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Journal of Plant Taxonomy and Geography (*Webbia*) is a peer-reviewed journal on Plant Taxonomy, Nomenclature, Phylogeny, Phytogeography and Palaeobotany of the Vascular Plants.

The journal aims to allow research in botanical topics such as taxonomy, systematics, nomenclature, molecular phylogeny, conservation, biogeography, and history of botany, and botanical collections.

It was founded in **1905** in Florence by **Ugolino Martelli** (1860-1934), a botanist well known for his studies of and contributions to the systematics of the tropical genus *Pandanus* and on the Flora of Sardinia.

In the 19th century Florence represented one of the most important European centres in Plant Taxonomy and Phytogeography with several notable Italian botanists worth mentioning such as Filippo Parlatore, Teodoro Caruel, Eugenio Baroni, Stefano Sommier, Odoardo Beccari and Ugolino Martelli himself. In 1842 **Filippo Parlatore** (1817-1877) founded in Florence the *Herbarium Centrale Italicum (FI)*, which soon became one of the most important herbaria in the world. Most of the specimens described and/or cited in *Webbia* are still kept in it.

In 1905, and as a consequence of this multitude of activities in Plant Systematics and Phytogeography, Ugolino Martelli established the journal *Webbia-Raccolta di Scritti Botanici*, firstly published annually in a single issue, and later twice a year. Webbia also began to be a place of publication of contributions from Tropical Botany, especially after the Royal Colonial Herbarium founded in 1904 in Rome was moved to Florence in 1914, currently named Tropical Herbarium Study Center (Centro Studi Erbario Tropicale - Herbarium FT) belonging to the Department of Biology of the University of Florence.

Webbia had been created in honor of **Philip Barker Webb** (1793-1845), a close friend of Filippo Parlatore, who before passing away entrusted his personal herbarium and a library rich of old botanical books and publications to the then Botanical Museum in Florence.

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The expeditions of the research yacht Utowana and the building of the plant living collections of the oldest botanical garden of Cuba

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Abstract. Cienfuegos Botanical Garden is the oldest functioning botanical institution of Cuba. It was established originally as a joint endeavor between sugar magnate Edwin F. Atkins and Harvard University in 1901. Between 1925 and 1934, the research yacht Utowana performed ample plant germplasm collections for the USDA in the New and Old World as well as archeological and zoological surveys in the Neotropics. The botanical expeditions were conducted mostly, under the leadership of David Fairchild. In this contribution we review to what extent Utowana expeditions and collections were instrumental in building the living collections of Cienfuegos Botanical Garden. A total of 278 accessions (comprising 254 species) were introduced into this garden directly or indirectly through these expeditions. Currently 57 of these species (132 individuals) are still part of its living collections. Interestingly, five of the Caribbean expeditions of this research yacht carried plant material between the Cienfuegos Botanical Garden and two other botanic gardens that were operated by US entities, namely the Lancetilla Botanical Garden in Honduras (owned by the United Fruit Company) and the Summit Gardens in Panama City (managed by the Panama Canal governmental agency). Our study also shows that plant material collected during Utowana expeditions was sent from Old World and Caribbean Island botanic gardens to Cienfuegos Botanical Garden. Thomas Barbour, director of this botanical institution between 1927 and 1946 joined four of these plant hunting endeavors. He provided strong support for the growing of the Cienfuegos Botanical Garden living collections with plant material collected during Utowana expeditions.

Keywords: Greater Antilles, Allison Armour, David Fairchild, Thomas Barbour, Plant Exploration, Germplasm, Tropical Islands.

INTRODUCTION

With 13 botanical gardens and 22 institutional herbaria, Cuba has the most extensive network of professional botanists of the Caribbean Islands (Thiers 2021; Hernández 2016: 64). Officially inaugurated in 1901, Cienfuegos Botanical Garden (CBG) is the oldest of these botanic gardens (Figures 1–2). Two other botanic gardens were established much earlier; however, they disappeared a few years after their founding. The oldest of these two gardens was originally created by the Spanish Crown in an area of Havana that was not far from the Capitolio (Capitol building). This particular garden was in operation between 1817 and 1839 when its land was sold to build a train station. A few plants from its living collections were moved to the Quinta de Los Molinos estate, also in Havana. Currently the Los Molinos site is considered as a historical garden, and it is run by the Ministerio de Cultura (Leiva 1995). The second early botanic garden was a private initiative led by José Blain (1808–1877), and it was located in the Pinar del Río province (Álvarez Conde 1958: 281–286). It had 175 ha and was known as El Retiro (González 2017). Blain was a naturalist without formal botany training who introduced into this site plants from all over the world. After his death, the garden was abandoned and decayed (González 2017).

Cienfuegos Botanical Garden was originally owned and run by Harvard University (see below), and it received ample support from United States of America sources until 1961 when this famous university suspended its operations in Cuba. Then the garden became a unit of the Academia de Ciencias de Cuba (Clement 1963: 565; 1964: 446).

David Fairchild (1869–1954, Figure 3), the founder of the plant genetic resources program of the United States Department of Agriculture [USDA; reviewed by Hodge and Erlanson (1956)] was one of the most enthusiastic supporters of CBG (Grey 1927: 10, 14; 1936). Fairchild himself conducted plant exploration expeditions that brought material to the USDA germplasm repositories from all over the world (Fairchild 1938a). Among these USDA expeditions, those on board the research yacht Utowana (years 1925–1933, Figure 4) explored many areas of Asia, Africa, Europe, and the Caribbean Basin (Fairchild 1930a, 1934a, 1938a: 472–475). It is worth indicating that not all of these expeditions had plant exploration as a primary objective. For instance, the last endeavor of this vessel (February 1 – April 20, 1934) targeted the Bahamas and Hispaniola but did not have any botanist on board and focused exclusively on archeology, herpetology, and ornithology.

Figure 1. Geographical location of Cienfuegos Botanical Garden, Cuba.

In this contribution we present a historical study on the importance of the Utowana expeditions in establishing the living collections of the CBG. We will show how these expeditions were instrumental in: (1) bringing plant material directly from USDA stations to this botanic garden, (2) providing a wide array of tropical species from different regions of the world to be cultivated in Cuba, and (3) developing networks among botanic gardens of the Caribbean. The "Utowana plants" that are still growing in CBG represent a unique heritage for this island and are part of the living legacy of David Fairchild as a plant explorer and economic botanist.

The archivial and bibliographic research

Our research is largely built on the study of documents (Figure 5), photos, letters, and plant records housed in the archives and library of CBG and of Fairchild Tropical Botanic Garden. A preliminary study on links between the Utowana trips and the history of CBG published by Vasallo Rodríguez (2017) provided initial perspectives to our study.

Two unpublished USDA reports pertinent to two of the Utowana expeditions that targeted the Caribbean Basin (1931 and 1931–1932) were also consulted. These

