radiation of different organisms (McCullough et al. 2022). It is estimated that a total of 8,000 vascular plant species (c. 3,000 endemic) are found in the East Melanesian Islands, making it a biodiversity hotspot where deforestation is, unfortunately, increasing due to agriculture, coastal development, overharvesting of species, and mining activities in the past decades (Aalbersberg et al. 2012).

Alpinia, as currently delimited, is the largest genus of Zingiberaceae with ca. 260 species occurring in tropical and subtropical Asia, Australia, and the Pacific (Smith 1990; Newman et al. 2005 onwards). Phylogenetic studies using ITS and *mat*K/*trn*K regions, however, revealed that the genus is polyphyletic (Kress et al. 2005, 2007; De Boer et al. 2018; Docot et al. 2019a,b; Poulsen et al. 2024b) consisting of five clades scattered throughout the tribe Alpinieae. Only the clade containing the type species, *A. galanga* (L.) Willd., will retain the genus name *Alpinia*, and revisions continue to progress as more taxa are added into the phylogenetic tree of the tribe Alpinieae (e.g., reinstatement of *Adelmeria* Ridl. from *Alpinia* by Docot et al. 2019b).

Peekel (1984) published the flora of the Bismarck archipelago, which includes 15 species of Zingiberaceae, four of which were placed in *Alpinia*. The present paper aims to understand and describe an unusual species collected by A.D. Poulsen and collaborators in New Ireland, Papua New Guinea in 2013 followed up by additional surveys on this island in 2023. Historic collections were also studied in herbaria mostly hitherto identified as *Alpinia oceanica* Burkill, a common species in the Bismarck Archipelago. The unusual species has telescopically extended cincinni in which the bracteoles are distichously arranged; a trait found in three other separate lineages within *Alpinia* sensu lato (the *carolinensis*, *eubractea*, and *rafflesiana* clades; sensu Kress et al. 2005). Therefore, phylogenetic analyses were performed to ascertain the placement of the collections from the Bismarck Archipelago with the unusual inflorescence structure.

MATERIALS AND METHODS

Recent materials used in this study were collected during expeditions in 2013 and 2023 conducted in New Ireland, Papua New Guinea following international and national regulations. A wide range of specimens of relevant species especially *Alpinia* species with telescopically extended cincinni and distichously arranged bracteoles deposited at A, AAU, BISH, BM, BO, BRI, C, CANB, CNS, E, FI, G, GH, K, L, LAE, MEL, NSW, NY, P, PRC, SING, UC, and US including types were examined. Acronyms of herbaria follow Index Herbariorum (Thiers continuously updated). Protologues of relevant species and taxonomic revisions of *Alpinia* (e.g., Smith 1975, 1990) were also scrutinised.

The total genomic DNAs of the samples used in this study were extracted using DNeasy Plant Mini Kit (Qiagen®, Germany) following the manufacturer's protocol. The ITS region, which is one of the best DNA barcode candidates for identifying species within Zingiberaceae (Shi et al. 2011; Tan et al. 2020), was amplified using Docot et al. (2019b) PCR mix and thermal profile. PCR products were sent to Macrogen© (Seoul, Korea) for purification and sequencing services.

The newly generated sequences were assembled and edited in Geneious Prime v. 2025.03 (https://www.geneious.com) and were aligned using Muscle 3.7 (Edgar 2004) in the CIPRES portal (Miller et al. 2010) resulting in the data matrix used in this study. We reconstructed the phylogeny of the tribe Alpinieae using 109 ITS accessions representing 97 taxa (see Appendix 1 for the complete accession details of the sequences).

Maximum-likelihood (ML) and Bayesian inference (BI) phylogenetic trees were constructed using RAxML-HPC2 on ACCESS v. 8.2.12 (Stamatakis 2014) and MrBayes on ACCESS v. 3.2.7a (Huelsenbeck & Ronquist 2001) respectively, both of which performed in CIPRES portal (Miller et al. 2010). A general time reversible model (GTR+I+Γ) was used for both Maximum likelihood and Bayesian inference analyses as indicated on the Akaike information criterion (AIC) implemented in Modeltest v. 3.06 (Posada & Crandall 1998). Bootstrap support values were obtained by running 1000 replicates. Four Markov Chain Monte Carlo (MCMC) chains were performed for 10 million generations with trees sampled every 1000th generation. To confirm convergence, values for potential scale reduction factor (PSRF) and standard deviation of the split frequencies between two runs were considered. Tracer v. 1.7.1 (Rambaut et al. 2018) was used for an additional convergence test to check if each parameter had an effective sample size (ESS) >100. Trees saved prior to convergence were discarded as burn-in

(10,000 trees), creating a 50% majority-rule consensus tree constructed from the remaining trees. The data matrix used and trees produced have been deposited in Zenodo (https://doi.org/10.5281/zenodo.15046066).

The extent of occurrence (EOO) and area of occupancy (AOO) were calculated using the Geospatial Conservation Assessment Tool (GeoCAT) (Bachman et al. 2011: www.geocat.kew.org/) and were then assessed using the International Union for Conservation of Nature (IUCN) criteria (IUCN Standards and Petitions Subcommittee 2024). The distribution map produced in this study was generated using SimpleMappr (Shorthouse 2010).

RESULTS AND DISCUSSION

Our molecular phylogenetic results, both in the ML and BI trees, found the five clades of *Alpinia* (Fig. 1) inside the tribe Alpinieae and the topologies are congruent with each other and those found in previous studies (e.g., Kress et al. 2005, 2007; Docot et al. 2019a,b). The four samples of the new species appeared within the *Alpinia eubractea* clade and formed a monophyletic group in a sister relationship to a clade composed of samples of *A. oceanica* and *A. vittata* W.Bull. Together with *A. purpurata* (Vieill.) K.Schum., these constitute the *Guillainia* subclade sensu Docot et al. (2019b). The *Guillainia* subclade is native in the Bismarck Archipelago and Western Pacific but not wild on mainland New Guinea (Smith 1975).

Based on molecular data, most *Alpinia* sensu lato species with telescopically extended cincinni, in which the bracteoles are distichously arranged, belong to the *Alpinia carolinensis* clade, which includes species from the *Alpinia* sect. *Myriocrater* K.Schum. and *Alpinia* subsect. *Pycnanthus* R.M.Sm. sensu Smith (1990). Telescopically extended cincinni are, however, also observed in species within the *Alpinia rafflesiana* clade (e.g., *A. rufa* (C.Presl) Náves) and in the *Alpinia eubractea* clade (e.g., *A. eubractea* K.Schum.) where the new species is placed. This indicates that this character is likely convergent within the tribe Alpinieae and not a diagnostic synapomorphy unique to one clade.

The new species formed a sister relationship with *Alpinia oceanica* and *A. vittata* and have overlapping distributions. The possibility that the latter two species are conspecific was discussed by Smith (1975) based on herbarium material. Specimens with reproductive parts from the type locality of *A. vittata* (New Ireland, Papua New Guinea) are yet to be made and will be critical to address this hypothesis. Until this has been resolved, *A. vittata* can at least easily be distinguished from *A. oceanica* by its variegated lamina. As the new species has plain green leaves, it is therefore most similar to *A. oceanica* (see Table 1 for a complete morphological comparison), although it sufficiently differs from it by other characters as elaborated below.