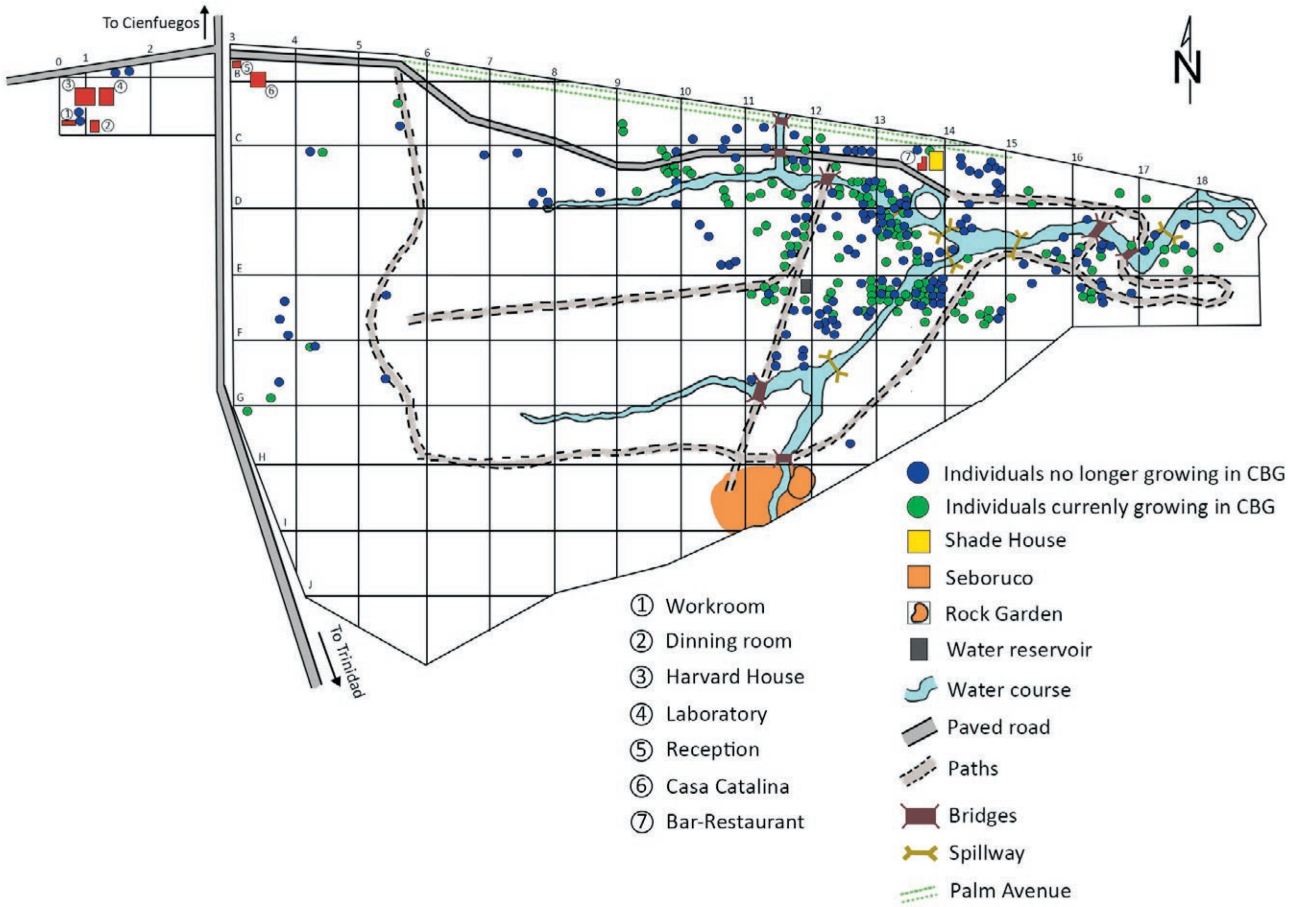


Figure 2. Current plan of Cienfuegos Botanical Garden showing its main facilities, alpha-numeric grid mapping system, and present/past location of individuals that reached this garden through Utowana expeditions.

two documents are housed in the US National Archives at College Park, Maryland (Armour 1931; Dorsett 1936). Robert M. Grey (see below) also produced an unpublished report on plants introduced in CBG between 1933–1935 (Grey ca. 1935, Figure 6). Among the published accounts, two reports (Figure 6) on the activities and collections of CBG were also relevant to our research as they list plant species growing in this garden in 1926 and 1933, respectively (Grey 1927; Grey and Hubbard 1933). Furthermore, CBG still keeps the original index-cards that were used to record the accessions that were introduced into this garden (Figure 7).

Determining the provenance of pre-1934 material cultivated in CBG was facilitated by information found in 19 issues of the USDA germplasm inventories that were published between the years 1923–1935. This was a regularly published journal entitled "United States Department of Agriculture. Inventory."

Through these bibliographic and archival resources, we identified those plant species introduced in CBG that were associated with Utowana expeditions (Online Supplementary Table 1). These species fell into three different categories: (1) material mailed directly from Asia or Africa during the Old World Utowana endeavors; (2) USDA germplasm accessions that the Utowana delivered to CBG during one of her five visits to Cienfuegos. This category mostly had samples that came from other Utowana expeditions, however, we also found a few non-Utowana accessions that are also included in this contribution; and (3) samples collected in the Caribbean Basin during one of the five Utowana expeditions that visited Cienfuegos. Most of these samples were delivered directly to the Garden once this vessel reached Cuba; however, we found that some of the samples were mailed to CBG from USA after the expedition was finished.

Cienfuegos Botanical Garden: an historical overview

A few scholarly publications have already discussed several aspects of the trajectory and importance of CBG

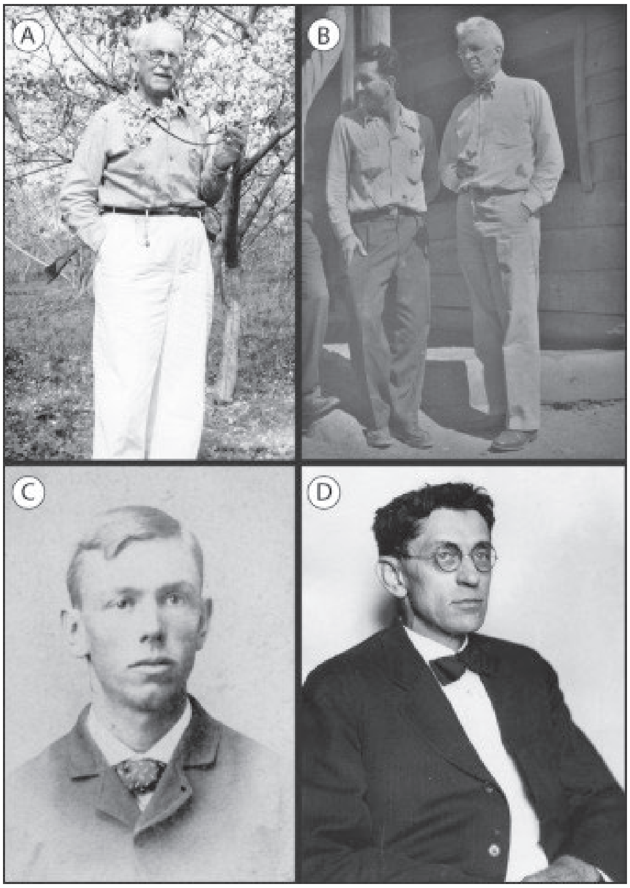


Figure 3. Relevant personalities in the history of Utowana expeditions and of Cienfuegos Botanical Garden. (A) David Fairchild. (B) Ángel Valiente (left) and Wilson Popenoe (right). (C) Palemon H. Dorsett. (D) Guy N. Collins. Courtesy of Archive and Library of Fairchild Tropical Botanic Garden (A, C), Library of Cienfuegos Botanical Garden (B), and Hunt Institute for Botanical Documentation (D).

(i.e., Grey 1927; Cahan 1991; Agüero and Ríos 1994; Howard 2000; Ojeda Quintana et al. 2007; Scott 2007; Fernández-Prieto 2018). As we read these works, some inconsistencies mostly regarding relevant historical dates were found. A critical review of the history of CBG is beyond the scope of this contribution, and therefore, here we provide only an overview of the main events that defined CBG. They are important for understanding the links that this garden had with David Fairchild and the USDA plant introduction program that he led. Our archival research showed that David Fairchild had extensive correspondence with most of the personalities who were directly involved in the developing of CBG. Many of them were pivotal for the introduction of plant material in CBG through the Utowana expeditions.

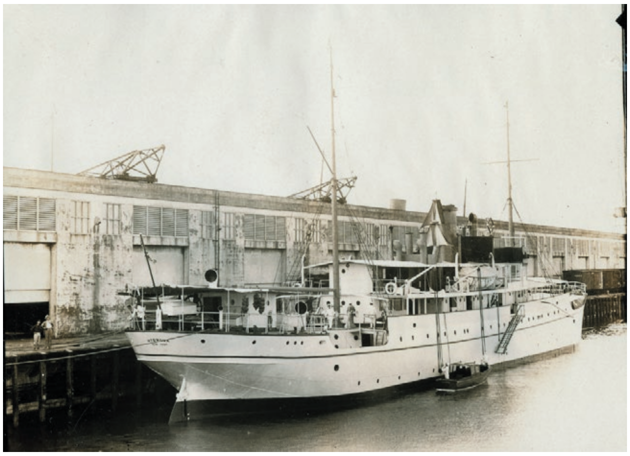
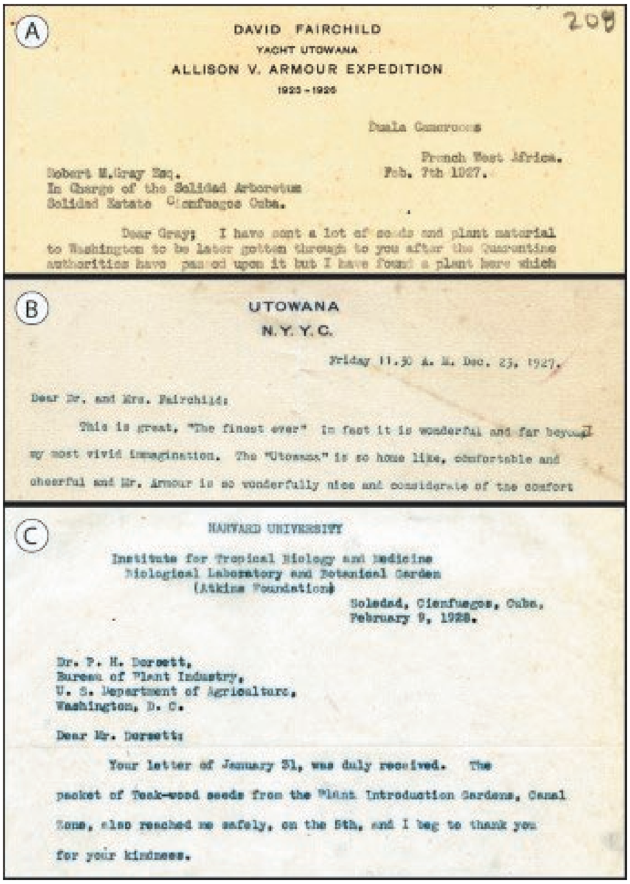