TAXONOMIC TREATMENT

Alpinia arachniformis A.D.Poulsen **sp. nov.** (Figures 2, 3 & 5).

Type: Papua New Guinea, New Ireland Province, Karu Forestry station, 2013; 3°28'15.4"S 152°13'58.5"E; 10 m elevation; 29 April 2013; *A.D. Poulsen, Ø. Lofthus & B. Sule 2893* (holotype LAE; isotypes BO, E + spirit, L, O, SING).

Diagnosis

Similar to *Alpinia oceanica* Burkill in the vegetative characters but differs by the erect inflorescence (vs mostly pendulous); exposed distal peduncle (vs hidden within sheaths); cincinni laxly arranged (5–8 mm apart) along the rachis, 3–11 cm long with 2 mm long stalk at base and composed of up to 15 flowers (vs congested, 3–7 cm long, sessile, up to 7); and linear labellum with a retuse apex (vs narrowly triangular, apex truncate).

Description

Terrestrial herb in loose clump, sometimes covering several square metres. Rhizome 1–2 cm diameter, white to cream internally, stilt roots absent; scales chartaceous, 9 × 18 mm, light brown, glabrous, apex acute. Leafy shoots 11–12 cm apart, pseudostem 1.6–3 m long, base 2.7–3.5 cm diameter; sheath light green with paler longitudinal lines, striate when dry, glabrous to slightly pubescent; ligule entire, 9–11 × 7–10 mm (when flattened), mid-green to light brown, densely pubescent, apex rounded; lamina sessile, narrowly ovate, 38–60 × 7–13 cm, plicate, mid-green above, light green beneath, glabrous on both sides, midrib beneath with scattered hairs, base cuneate, margin entire, glabrous, apex acute. Inflorescence terminal to the leafy shoot, a panicle, 15–25 cm long; inflorescence bracts 2–3: basal one clasping, white, brown with age, glabrous, apex sometimes with foliaceous mucro, the second (and third) similar to floral bracts; distal peduncle 4.5–7 cm long (measured from the lowermost inflorescence bract to the lowermost fertile bract), ± exposed, white or greenish white, densely pubescent; rachis 6–15 cm long, white or greenish white, densely pubescent, with 15–30 cincinni each with up to 15 flowers; cincinni 5–8 mm apart and alternately arranged along rachis, ± perpendicular, 2.8–11 cm long,

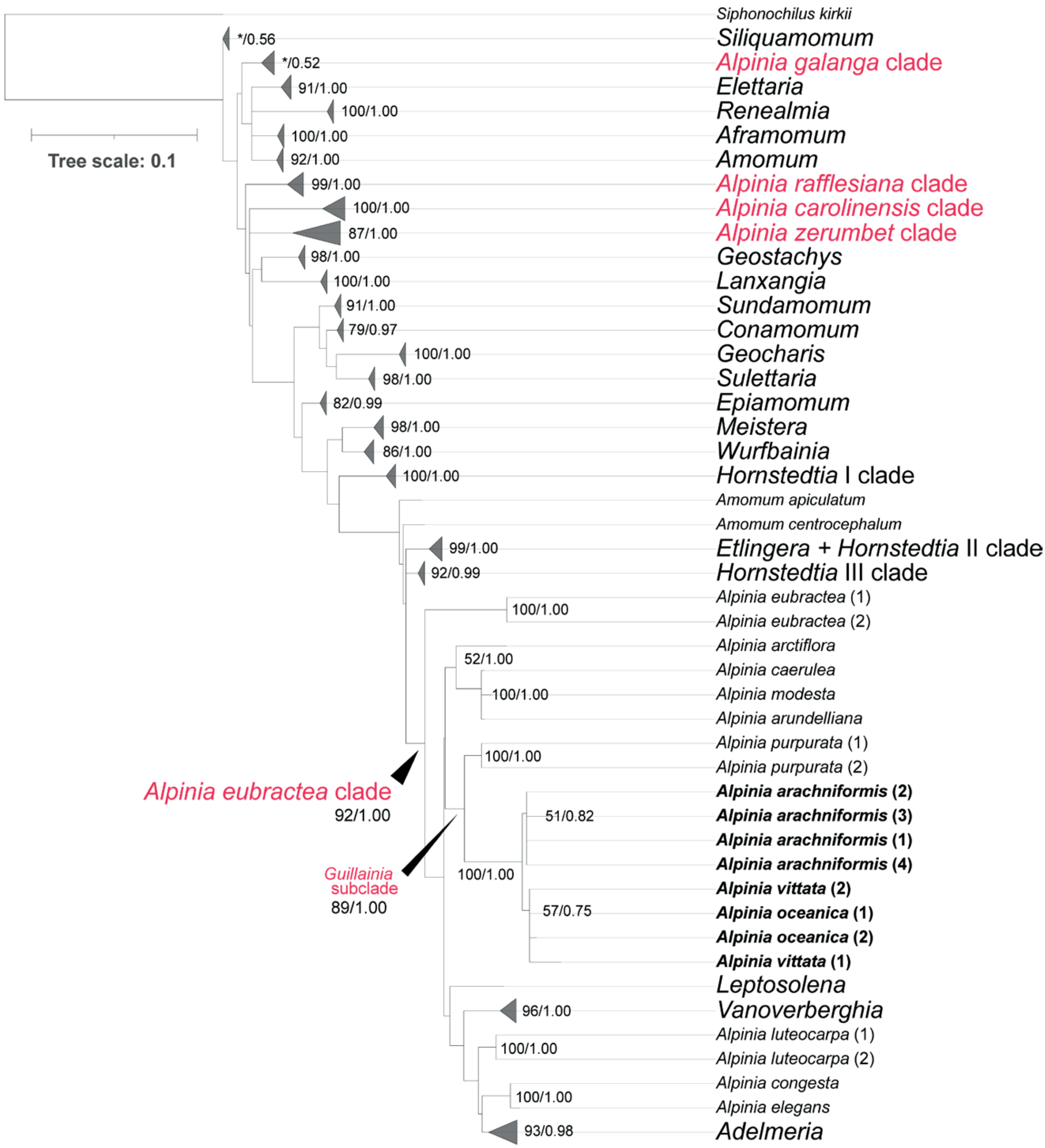

Figure 1. Maximum likelihood phylogenetic tree of the tribe Alpinieae based on ITS sequence data. Genera and clades within the tribe Alpinieae were collapsed, and the five clades of *Alpinia* defined by Kress et al. (2005, 2007), as well as the *Guillainia* subclade, are in red font. Bootstrap values obtained from Maximum likelihood and posterior probabilities from Bayesian inference are provided on the branches. An asterisk (*) denotes posterior bootstrap supports and probability values < 50/0.5. Taxa included in this study for the first time are marked in bold, while additional material downloaded from GenBank is in normal font.

elongating with age, stalk c. 2 mm long; fertile bracts ovate, 17–30 × 15–20 mm, white or greenish white, glabrous, base slightly pubescent, apex rounded; bracteoles tubular, 9–13 mm long, membranous, white, pinkish white when young, brown and decaying when mature, glabrous except the pubescent upper margin, V-shaped