Figure 4. Research yacht Utowana in Puerto Colón, Panama, photo taken during the 1928 expedition of Palemon H. Dorsett to the Caribbean region. Courtesy of USDA National Agricultural Library Special Collections.

The origin of CBG stems from the inability of the Sarría family to pay off their accumulated financial debts. In 1881, this resulted in US entrepreneur Edwin F. Atkins (1850–1926) and his partner Joaquín Torriente acquiring a group of the properties of this family by foreclosure, including the Soledad Plantation. Later, in 1884, Atkins bought Torriente's assets (Scott 2007: 10; Rodríguez Eguiguren 2008: 73). The Atkins Sugar Estate was far from other human settlements and communicated with the main town of Cienfuegos by a railway that led to a dock located in Belmonte, on the banks of the Caunao River. From this site a small steamship carried passengers and goods across Cienfuegos Bay in a two-hour journey (Figure 1). By 1914, the property had over 7,203 ha, 40 km of railroad, and four locomotives (Lapique and Segundo 2011: 159–160).

Sugar cane harvesting was the main economic activity of the estate, which included a sugar mill known as Central Soledad. In 1899 Atkins became interested in the possible development of better varieties of this crop through selection and crossing, for which he consulted Prof. George L. Goodale (1839–1923, Figure 8) and Prof. Oakes Ames (1874–1950, Figure 8), both from Harvard University (Barbour and Robinson 1940: 140). In 1900 Atkins met with them in Central Soledad, and it was decided to establish the "Harvard Botanic Station for Tropical Research and Sugar Cane Investigation." This botanic station became part of the infrastructure and facilities of the Atkins Sugar Estate (Grey 1927: 3). Therefore, CBG was originally a joint endeavor between Atkins and Harvard University. The garden was formally inaugurated in September of 1901 on Colonia Limones (Grey 1927: 3), and it was also known informally as Soledad



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DAVID FAIRCHILD
YACHT UTOWANA
ALLISON V. ARMOUR EXPEDITION
1925 - 1926

Duala Cameroons
French West Africa.
Feb. 7th 1927.

Robert M.Gray Esq.
In Charge of the Solidad Arboretum
Solidad Estate Cienfuegos Cuba.

Dear Gray; I have sent a lot of seeds and plant material to Washington to be later gotten through to you after the Quarantine authorities have passed upon it but I have found a plant here which

UTOWANA
N.Y.Y.C.

Friday 11.30 A. M. Dec. 23, 1927.

Dear Dr. and Mrs. Fairchild:

This is great, "The finest ever" in fact it is wonderful and far beyond my most vivid imagination. The "Utowana" is so home like, comfortable and cheerful and Mr. Armour is so wonderfully nice and considerate of the comfort

HARVARD UNIVERSITY
Institute for Tropical Biology and Medicine
Biological Laboratory and Botanical Garden
(Atkins Foundation)

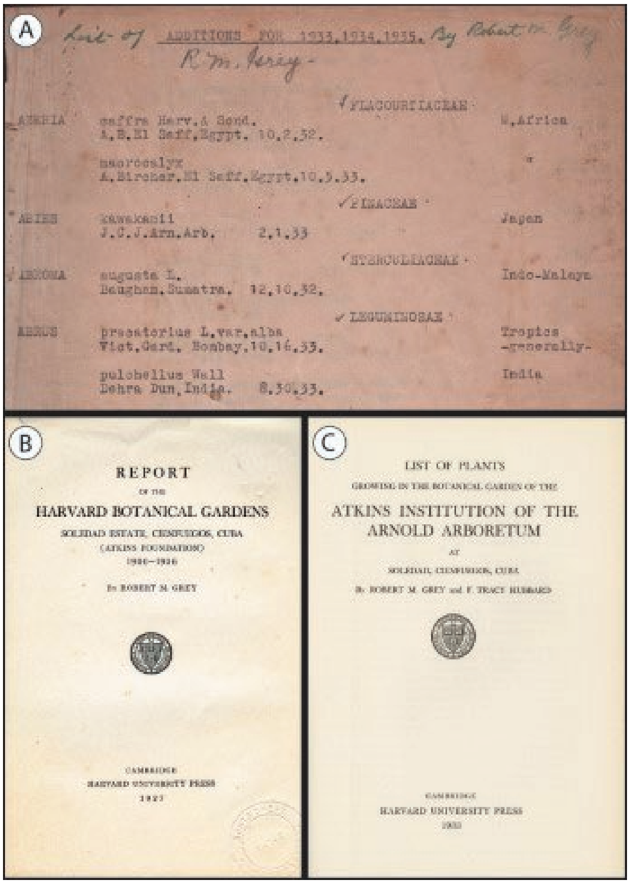
Soledad, Cienfuegos, Cuba,
February 9, 1928.

Dr. P. H. Dorsett,
Bureau of Plant Industry,
U. S. Department of Agriculture,
Washington, D. C.

Dear Mr. Dorsett:

Your letter of January 31, was duly received. The packet of Teak-wood seeds from the Plant Introduction Gardens, Canal Zone, also reached me safely, on the 5th, and I beg to thank you for your kindness.

Figure 5. Selection of correspondence excerpts that were examined in this study. (A) Letter of David Fairchild to Robert M. Grey from West Africa, dated 7-Feb.-1927. (B) Letter of Palemon H. Dorsett to the Fairchilds from Utowana, dated 23-Dec.-1927. (C) Letter of Robert M. Grey to Palemon H. Dorset from Cienfuegos Botanical Garden, dated 9-Feb.-1928. Courtesy of Archive and Library of Fairchild Tropical Botanic Garden.



List of ADDITIONS FOR 1933,1934,1935. By Robert M. Grey
R. M. Grey -

		✓FLACOURTIACEAE	
ABERIA	caffra Harv.& Sond. A.B.El Saff,Egypt. 10,2,32.		W,Africa
	macrocalyx A.Bircher.El Saff.Egypt.10.5.33.		"
		✓PINACEAE	
ABIES	kawakamii J.C.J.Arn.Arb. 2,1,33		Japan
		✓STERCULIACEAE	
ABROMA	augusta L. Baughan.Sumatra. 12,10,32.		Indo-Malaya
		✓LEGUMINOSAE	
ABRUS	precatorius L.var.alba Vict.Gard. Bombay.10.16.33.		Tropics -generally-
	pulchellus Wall Dehra Dun,India. 8.30.33.		India