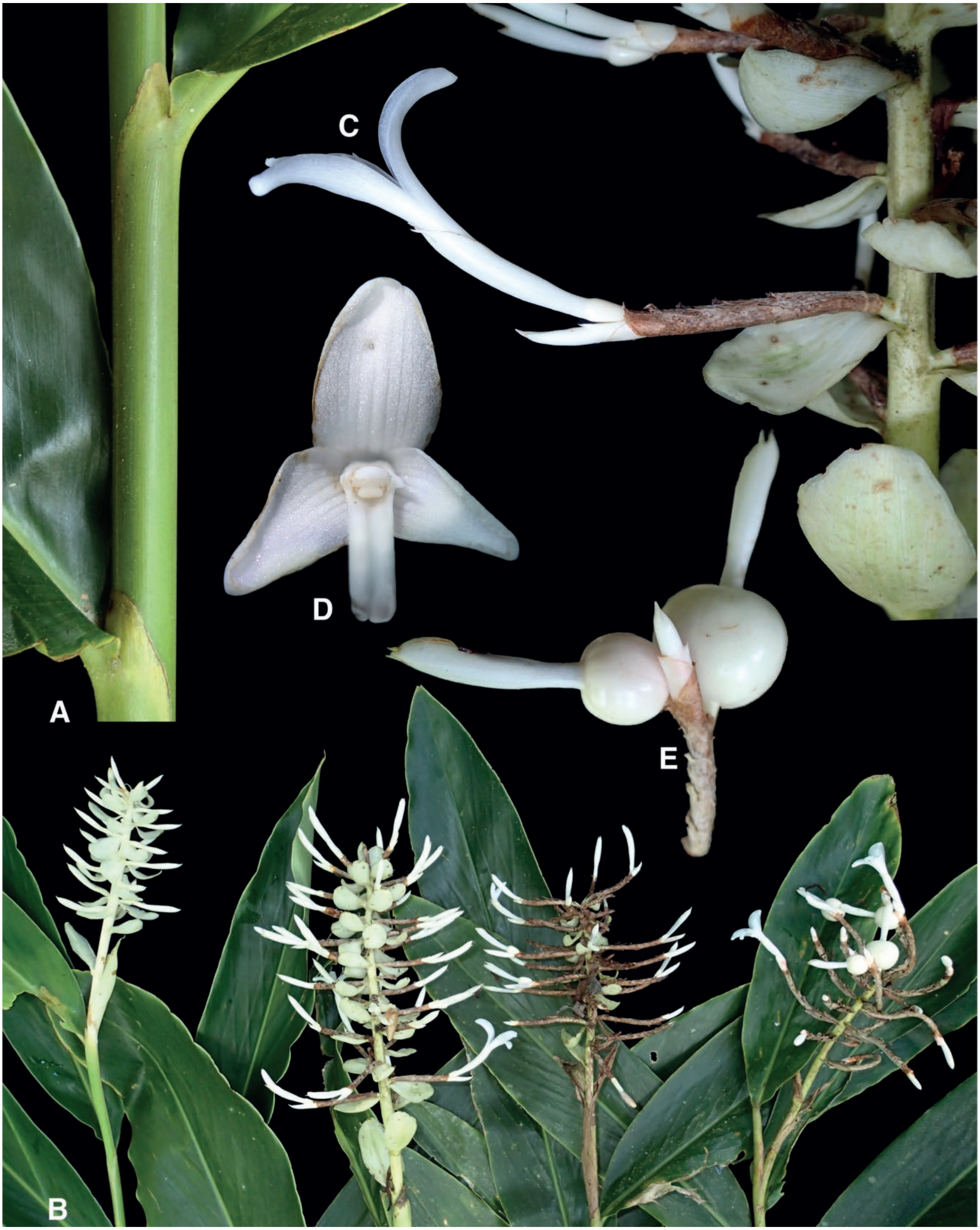

Figure 2. *Alpinia arachniformis* A.D.Poulsen **A.** Pseudostem showing the sheaths and ligules. **B.** Inflorescences in different stages. **C.** Cincinnus with supporting bract. **D.** Flower (front view). **E.** Fruits. Based from *A.D. Poulsen et al. 2893* (type). Photos: A.D. Poulsen.

incision c. 3 mm long, apex acute, mucronate; flowers 5–8 cm long, white; pedicel 9–13 mm long, white, glabrous to slightly pubescent; calyx tubular, 20–26 mm long, white, glabrous except the pubescent 3-dentate apex, incision 3–4 mm long; floral tube 20–26 mm long, narrow, slightly widening towards apex, white, glabrous outside and inside; dorsal corolla lobe narrowly ovate, 13–22 × 5–9 mm, white, glabrous, apex cucullate; lateral corolla lobes narrowly ovate to oblong, 14–21 × 4–5 mm, white, glabrous, apex cucullate; staminal tube 3–4 mm long, white, glabrous; labellum 9–15 mm long, linear, glabrous, white, 7.5–13 × 1.5–2.5 mm, fleshy, curved, held flat to the stamen, apex retuse, 1.5–2 × 1.5–2.5 mm, petaloid; lateral staminodes connate basally to the labellum, free part flattened, tooth-like, c. 15 mm long diverging c. 5–7 mm above the base of the labellum; stamen subsessile (filament < 1 mm long), 9–11 mm long; anther 8–12 × 2–4 mm, connective white, pubescent throughout or only laterally; anther crest rounded, 1–2 × 1.5–3 mm, white, glabrous, apex truncate; thecae 10–12 × 1–1.8 mm, white, glabrous, dehiscing through their entire length, base slightly spur-like; style 34–35 mm long, white, glabrous, pilose near apex; stigma clavate, c. 2 mm wide, white, pubescent, apex truncate, ostiole transverse, narrowly elliptic, facing downwards, lower margin ciliate; epigynous gland c. 1 mm long, yellow, glabrous, partially encloses the style; ovary partially or entirely exposed above bracteole, obovoid, 4–6 × 3–4 mm, red or white, glabrous, trilocular, placentation axile. Fruits globose, 26–29 × 25–30 mm, white, sometimes tinged faintly pink at base, glabrous, calyx persistent; seeds c. 3 mm wide and long, ovoid and angular, dark brown (in spirit), glabrous, arillate.

Etymology

The elongated cincinni suggest a spider-like resemblance.

Local names and uses

Gorgor (Pidgin English / Tok Pisin language) and ngu-ngau (Konomalu language).

Phenology

Flowering and fruiting throughout the year.

Distribution and habitat

Alpinia arachniformis has only been documented in the islands of New Ireland and New Hanover (Fig, 4) and is thus endemic to the province of New Ireland, Papua New Guinea. The species grows in the lowlands (0–10 m a.s.l., in open coastal forests (as close as 10 m to the beach) but is often found in disturbed vegetation in garden areas or along roads.