REPORT
OF THE
HARVARD BOTANICAL GARDENS
SOLEDAD ESTATE, CIENFUEGOS, CUBA
(ATKINS FOUNDATION)
1900–1926
By ROBERT M. GREY

CAMBRIDGE
HARVARD UNIVERSITY PRESS
1927

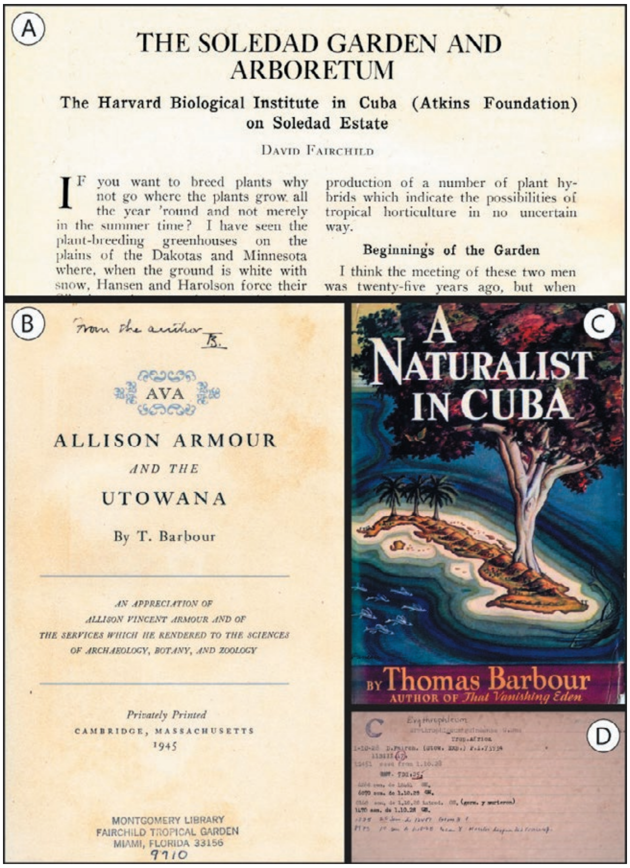
LIST OF PLANTS
GROWING IN THE BOTANICAL GARDEN OF THE
ATKINS INSTITUTION OF THE
ARNOLD ARBORETUM
AT
SOLEDAD, CIENFUEGOS, CUBA
By ROBERT M. GREY and F. TRACY HUBBARD

CAMBRIDGE
HARVARD UNIVERSITY PRESS
1933

Figure 6. Inventories of plant material cultivated in Cienfuegos Botanical Garden. (A) Unpublished account of plant introductions for the years 1933–1935 that was prepared by Robert M. Grey. (B) Cover of report published by Grey (1927). (C) Cover of report published by Grey and Hubbard (1933). Courtesy of Library of Cienfuegos Botanical Garden (A).

Garden or just as "Soledad." Prof. Ames, remotely from Harvard, became the first director of the station (Cahan 1991: 23, 31). Robert M. Grey (Figure 8), an experienced plant breeder, was named as superintendent, and he oversaw the actual garden operations until his retirement in 1936 (Merrill 1940: 74; Cahan 1991: 27). Through hybridization and selection procedures Grey was the first person to achieve a successful breeding program for sugar cane in Cuba (Clement et al. 1954: 1; Baró et al. 1985: 3; Fernández-Prieto 2018: 181), and he was one of the pioneers of this activity in the Caribbean region.

In 1919, Atkins transferred the administration and property of the garden to Harvard University. This operation included a substantial endowment of $100,000. This undertaking had important consequences as it also included additional land (Cahan 1991: 28). The next relevant infrastructure development happened in 1924, when the "Harvard House" or "Casa Harvard" was opened (Figure 9). This was a building that had a small dormitory and a laboratory; and it was well equipped with a small herbarium, research instruments, and optical equipment to facilitate the work of visitors (Merrill 1940: 70). The construction of this facility marked a turning point that made CBG a truly scientific institution, surrounded by a unique living collection of tropical plants. Many students, faculty, and naturalists started visiting Soledad Garden and eventually this required the construction of a real dormitory. Built in 1938, this new building received the name of "Casa Catalina" to honor Mrs. Katharine Atkins (Figure 9), wife of Edwin Atkins. The project was jointly funded by her and Barbour (Merrill 1940: 72). Today, Harvard House functions as the administrative office of CBG. Casa Catalina



THE SOLEDAD GARDEN AND ARBORETUM

The Harvard Biological Institute in Cuba (Atkins Foundation) on Soledad Estate

David Fairchild

If you want to breed plants why not go where the plants grow all the year 'round and not merely in the summer time? I have seen the plant-breeding greenhouses on the plains of the Dakotas and Minnesota where, when the ground is white with snow, Hansen and Harolson force their

production of a number of plant hybrids which indicate the possibilities of tropical horticulture in no uncertain way.

Beginnings of the Garden

I think the meeting of these two men was twenty-five years ago, but when

From the author B.

AVA

ALLISON ARMOUR

AND THE

UTOWANA

By T. Barbour

AN APPRECIATION OF
ALLISON VINCENT ARMOUR AND OF
THE SERVICES WHICH HE RENDERED TO THE SCIENCES
OF ARCHAEOLOGY, BOTANY, AND ZOOLOGY

Privately Printed
CAMBRIDGE, MASSACHUSETTS
1945

A NATURALIST IN CUBA

BY Thomas Barbour
AUTHOR OF *That Vanishing Eden*

Figure 7. Relevant material consulted during this study. (A) Cover page of article published by Fairchild (1924) after his first visit to CBG. (B) Cover of book published by Barbour (1945a) pertinent to his expeditions on board Utowana. (C) Cover of book published by Barbour (1945b) on the natural history of Cuba. (D) Example of card that was used to record plants introduced in to CBG. Courtesy of Library of Cienfuegos Botanical Garden (D).

Figure 8. Relevant personalities in the history of Cienfuegos Botanical Garden: (A) Thomas Barbour (left) and Robert M. Grey (right). (B) Oakes Ames. (C) George L. Goodale. (D) Frank G. Walsingham. Courtesy of Archive and Library of Fairchild Tropical Botanic Garden (A), Herbarium Library of Harvard University (B, C), and Library of Cienfuegos Botanical Garden (D).

continues operating as a guest house, but it is also used for meetings, conferences, and as a place where technicians and researchers can have breaks during their regular working-hours. This infrastructure facilitated several higher education activities that included internships in tropical botany for students at Harvard University as well as summer courses with Carleton University in Ottawa, Harvard University, the Central University of Las Villas, Cuba and other Cuban educational institutions (Agüero and Ríos 1994: 13; Ojeda Quintana et al. 2007: 52). The first summer graduate course targeted students from Harvard University and took place in 1950 (Clement 1954a: 300–301, 1954b: 202).

As the garden was expanding, new structures and facilities were built. They included ponds and small dams; water reservoirs; windmills to extract water from wells; and roads and bridges that facilitated access to the different areas of the garden as shown in the plan made in 1933 (Figure 10). In 1950 the living collections were mapped (Clement 1954b: 199), and it is likely that this was the source for the current grid system that divides the garden into plots where plants are located (Figure 2). The arrangement is based on a network of 100 x 100 m^2 alpha-numeric squares; each of them further divided into four quadrants that are identified with Roman numerals. This mapping structure is still in place, and during our research it helped us to locate those plants that were associated with the Utowana expeditions (Figure 2). The garden was officially opened to the public in 1953 (Valiente 1953a, 1953b), and Clement (1956: 366) provided details on outreach and educational material that was then made available to visitors.

Since the early establishment of the garden, the Atkins were interested in plants that had gardening, ornamental, and economic value. Over the years, the

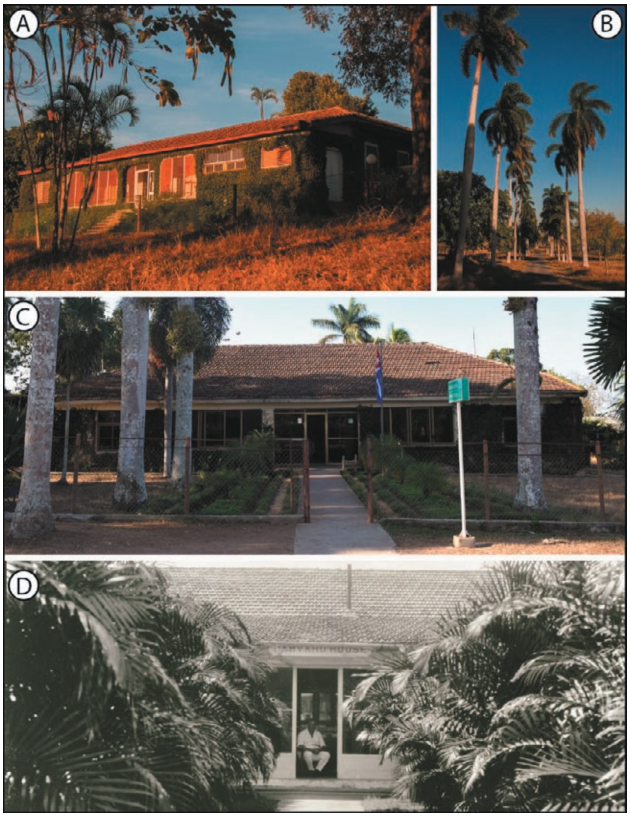


Figure 9. Sites of Cienfuegos Botanical Garden: (A) Casa Catalina. (B) Avenida de las Palmas or Palm Avenue. (C) Casa Harvard. (D) Casa Harvard, with Thomas Barbour siting at the entrance door. Photo credits: Rosario Domínguez Basail (A, B), Rosalina Montes Espín (C). Courtesy of Archive and Library of Fairchild Tropical Botanic Garden (D).

garden has added forestry, horticulture, conservation, and education as central components of its mission. Mr. Grey facilitated the initial interests of the Atkins by starting to assemble a living collection that had a wide array of tropical species (Merrill 1940: 66). To build such a rich garden, he relied on several collaborators, mostly from the United States (Grey 1927: 9–10, 14). It is likely that Ames and Goodale facilitated these connections through the high reputation of Harvard University. It is worth mentioning that as the garden was growing conflicts occurred between Harvard and Atkins. Decisions needed to be made on whether sugar cane breeding or building a collection of tropical plants should be the main priority (reviewed by Fernández-Prieto 2018).