Proposed conservation assessment

Based on the IUCN red list categories and criteria (IUCN Standards and Petitions Committee, 2024), *Alpinia arachniformis* is provisionally assessed as Vulnerable (VU B2ab(iii), D). The area of occupancy (AOO) is estimated to be less than 2,000 km^2 (total AOO is 32 km^2) while the extent of occurrence (EOO) is estimated to be less than 20,000 km^2 (total EOO is 5,202.04 km^2). Only three out of eight sites were visited by the authors and an estimated 20 mature individuals were observed. Threats include logging and conversion of forests into agricultural and residential gardens but this species thrives in disturbed areas, such as roadsides. The assessment shall be updated as more information becomes available on *A. arachniformis* as well as its habitat.

Notes

Based on the collections we have examined, the inflorescence of *A. oceanica* is most often pendulous. This character can be used to distinguish the new species initially as it is always erect. In *A. arachniformis*, the distal part of the peduncle is always exposed (6–7 cm long) which is always hidden within the leaf sheaths in *A. oceanica*. Whereas the inflorescence is up to 7 cm long in *A. oceanica*, it may elongate up to 11 cm long with age in *A. arachniformis* (Fig 2B). Moreover, the cincinni of *A. arachniformis* are laxly arranged (5–8 mm apart) along the rachis with 2 mm long stalks, which produce up to 15 flowers whereas *A. oceanica* has sessile cincinni arranged tightly along the rachis with up to five flowers. According to Smith (1975), the floral bracts of *A. oceanica* vary from mid-green to mid-green with pink streaks (appearing pinkish-green), and white but most of the time, the floral bracts are of one colour only. In *A. arachniformis,* the floral bracts are consistently white or greenish-white. Moreover, the bracteoles of *A. oceanica* are split up to ¾ its length from apex (incision is c. 16 mm long) whereas the incision is only 3 mm long in *A. arachniformis*. The fruit colour of *A. oceanica* is also highly variable ranging from white, greenish-white, pink, to red. In *A. arachniformis* the fruit is always white, sometimes slight tinged pink.

Smith (1975) discussed the variation of the labellum of *Alpinia oceanica* based on several collections including specimens from New Ireland (*A.N. Millar NGF 23820* and *M.J.E. Coode & P. Katik NGF 40107*) that have a more or less linear labellum with prominent lateral teeth (the lateral staminodes) whereas material from

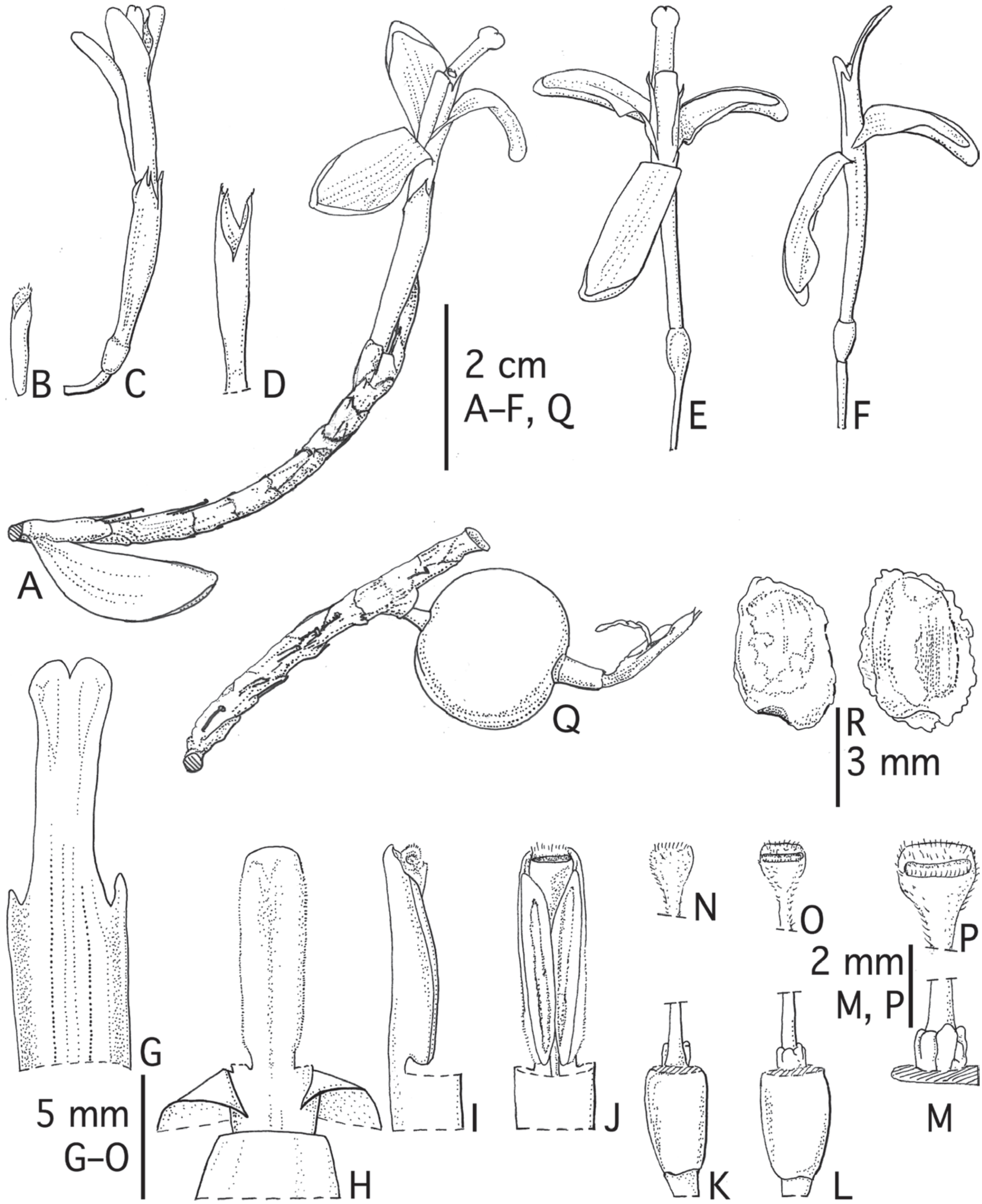

Figure 3 *Alpinia arachniformis* A.D.Poulsen. **A.** Cincinnus with supporting bract. **B.** Bracteole. **C.** Flower, bracteole removed. **D.** Calyx. **E.** Flower, calyx removed, dorsal view. **Figure 3.** Flower, calyx removed, lateral view. **G.** Labellum, flattened. **H.** Stamen, dorsal view. **I.** Stamen lateral view. **J.** Stamen ventral view. **K.** Ovary and epigynous gland, dorsal view. **L.** Ovary and epigynous gland, ventral view. **M.** Epigynous gland. **N.** Stigma, dorsal view. **O–P.** Stigma, ventral view. **Q.** Infructescence. **R.** Seeds with aril. Drawn from the type (*A.D. Poulsen et al. 2893*) by A.D. Poulsen.

elsewhere had a more or less triangular labellum only occasionally with lateral teeth. The characters observed in the cited collections above match a few other collections we have examined from New Ireland that we identified as representing *A. arachniformis*. If spirit material is available, these characters are also useful to distinguish the *A. arachniformis* from *A. oceanica*.

Interestingly, a 3–4 mm long staminal tube was observed in *Alpinia arachniformis* as well as in *A. oceanica* and *A. vittata* which is the first time this is documented within the *Alpinia eubractea* clade. The staminal tube is a diagnostic character of the genus *Etlingera* Giseke, which in molecular-based analyses (e.g., Kress et al. 2007; De Boer et al. 2018) is sister to the *Alpinia eubractea* clade that includes the three species (Fig. 1).

During the fieldwork in 2023, a collection was made (*A.D. Poulsen et al. 3313*) of a stand of *Alpinia* where the inflorescence had short cincinni (up to 3–4 cm long) some of which were bearing fruits (Fig. 5B). The local people insisted that this collection represented a different species than *A. arachniformis* collected with them nearby on the same date (*A.D. Poulsen et al. 3314*). In the phylogenetic tree of the present study, however, both collections grouped with the type of *A. arachniformis* and one other sample of a collection also having long cincinni (Fig. 1). As we examined collections from several herbaria, we found a few matching the morphology of *A.D. Poulsen et al. 3313*. We compared these specimens to the type of *A. arachniformis* but no other differences than the shorter cincinni were found. Because of that, all the specimens mentioned are identified here as *A. arachniformis*. The alternative options would be to treat the short-cincinni plants at a subspecies, a variety, or as a hybrid of *A. arachniformis* and *A. oceanica*, which occurs sympatrically. Our interpretation is that the cincinni will elongate during the season and probably also with the age of the plant. Future studies using population genetic methods may cast light on the underlying causes of the variation in elongation of the cincinnus, as well as potential hybridization. Meanwhile, we believe that the fruits may set at various points along the cincinnus, and long-term observation of the development of the inflorescence is needed to establish at what stage the fruits are produced.

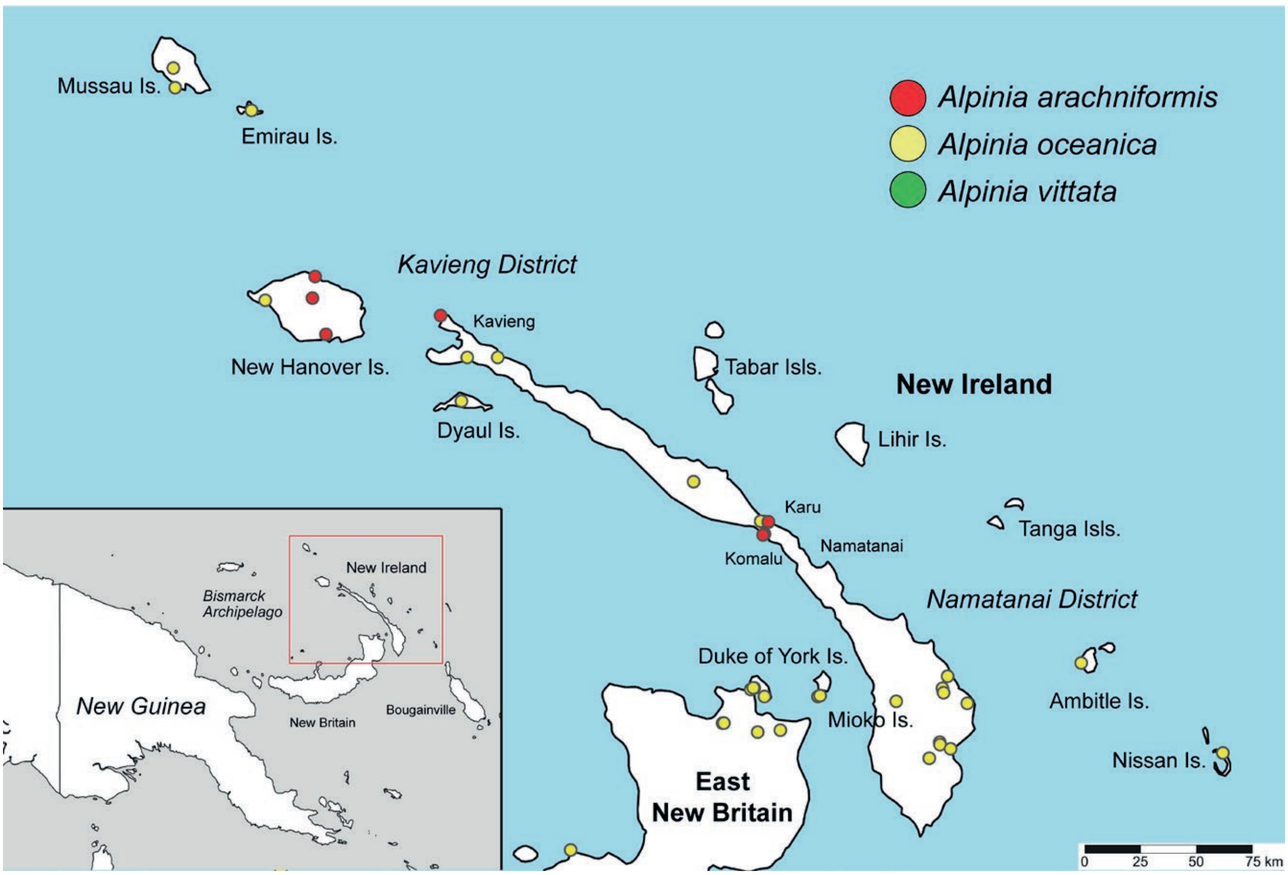

Figure 4. Distribution map of *Alpinia arachniformis* A.D.Poulsen (red circles), *A. oceanica* (yellow), and *A. vittata* (green, cultivated).

Table 1. Comparison between *Alpinia arachniformis, Alpinia oceanica*, and *Alpinia vittata.*

Morphological characters	*Alpinia arachniformis*	*Alpinia oceanica*	*Alpinia vittata*
Sheath	glabrous to slightly pubescent	glabrous	glabrous
Ligule	pubescent	glabrous to pubescent	densely pubescent
Petiole	sessile	sessile to c. 5 mm long	2–3 mm long
Lamina	mid-green above, light green beneath; apex acute	mid-green above, light green beneath; apex caudate	variegated with cream to white lines, lighter beneath; apex obtuse
Inflorescence	erect	mostly pendulous, rarely erect	pendulous
Distal peduncle	exposed part 6–7 cm long	hidden within the sheaths	hidden within the sheaths
Cincinni	with 2 mm stalk; 3–11 cm long; laxly arranged along the rachis; with up to 15 flowers	sessile; up to 3–7 cm long; tightly or laxly arranged along the rachis; with up to 5 flowers	sessile; 6–7 cm long; laxly arranged along the rachis; with up to 6 flowers
Floral bract	white or white with green streaks; margin glabrous	green, green with pink streaks (appearing pinkish green), and white; margin pubescent	light green; margin pubescent
Bracteole and its V-shape incision	9–12 mm long (incision c. 3 mm long)	10–23 mm long (incision c. 16 mm long)	14–15 mm long; (incision c. 10 mm long)
Staminal tube	3–4 mm long	2–3 mm long	6–7 mm long
Labellum	linear; apex retuse	narrowly triangular; apex truncate	narrowly triangular; apex truncate
Lateral staminodes	always present as flattened tooth-like structures	occasionally present as flattened tooth-like structures	absent
Fruit	white, tinged faintly pink	white, light green, or pale red	not observed