In 1927, one year after the death of Atkins, Prof. Thomas Barbour (1884–1946, Figure 8), director of the Museum of Comparative Zoology of Harvard University was appointed as the new garden director with the job title of "custodian" (Merrill 1940: 73). Barbour was a prestigious naturalist and herpetologist with a wide experience in tropical biology and ecology (Barbour 1943; Bigelow 1952). Also by 1927, the site was officially known as "Harvard Botanical Gardens, Soledad Estate (Atkins Foundation)" as indicated in the cover page of the garden's report that Grey (1927) wrote for the 1900–1926 period. This new name highlights how the garden was focusing more and more on the introduction of a wide range of tropical plants and not only on sugar cane breeding. Barbour spoke Spanish fluently, had a pleasant personality, and above all was familiar with the natural history of Cuba (Merrill 1940: 73; Barbour 1945b (Figure 7); Raby 2017: 73); therefore, it is not surprising that despite his training as a zoologist he was selected by Harvard to replace Ames who was more introvert and did not have Barbour's background in the Spanish language and the Cuban biota (Raby 2017: 73). Barbour first visited the botanic station in 1909, and under his tenure the garden flourished. The presence of Barbour in Soledad contributed to the expansion of the garden activities into different disciplines such as medicine, agriculture, and basic research (Fernández-Prieto 2018: 171–172). The relevance of Barbour's contribution to the history of CBG is stressed in a letter that Clement (1946) sent to Brother León shortly after Barbour passed away. This correspondence highlighted how the great Harvard professor supported the garden financially and was instrumental for the cultivation of plants from around the world; particularly palms, bamboos, and timber trees among many others. Some of these species, for instance teak (*Tectona grandis* L.f., Lamiaceae), was among the earliest plants introduced into Cuba that played a role in gardening, forestry, and horticulture.

Barbour had a solid friendship with David Fairchild (Fairchild 1946) and between 1928 and 1934 he joined four of the Caribbean expeditions of the Utowana (Barbour 1945a; Fairchild 1946, Figure 7). In 1932 the garden had another name change and became the "Atkins Institution of the Arnold Arboretum, Harvard University," this formal affiliation with Harvard stressed the relevance that CBG had for this academic institution (Merrill 1940: 66).

In 1932, at the recommendation of David Fairchild, Frank G. Walsingham (Figure 8) arrived at Soledad as assistant superintendent (Walsingham 1932a, 1932b). He was graduated of the Kew gardening program; his mission was helping Grey to manage the plant records, the germplasm exchange program, and the regular routines involved in plant propagation (Merril 1940: 74). He remained in the garden until his retirement in 1956, after which he returned to his native Scotland (Clement 1956). Walsingham was replaced by Ángel Valiente (1926–1988, Figure 3), a Cuban agronomist who gradu-

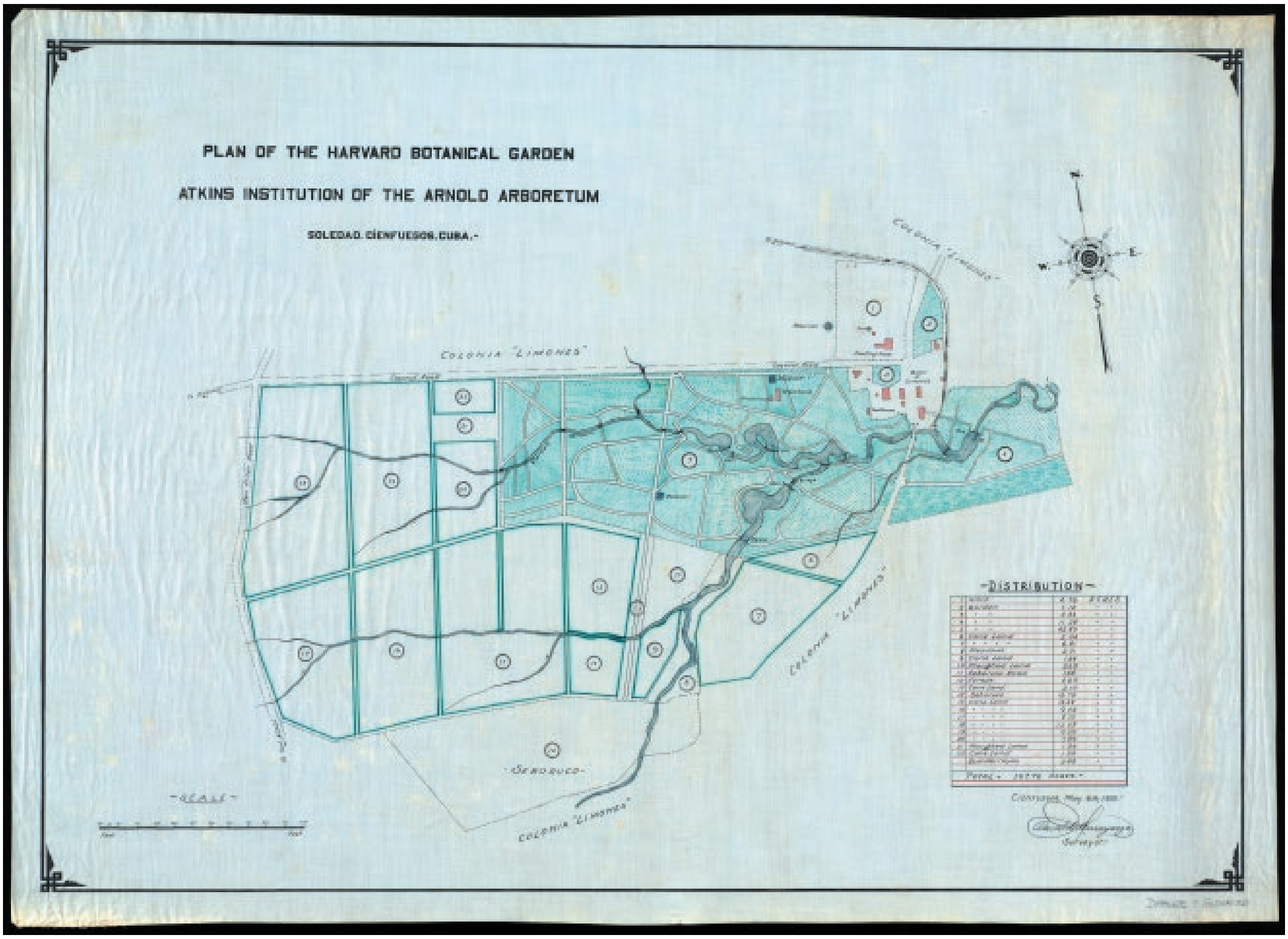


Figure 10. Plan of Cienfuegos Botanical Garden made by Oswaldo Binayarza in 1933. Courtesy of Arnold Arboretum.

ated from the Panamerican Agricultural School, Zamorano, Honduras (Aracelis Valiente pers. comm.). He proved to be an excellent administrator and was a key figure in 1960, when the garden started its transition from Harvard University to the Cuban Government. In 1962, Valiente was appointed director of CBG, a position that he held until 1982 (Agüero and Ríos 1994: 16).

The living collections of the garden built rapidly, and by December 1925 it had 1358 species (Grey 1927: 14). By 1933, this number increased to 1970, belonging to 921 genera and 165 families (Grey and Hubbar 1933: vi). More recently, in 1993, 1684 species representing 104 families were recorded (Rodríguez et al. 1993: 9, 217). The most recent inventory, from September 2020, accounted for 1962 species in 130 families. This living collection has plants from all over the world, and 80% of them are exotic species which are not native to Cuba (Ojeda Quintana et al. 2007: 54). The most important groups are palms, legumes, ficus, and bamboos. The garden surface area also increased over the years, initially it had 4.4 hectares but by 1933 it was spread over 67.9 ha as indicated in the garden plan made by Oswaldo Binayarza (Figure 10). It currently has 94 ha, of which 73 ha are for the arboretum, 7 ha belong to the palmetum, 10 ha are devoted to natural forests, and the rest are for administration facilities, nurseries, exhibits, and marketing activities (Figure 1).