Additional specimens examined

Papua New Guinea. New Hanover Island, north coast, 2°55'S, 150°10'E, 20 October 1955, *J.S. Womersley & A.C. Richardson NGF* 7969 (LAE); Lavongai subdistrict, Lamet, 2°23'S, 150°10'E, 12 October 1974, *J.R. Croft LAE 65551*, (A, BISH, BRI, CANB, E, L, LAE); edge of Taskul airstrip, 2°33'S, 150°28'E, 10 m a.s.l., 25 September 1979, *O. Gideon LAE 76077* (LAE). New Ireland Island, Kavieng District, sea level, 31 October 1964, *A.N. Millar NGF 23820* (BRI, CANB, GH, K, L, LAE); Namatanai District, near Komalu village, 3°31'19"S, 12°58'6"E, 50 m a.s.l., 2 October 2023, *A.D. Poulsen et al. 3313* (E, L, LAE, SING); Kabohbok, 3°31'35.1"S, 12°36"E; 10 m a.s.l., 2 October 2023, *A.D. Poulsen et al. 3314* (E, LAE, SING); Karu Forestry Station, 3°28'6.4"S, 14°1.8"E, 2 m a.s.l., 2 October 2023, *A.D. Poulsen et al. 3316* (E, LAE).

Key to *Alpinia* species of the Bismarck Archipelago

The first attempt of a checklist of *Alpinia* of the Bismarck Archipelago is by Peekel (1984) but did not include a key. Here we provide the first key to the *Alpinia* species of the archipelago.

1a. Floral bract persistent **2**

1b. Floral bract deciduous or absent **5**

2a. Lamina sessile; corolla exerted from the calyx less than ¼ its length; floral bracts ovate; lateral staminodes tooth-like or absent **3**

2b. Lamina petiolate; corolla exerted from the calyx more than ¾ its length; floral bracts obovate; lateral staminodes ovate .... ***A. purpurata***

3a. Sheath pubescent; ligule pubescent; lamina apex acute; inflorescence always erect; cincinni 3–11 cm long with up to 15 flowers; labellum linear .... ***A. arachniformis***

3b. Sheath glabrous; ligule glabrous; lamina apex caudate; inflorescence mostly pendulous; cincinni 2–4 cm long with up to 5 flowers; labellum narrowly triangular **4**

4a. Lamina mid-green above; fruits globose .... ***A. oceanica***

4b. Lamina variegated with cream to white lines; fruits unknown .... ***A. vittata***

5a. Lamina oblong; labellum petaloid, broadly triangular-ovate, yellow and red .... ***A. novae-pommeraniae***

5b. Lamina narrowly ovate; labellum fleshy, quadrilobed, white tinged pink .... ***A. pulchella***

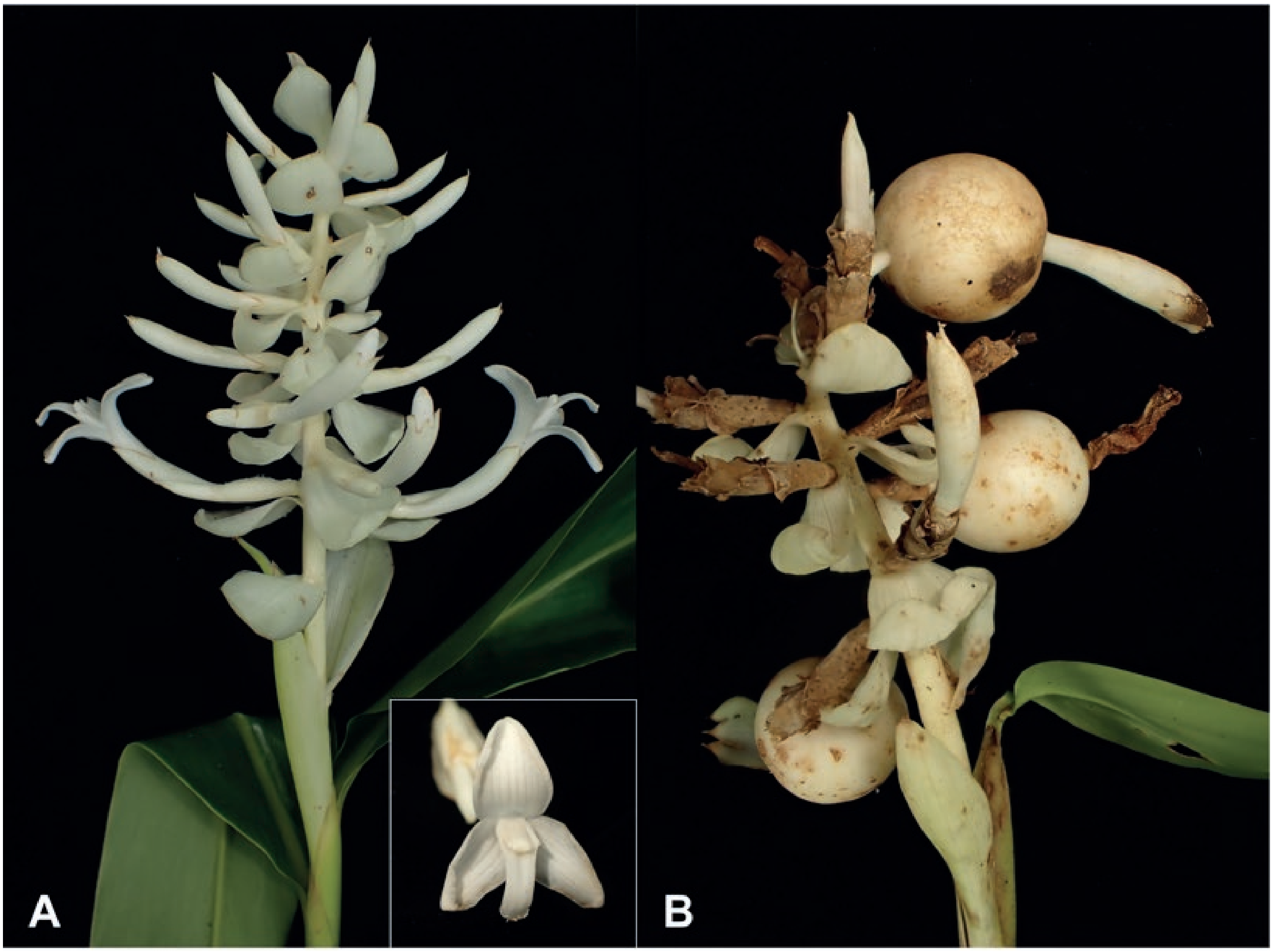

Figure 5. *Alpinia arachniformis* A.D.Poulsen with short cincinni. **A.** Inflorescence (inset: frontal view of a flower). **B.** Almost mature inflorescence. Photos: A.D. Poulsen of *A.D. Poulsen et al. 3313* (not the type).

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Appendix I. List of taxa sampled with GenBank accession numbers (ITS, *trn*K/*mat*K) and voucher information. GenBank accession numbers in **bold font** were generated for this study.

Species	ITS	Country/Region of origin	Reference / Voucher
Tribe Alpinieae			
Adelmeria alpina Elmer	LT717096	Philippines	R.V.A. Docot 0051a (USTH)
Adelmeria dicranochila Docot & Banag	LT717101	Philippines	R.V.A. Docot 0048 (USTH)
Adelmeria gigantifolia (Elmer) Elmer	LT717097	Philippines	R.V.A. Docot 0037 (USTH)
Adelmeria isarogensis Docot & Banag	LT717102	Philippines	R.V.A. Docot 0065 (USTH)
Adelmeria leonardoi Docot & Banag	LT717103	Philippines	R.V.A. Docot 0075 (USTH)
Adelmeria oblonga Merr.	LT717098	Philippines	R.V.A. Docot 0056 (USTH)
Adelmeria paradoxa (Ridl.) Merr.	LT717099	Philippines	R.V.A. Docot 0048 (USTH)
Adelmeria pinetorum (Ridl.) Ridl.	LT717100	Philippines	R.V.A. Docot 0030 (USTH)
Adelmeria undulata Docot & Banag	LT717104	Philippines	R.V.A. Docot 0071 (USTH)
Aframomum angustifolium (Sonn.) K.Schum.	AF478704	Madagascar	W.J. Kress 92-34`03 (US)
Aframomum cereum (Hook.f.) K.Schum.	AF478706	Gabon	W.J. Kress 98-6268 (US)
Alpinia aenea B.L.Burtt & R.M.Sm.	AY742351	Indonesia	G. Argent 0016 (E)
Alpinia arachniformis A.D.Poulsen (1)	**PQ165160**	Papua New Guinea	A.D. Poulsen et al. 2893 (E)
Alpinia arachniformis A.D.Poulsen (2)	**PQ165161**	Papua New Guinea	A.D. Poulsen et al. 3313 (E)
Alpinia arachniformis A.D.Poulsen (3)	**PQ165162**	Papua New Guinea	A.D. Poulsen et al. 3314 (E)
Alpinia arachniformis A.D.Poulsen (4)	**PQ165163**	Papua New Guinea	A.D. Poulsen et al. 3316 (E)
Alpinia arctiflora (F.Muell.) Benth.	AY742336	Australia	A. Rangsiruji 48 (E)
Alpinia argentea (B.L.Burtt & R.M.Sm.) R.M.Sm.	AY742337	Malaysia	CS 02-303 (HLA)
Alpinia arundelliana (F.M.Bailey) K.Schum.	AY742338	Australia	A. Rangsiruji 49 (E)
Alpinia boia Seem.	AY742340	Fiji	see Rangsiruji et al. (2000)
Alpinia brevilabris C.Presl	AY742341	Philippines	see Rangsiruji et al. (2000)
Alpinia caerulea (R.Br.) Benth.	AY742342	Australia	A. Rangsiruji 50 (E)
Alpinia calcarata (Haw.) Roscoe	AF478710	China	W.J. Kress 94-3657 (US)
Alpinia capitellata Jack	KJ507890	Malaysia	-
Alpinia carolinensis Koidz.	AF478711	Micronesia	W.J. Kress 94-5254 (US)
Alpinia coeruleoviridis K.Schum.	AY742343	Indonesia	A. Rangsiruji 240 (E)
Alpinia congesta Elmer	LT717106	Philippines	R.V.A. Docot 0018 (USTH)
Alpinia cylindrocephala K.Schum.	AY742345	Indonesia	M.F. Newman & J. Škorničková 1467 (E)
Alpinia elegans (C.Presl) K.Schum.	AF478713	Philippines	W.J. Kress 99-6412 (US)
Alpinia eubractea K.Schum. (1)	AY742347	Indonesia	529 (E, Leiden)
Alpinia eubractea K.Schum. (2)	LT717108	Indonesia	A.D. Poulsen et al. 2739 (E)
Alpinia foxworthyi Ridl.	AF478714	Philippines	see Rangsiruji et al. (2000)
Alpinia galanga (L.) Willd. (1)	AF478715	ex hort. Hawaii	Lyon Arbor. 83.505 (HLA)
Alpinia galanga (L.) Willd. (2)	AY424739	ex. hort. E	A. Rangsiruji 3 (E)
Alpinia haenkei C.Presl	AY742354	Philippines	L-82.0072 (HLA)
Alpinia javanica Blume	AY742358	Malaysia	A. Rangsiruji 53 (E)
Alpinia ligulata K.Schum.	AY742361	Malaysia	see Rangsiruji et al. (2000)
Alpinia luteocarpa Elmer (1)	AF478717	Philippines	W.J. Kress 99-6403 (US)
Alpinia luteocarpa Elmer (2)	LT717110	Philippines	R.V.A. Docot 0028 (USTH)
Alpinia melichroa K.Schum.	KY438060	Indonesia	A.D. Poulsen & Sharp 2834 (E)
Alpinia monopleura K.Schum.	KY438054	Indonesia	S.M. Scott 02-101 (E)
Alpinia murdochii Ridl.	KY438007	Malaysia	O. Šída, T. Fér & E. Záveská M-11-1 (PR)
Alpinia nigra (Gaertn.) Burtt	KJ946272	India	M.R. Vinitha 92522 (CALI)
Alpinia nutans (L.) Roscoe	AY742369	Malaysia, Thailand	L-91.0066, CS 02-337 (HLA)
Alpinia oceanica Burkill (1)	**PQ165165**	Papua New Guinea	A.D. Poulsen et al. 3307 (E)
Alpinia oceanica Burkill (2)	**PQ165164**	Papua New Guinea	A.D. Poulsen et al. 3309 (E)

(Continued)

Appendix I. (Continued).