David Fairchild had a strong association with CBG, and in 1924 he made his first visit to Soledad (Fairchild 1924, Figure 7). Grey (1927: 10) reported that between 1905 and 1907 Fairchild sent to the garden samples of over 40 species. It appears that the first shipment was for a collection of *Vangueria infausta* Burrch (Rubiaceae) that reached Soledad in 1905 (Grey and Hubbar 1933: 204). Grey (1936) recognized the importance of Fairchild in the early stages of the garden, and he stated: "as early as 1907 and 1908 a majority of the species were obtained through the kindness of Dr. David Fairchild […] at that time, it was impossible to procure from any other source."

Table 1. The eight research expeditions of Utowana that visited the Caribbean Islands.

Dates	Visited regions	Aim of expedition	Expedition members / Reference
January 3 – February 1, 1928[1]	Cuba, Central America, Mexico	Plant surveys	Palemon Dorsett (USDA) / Dorsett (1927), Grey (1928), Higgins and Watson (1929)
February 10 – April 4, 1928[1]	Cuba, Jamaica, Central America, Cayman Islands	Herpetological surveys	Thomas Barbour (Harvard University)[2] / Barbour (1928)
February 2 –April 15, 1929[1]	Greater Antilles, Lesser Antilles, Trinidad and Tobago, Leeward Antilles, Colombia, Central America	Herpetological surveys and US Navy intelligence information	Thomas Barbour (Harvard University) / T. Barbour (1945), Henderson and Powell (2003)
February 3 – May 4, 1931[1]	The Bahamas, Cuba, Cayman Islands, Central America, Mexico, Baja California	Plant, herpetological, and ornithological surveys	Thomas Barbour (Harvard University); Guy Collins, Thomas Kearney, James Kempton (USDA) / Armour (1931), T. Barbour (1945), M. Barbour (1945), Poe (2014)
December 30, 1931 – April 11, 1932	The Bahamas, Cuba, Hispaniola, Lesser Antilles, Trinidad and Tobago, Guyana, Suriname	Plant surveys	David Fairchild, Palemon Dorsett, Harold Loomis (USDA); Leonard Toy (University of Florida) / Dorsett (1936), Francisco-Ortega et al. (2019)
December 16, 1932 – January 10, 1933	The Bahamas, Cuba, Haiti	Apparently without a research mission	Haitian authorities / Anonymous (1933), Fairchild (1933), Barbour (1933)
February 16 – April 7, 1933[1]	The Bahamas, Cuba, Cayman Islands, Jamaica, Swan Island, Panama	Plant, herpetological, and ornithological surveys	Thomas Barbour, James Greenway (Harvard University), David Fairchild (USDA) / Fairchild (1932–1942), T. Barbour (1945), Henderson and Powell (2003)
February 1 – April 20, 1934	The Bahamas, Hispaniola	Herpetological and archeological surveys	Thomas Barbour, James Greenway (Harvard University); Froelich Rainey (Yale University) / Rainey (1941, 1992), T. Barbour (1945), Henderson and Powell (2003)

[1] Expedition that visited Cienfuegos Botanical Garden.
[2] Thomas Barbour joined the expedition in Panama.

Utowana expeditions: plant hunting in Africa, the Americas, Asia, and Europe

Wealthy businessman Allison Armour (1863–1941) owned the Utowana, and he also provided financial support for the plant exploration expeditions that were undertaken on board this research yacht (Anonymous 1931a). Between 1925 and 1927 these plant hunting enterprises were led by David Fairchild and they only targeted the Old World including the Canary Islands, Portugal, Tropical West Africa, and the Western Mediterranean. Several accounts of the collected plants and activities pertinent to the 1925–1927 expeditions were subsequently published by Fairchild (1927a, 1927b, 1928a, 1928b, 1930a, 1930b, 1930c, 1930d, 1932, 1934b, 1939a, 1939b, 1950). In 1925 when the Utowana was cruising across the Mediterranean her engines failed and she could not take Fairchild and his team to Asia (Fairchild 1930a: 256, 262). Therefore, the portion of the trip that explored Java, Singapore, Sri Lanka, and Sumatra was carried out using commercial passenger ships; however, plant exploration in these regions was still sponsored by Armour and collections associated to these Asian expeditions have been included here as part of the Utowana endeavors. The trips to Sri Lanka and the Malay Archipelago were documented in the only known movie that shows David Fairchild (available online at: https://www.youtube.com/watch?v=CU-Zcp_fpPg). This particular motion picture was part of a set of three documentaries that represent the earliest films on plant hunting expeditions ever made (Francisco-Ortega et al. 2020). Relevant to our research, plant material collected during the 1925–1927 Utowana expeditions reached CBG (see below).

Between 1927 and 1934 the Utowana visited the Old and New World, including the Mediterranean region, Europe, the Azores, and the Caribbean Basin. These expeditions had a broader scope and not only focused on plant hunting but also on zoological and archeological research. Anonymous (1931a, 1932, 1934, 1935) provided details of the itineraries followed by these voyages. Brief descriptions for six of the eight trips of this vessel to the Caribbean Islands (Table 1) are listed below, as they were relevant to the building of the plant living collections of

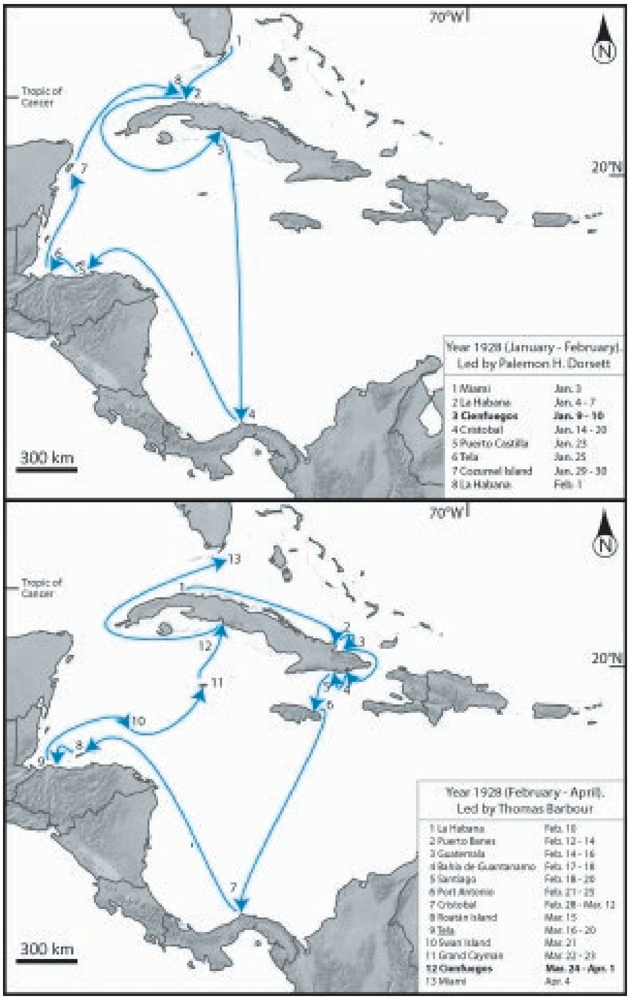


Figure 11. Itinerary followed by the research yacht Utowana during the two Caribbean expeditions of 1928. Notice that one expedition had Pamelon H. Dorsett (January 3 – February 1) as the leading naturalist and the second one had Thomas Barbour (February 10 – April 4) in this role.

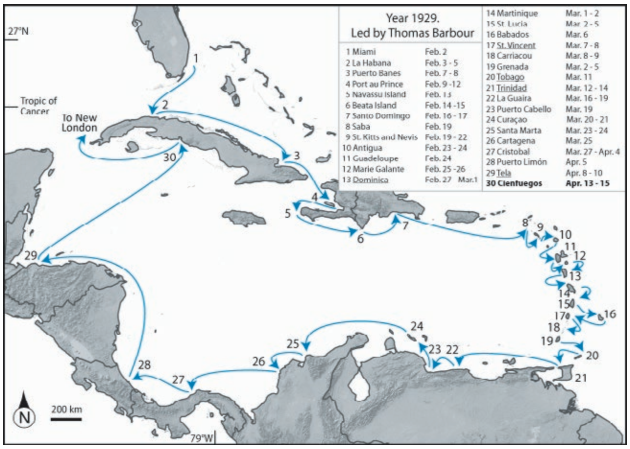


Figure 12. Itinerary followed by the research yacht Utowana during the Caribbean expedition of 1929. The expedition (February 2 – April 15) had Thomas Barbour as the leading naturalist.

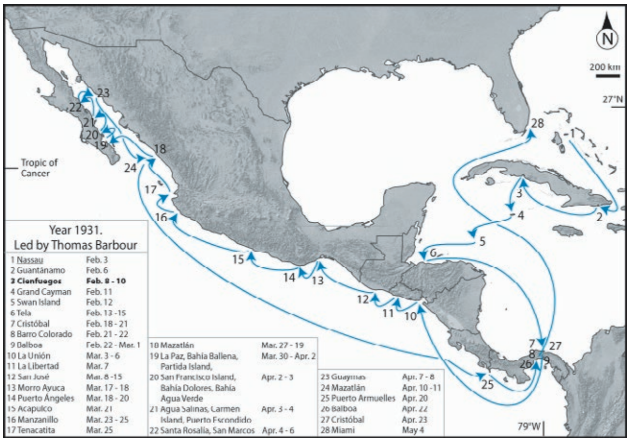
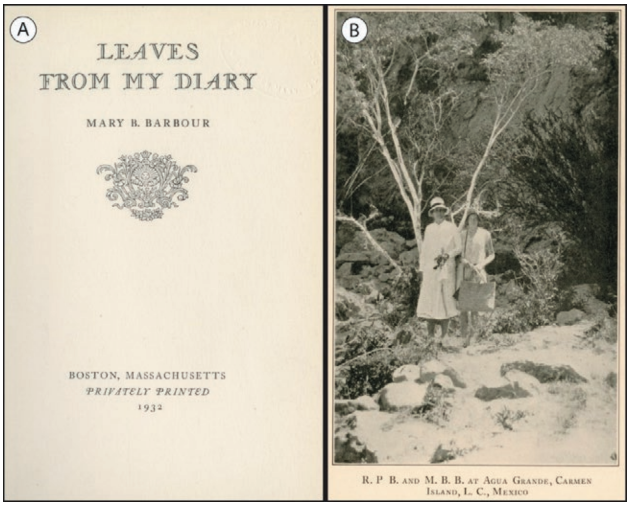


Figure 13. Itinerary followed by the research yacht Utowana during the Caribbean expedition of 1931. The expedition (February 3 – May 4) had Thomas Barbour as the leading naturalist.

CBG. David Fairchild only joined the 1931–1932, and the 1933 enterprises.

The first Caribbean trip of the Utowana took place in 1928 (Figure 11), between January 3 (Miami) and February 1 (Havana). Famous USDA plant explorer Palemon H. Dorsett (1862–1943, Figure 3) was the only botanist who undertook this journey. We have not located any report or publication focusing on this voyage. However, we have found a few details of this trip through our archival research (Dorsett 1927, 1928; Grey 1928; Figure 5), and also the published "USDA Germplasm Inventory Reports" (Taylor and Ryerson 1929; Ryerson 1930) and "Annual Reports of the Canal Zone Plant Introduction Gardens" (Higgins and Watson 1929). Cienfuegos was the second visited locality (January 9–10). The main objective of this trip was to deliver plant material from the USDA germplasm repositories to CBG, the Summit Gardens in the Panama Canal Zone, and the Lancetilla Botanical Garden in Honduras. The Summit Gardens were managed by the Panama Canal governmental agency (Federal Register Executive Order 10263– July 1, 1951). In 1928, James E. Higgins (1873–1938) was its Agronomist in Charge before becoming its Director in 1930 (Croat 1971). Previously, Higgins had academic positions in the Philippines and in the Hawaiian Islands (Anonymous 1939). The Lancetilla Garden was owned and operated by the United Fruit Company (Plucknett et al. 1987: 56– 57; Hazlett 2017), and dur-



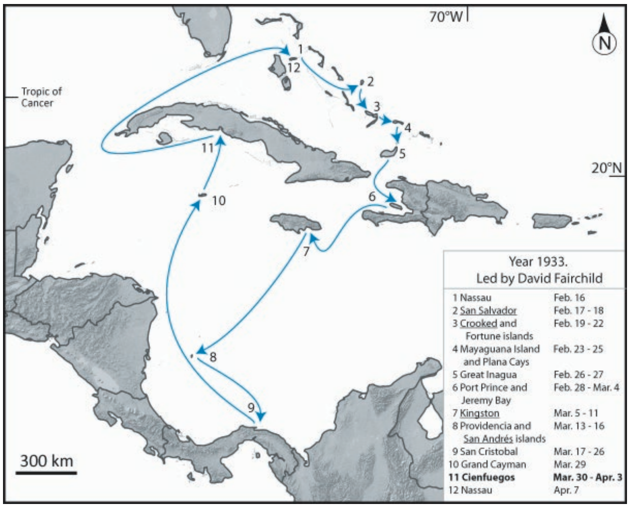
LEAVES
FROM MY DIARY

MARY B. BARBOUR

BOSTON, MASSACHUSETTS
PRIVATELY PRINTED
1932

R. P B. AND M. B. B. AT AGUA GRANDE, CARMEN ISLAND, L. C., MEXICO

Figure 14. (A) Cover page of book published by Barbour (1932) that has the travelogue of the 1931 Utowana expedition to the Caribbean. (B) Rosamond P. Barbour (left) and her daughter Mary B. Barbour (right), photo reproduced from Barbour (1932).



Year 1933.
Led by David Fairchild

1 Nassau	Feb. 16
2 San Salvador	Feb. 17 - 18
3 Crooked and Fortune islands	Feb. 19 - 22
4 Mayaguana Island and Plana Cays	Feb. 23 - 25
5 Great Inagua	Feb. 26 - 27
6 Port Prince and Jeremy Bay	Feb. 28 - Mar. 4
7 Kingston	Mar. 5 - 11
8 Providencia and San Andrés islands	Mar. 13 - 16
9 San Cristobal	Mar. 17 - 26
10 Grand Cayman	Mar. 29
11 Cienfuegos	**Mar. 30 - Apr. 3**
12 Nassau	Apr. 7

Figure 15. Itinerary followed by the research yacht Utowana during the Caribbean expedition of 1933. The expedition (February 16 – April 7) had David Fairchild as the leading botanist.

ing Dorsett's visit, Wilson Popenoe (1892–1961, Figure 3) was its director. Prior to this appointment Popenoe worked for the USDA as an agricultural explorer under the supervision of David Fairchild (Woodger 1983). During his tenure with the USDA, Popenoe was a strong supporter of CBG, and Grey (1927: 14) indicated that he and Fairchild jointly arranged for Soledad to receive 50 species of tropical plants from this federal agency just between 1925 and 1926.

Following Dorsett's trip, it seems that Barbour was the only naturalist who participated in the second voyage of the Utowana to the Caribbean Basin (Figure 11). This trip took place in 1928, and it also visited Cienfuegos (March 24 – April 1). The journey started on February 10 (Havana) and ended on April 4 (Miami). The expedition resulted in a publication on the reptile fauna of Bay Islands, Honduras (Barbour 1928). Barbour only took part in the last portion of the trip as he joined the vessel in Panama (Barbour 1945a: 8). Plant material collected during this expedition was brought to CBG (see below).

The third of the Utowana's jouneys to the Caribbean took place in 1929 (February 2, Miami through April 15, Cienfuegos). This was an extensive trip to Cuba, Hispaniola, Lesser Antilles, Tobago, Trinidad, Venezuela, Colombia, and Central America that also included visits to the Lancetilla and Summit gardens (Figure 12). No botanists joined this expedition, and it seems that one of the main aims of the trip was to obtain "certain confidential information" for the US Navy from the Lesser Antilles (Barbour 1943: 125, 1945a: 10). Details of the zoological outcomes of the expedition were reviewed by Henderson and Powell (2004). Barbour (1943: 124–131, 1945a: 10–20) provided an extensive account of the itinerary. Interestingly, one of the objectives of this trip was to collect plant material in the Lesser Antilles to be introduced into Florida (Barbour 1943: 125). Some of this material was also delivered to CBG (see below).