Species	ITS	Country/Region of origin	Reference / Voucher
Alpinia officinarum Hance	AF478718	China	W.J. Kress 00-6614 (US)
Alpinia oxyphylla Miq.	AY74372	China	Liao 020707 (SCIB)
Alpinia purpurata (Vieill.) K.Schum.	AY742375	Melanesia	A. Rangsiruji 9 (E)
Alpinia purpurata (Vieill.) K.Schum.	KY438102	Solomon Islands	A.D. Poulsen 2467 (E)
Alpinia rafflesiana Wall. ex Baker	AY742376	Malaysia	Ibrahim & Jong s.n. (Kress 97-6119) (E)
Alpinia rufa (C.Presl) Náves	LT717109	Philippines	R.V.A. Docot 0063 (USTH)
Alpinia sibuyanensis Elmer	AY742381	Philippines	L-99.0098 (HLA)
Alpinia vittata W.Bull (1)	**PQ165159**	Papua New Guinea	A.D. Poulsen et al. 3315 (E)
Alpinia vittata W.Bull (2)	**PQ165158**	Papua New Guinea	A.D. Poulsen et al. 3317 (E)
Alpinia warburgii K.Schum.	AY742388	Indonesia	SUL02-169 (E)
Alpinia zerumbet (Pers.) B.L.Burtt & R.M.Sm.	AY742389	ex. hort. E	A. Rangsiruji 18 (E)
Alpiniua modesta F.Muell. ex K.Schum.	AY742364	Australia	A. Rangsiruji 51 (E)
Amomum apiculatum K.Schum.	KY438083	Indonesia	A.D. Poulsen & Hatta 2275 (ANDA)
Amomum centrocephalum A.D.Poulsen	KY438010	Indonesia	A.J. Droop 29 (E)
Amomum maximum Roxb.	AY351995	China	Y.M. Xia 725 (HITBC)
Amomum subulatum Roxb.	KY438086	India	J. Mood 3218 (ASSAM)
Amomum trianthemum K.Schum.	KY438090	Indonesia	M.F. Newman et al. 118 (E)
Conamomum cylindrostachys (K.Schum.) Škorničk. & A.D.Poulsen	AB097240	Malaysia	S. Sakai 357 (KYO)
*Conamomum xanthophlebium (*Baker) Škorničk. & A.D.Poulsen	KY438018	Indonesia	A.J. Droop 81 (E)
Elettaria cardamomum (L.) Maton	KY438100	Malaysia	J. Leong-Škorničková JLS-432 (SING)
Elettaria floribunda Thwaites	AY742334	Sri Lanka	A. Weerasooriya s.n. (K)
Elettaria involucrata Thwaites	AY742348	Sri Lanka	A. Weerasooriya s.n. (K, PDA)
Epiamomum angustipetalum (S.Sakai & Nagam.) A.D.Poulsen & Škorničk.	AB097245	Malaysia	S. Sakai 389 (KYO)
Epiamomum roseisquamosum (S.Sakai & Nagam.) A.D.Poulsen & Škorničk.	AB097246	Malaysia	S. Sakai 188 (KYO)
Etlingera corrugata A.D.Poulsen	KY438084	Malaysia	J. Leong-Škorničková JLS-220 (SING)
Etlingera fimbriobracteata (K.Schum.) R.M.Sm.	KY438005	ex hort. SBG	J. Leong-Škorničková GRC-362 (SING)
Etlingera yunnanensis (T.L.Wu & S.J.Chen) R.M.Sm.	AY352014	China	Y.M. Xia 738 (W.J. Kress 95-5511) (HITBC)
Geocharis fusiformis (Ridl.) R.M.Sm.	AF414487	Malaysia	L.B. Pedersen 1141 (C)
Geocharis macrostemon (K.Schum.) Holttum	KY438104	Indonesia	A.J. Droop 19 (E)
Geostachys densiflora Ridl.	KY438011	Malaysia	O. Šída, T. Fér & E. Záveská M-11-2 (PR)
Geostachys megaphylla Holttum	AY351987	China	Y.M. Xia 721 (HITBC)
Hornstedtia hainanensis T.L.Wu & S.J.Chen	AF478766	China	W.J. Kress 97-5769 (US)
Hornstedtia leonurus (J.Koenig) Retz.	KY438012	Singapore	J. Leong-Škorničková et al. SNG 72 (SING)
Hornstedtia sanhan M.F.Newman	AY769844	Vietnam	M.F. Newman 202 (E)
Hornstedtia scyphifera (J.Koenig) Steud.	KY438021	Singapore	J. Leong-Škorničková et al. SNG-21 (SING)
Hornstedtia cf. *scyphifera* (J.Koenig) Steud.	KY620235	Indonesia	A.J. Droop 4 (E)
Hornstedtia tomentosa (Blume) Bakh.f.	KY438074	ex hort. SBG	J. Leong-Škorničková GRC-169 (SING)
Lanxangia coriandriodora (S.Q.Tong & Y.M.Xia) M.F.Newman & Škorničk.	KY438067	Indonesia	A.J. Droop 76 (E)
Lanxangia tsaoko (Crevost & Lemarié) M.F.Newman & Škorničk.	AY352007	China	Y.M. Xia 734 (HITBC)
Leptosolena haenkei C.Presl	AY742331	Philippines	Funakoshi & Co 2006 (US)
Meistera echinocarpa (Alston) Škorničk. & M.F.Newman	KY438068	Laos	V. Lamxay 1315 (E)
Meistera koenigii (J.F.Gmel.) Škorničk. & M.F.Newman	KY438112	Laos	V. Lamxay 2078 (NLS)
Meistera propinqua (Ridl.) Škorničk. & M.F.Newman	AY351999	Philippines	Lyon Arbor. 93.0558 (HLA)

(Continued)

Appendix I. (Continued).

Species	ITS	Country/Region of origin	Reference / Voucher
Plagiostachys sp.	KY438024	ex hort. SBG	J. Leong-Škorničková JLS-1882 (SING)
Renealmia alpina (Rottb.) Maas	AF478778	Tropical America	W.J. Kress 99-6407 (US)
Renealmia thyrsoidea (Ruiz & Pav.) Poepp. & Endl.	AF478783	Tropical America	W.J. Kress 99-6406 (US)
Sulettaria anomala (R.M.Sm.) A.D.Poulsen & Lofthus,	KY438106	Malaysia	A.D. Poulsen & al. 2033 (AAU)
Sulettaria longipilosa (S.Sakai & Nagam.) A.D.Poulsen & Lofthus	AB097229	Malaysia	S. Sakai 380 (KYO)
Sundamomum durum (S.Sakai & Nagam.) A.D.Poulsen & M.F.Newman	JF715470	Malaysia	S. Sakai 362 (KYO)
Sundamomum hastilabum (Ridl.) A.D.Poulsen & M.F.Newman	KY438067	Indonesia	A.D. Poulsen & al. 2262 (E)
Vanoverberghia diversifolia Elmer	LT717105	Philippines	R.V.A. Docot 0034 (USTH)
Vanoverberghia rubrobracteata Docot & Ambida	MH270333	Philippines	R.V.A. Docot 0118 (USTH)
Vanoverberghia sasakiana Funak. & H.Ohashi	MH270332		Sekiguchi 23 (TI)
Vanoverberghia sepulchrei Merr.	AF478798	Philippines	Kress #95-5562 (US)
Vanoverberghia vanoverberghii (Merr.) Funak. & Docot	LT717107	Philippines	R.V.A. Docot 0005 (USTH)
Wurfbainia glabrifolia (Lamxay & M.F.Newman) Škorničk.& A.D.Poulsen	KY438049	Laos	V. Lamxay 2068 (NLS)
Wurfbainia uliginosa (J.Koenig) Škorničk. & A.D.Poulsen	KY438071	Laos	V. Lamxay 1021 (E)
Wurfbainia vera (Blackw.) Škorničk. & A.D.Poulsen	KY438099	Indonesia	A.J. Droop 10 (E)
Incertae cedis			
Siliquamomum oreodoxa N.S.Lý & Škorničk.	KY438093	Vietnam	S. Hul & N.S. Lý 3583 (E)
Siliquamomum tonkinense Baill.	KY438088	Vietnam	J. Leong-Škorničková et al. JLS-846 (SING)
Tribe Siphonochileae			
Siphonochilus kirkii (Hook.f.) B.L.Burtt	AF478794	East Africa	W.J. Kress 94-3692 (US)