Between February 3 (Nassau) and May 4 (Miami), 1931 the Utowana undertook the longest of her trips to the region (Figure 13). The yacht visited the Caribbean Basin (Cuba, Cayman Islands, Swan Island, Panama, and Honduras), crossed the Panama Isthmus, and cruised along the Pacific coasts of the Central America, Mexico, and the Gulf of California. Cienfuegos (February 8–10) was the third site visited during this journey. Barbour and three plant explorers from the USDA [Guy N. Collins (1872–1938, Figure 3), Thomas H. Kearney (1874–1956), and James Howard Kempton (1891–1970)] were the four biologists of this expedition. Collins' agricultural research focused on avocado and corn, while Kempton was a corn breeder (Fairchild 1938b; Rhoades 1984). Kearney joined the Utowana in Mazatlán, Mexico (M. Barbour 1932: 77), whereas the other two USDA plants explorers took part in the complete expedition. Kearney was an expert in cotton breeding (Kearney 1958). Wilson Popenoe (see above) was on the expedition between El Salvador and Guatemala (Armour 1931: 3). The three main plant genetic resources goals of the expedition were collecting: (1) corn relatives in Guatemala; (2) landraces and wild species of cotton in the Caribbean Islands and Baja California, respectively; and (3) wild species of avocado for breeding and grafting in Central America and Mexico. The team also collected plant material in the gardens of Lancetilla, Summit, and the San Salvador Experimental Station (Armour 1931: 2); therefore, bringing plants to CBG was not one of the aims of the voyage (see below). Barbour (1945a: 21–35) wrote extensively about this trip, and Poe (2014) reviewed the main zoological findings. Furthermore, Armour (1931) prepared a report for the USDA on the main plant hunting highlights of this enterprise. Armour's (1931) account includes 43 photos of CBG, but it does not include additional details of this garden. Barbour's daughter, Mary Barbour Kidder (1917–1977, Figure 14), also took part in the expedition, and wrote a diary (Figure 14) that has relevant details on several of the activities of the trip. From Mary Barbour's (1932: 19–23) work we know that during the Utowana's visits to Cienfuegos, the vessel anchored in Cienfuegos Bay. From there, expedition members moved to a small boat that navigated along the Caunao River, until reaching Belmonte. From this site, the team had a train ride to the town of Pepito Tey (then known as Soledad) where the CBG is located (Figure 1). Once in Pepito Tey they stayed in the Atkins's family house.

The fourth voyage of the Utowana to the Caribbean was led by David Fairchild. This expedition started and ended in Miami (December 31, 1931 – April 1, 1932) and targeted the Caribbean Islands, Guyana, and Suriname. Cuba (Guantanamo) was visited, but Cienfuegos was not included in this trip. Studies pertinent to this expedition, including its itinerary map, were previously published by Francisco-Ortega et al. (2018, 2019), Camas et al. (2020), and Chavarria et al. (2020). During this journey hundreds of germplasm collections were made, and many of them eventually reached CBG (see below).

In 1933 the Utowana made her last visit to Cienfuegos (March 30 – April 3), and this was an expedition with zoological and botanical activities that were jointly led by Fairchild and Barbour (Figure 15). Details on the plant hunting activities performed in Jamaica and Haiti were studied by Rose et al. (2017) and Francisco-Ortega et al. (2018), respectively. Henderson and Powell (2004) reviewed the main zoological highlights of this venture. Portions of this trip were described in an unpublished diary written by Fairchild (1932–1942), which is currently under study by our team, and Barbour (1945a: 35–38) provided additional descriptions of this voyage. The expedition (February 16 – April 7) started and ended in Nassau. Many germplasm accessions were introduced into CBG (see below). The trip also had an ornithological component, and James C. Greenway (1903–1989), a colleague of Barbour from Harvard University, was the third naturalist who participated in the endeavor.

PLANT MATERIAL INTRODUCED THROUGH THE UTOWANA EXPEDITIONS

Plant exploration expeditions on board the Utowana led to the introduction of 278 accessions (254 species) of plants into CBG (Tables 2–3). Arecaceae (52 species), Fabaceae (45 species), Moraceae (13 species, mostly in the genus *Ficus*), Orchidaceae (11 species), Malvaceae (10 species), and Rubiaceae (10 species) were the six families with the highest number of species (Table 3). Currently 57 of the species (132 individuals) that were brought to CBG through Utowana expeditions are still cultivated in the living collections of this garden (Figure 2, Online Supplementary Table 1).

The collections introduced in CBG through Utowana had a wide geographical origin (Table 4). Twenty-one species were Caribbean Island endemics, and 93 accessions (86 species) were restricted to the rest of the New World. However, most of them were Old World species (144 accessions, 128 species).

One hundred and thirteen of the introduced accessions (113 species) were collected in botanic gardens or research stations (Table 5) located in Africa (11 species), Asia (25 species), the Canary Islands (one species), the Caribbean Islands (40 species), Panama [five accessions (five species), two of them from Summit and three from Ancon and Barro Colorado Island], Honduras (23 species, all of them from Lancetilla) or Guyana (11 species). A total of 21 botanical gardens or research stations contributed material to CBG. Most of them were New World (13) institutions that were visited during the expeditions of Barbour in 1928 and 1929, Fairchild in 1931–1932, and Fairchild in 1933. The Trinidad Botanic Garden and St. Vincent Botanic Garden were visited twice, during the Barbour 1929 and Fairchild 1931–1932 Utowana expeditions. The remaining gardens were from Asia (5), Africa (2) and one from the Mediterranean. These other samples were collected during the Utowana 1925–1927 expedition to the Old World. Among all the gardens that provided plant material to Soledad, Lancetilla contributed with the highest number of species (22).

This material was not only important to CBG but also to other gardens and institutions in Cuba. Twenty one of these "Utowana species" provided germplasm that were shipped to eleven additional sites in Cuba. The recipients included private gardens, arboreta, tree fruit plantations, botanic gardens, germplasm banks, and experimental stations (Table 6). Five of these 21 species were sent because of their ornamental value, twelve for food production, five for forestry and reforestation projects, two as potential sources of natural medicines and

Table 2. Overview of material that reached Cienfuegos Botanical Garden (CBG) that was collected during Utowana's plant hunting endeavors. Plant material was introduced either directly during the actual expeditions or indirectly through shipments from the USDA Germplasm Repositories, Kampong Gardens (private residence of David Fairchild in Coconut Grove, Miami, Florida), or Harvard University.

Source of material collected during Utowana expeditions that was received by CBG	Source of the collections (Number of species / accessions)[1]										Total number of species / accessions that were shipped or delivered to CBG
	Utowana 1925–1927 (Africa, mainland Spain, Canary Islands)	Utowana 1925–1927 (Asia)	Barbour 1928	Barbour 1929	Barbour 1931	Fairchild 1931–1932	Fairchild 1933	Utowana collections from USDA Germplasm Repositories	Kampong	Unknown sources	
Utowana 1925–1927 (Africa, mainland Spain, Canary Islands)[2]	1/1	NA	NA	NA	NA	NA	NA	NA	NA	NA	1/1
Utowana 1925–1927 (Asia)[3]	NA	8/8	NA	NA	NA	NA	NA	NA	NA	NA	8/8
Dorsett 1928[4]	46/47	14/14	NA	NA	NA	NA	NA	9/9	0/0	1/1	70/71
Barbour 1928[4]	0/0	0/0	22/22	NA	NA	NA	NA	0/0	0/0	0/0	22/22
Barbour 1929[4]	0/0	0/0	0/0	25/25	NA	NA	NA	0/0	0/0	2/2	27/27
Barbour 1931[4]	0/0	0/0	0/0	0/0	1/1	NA	NA	0/0	0/0	2/2	3/3
Fairchild 1933[4]	1/1	1/1	0/0	0/0	0/0	0/0	20/20	1/1	8/8	7/7	37/38
Mailed from Harvard University, Kampong or USDA[5]	8/9	5/5	1/1	4/5	0/0	81/83	4/4	1/1	NA	NA	104/108

[1] Utowana expeditions are coded as: Utowana 1925–1927: Utowana expedition to the Old World that took place between 1925 and 1927, David Fairchild was its leader. Dorsett 1928: Utowana expedition that took place between January 3 and February 1, 1928, itinerary is shown in Figure 11, and Palemon Dorsett was its leader. Barbour 1928: Utowana expedition that took place between February 10 and April 4, 1928, itinerary is shown in Figure 11, and Thomas Barbour was its leader. Barbour 1929: Utowana expedition that took place between February 2 and April 15, 1929, itinerary is shown in Figure 12, and Thomas Barbour was its leader. Barbour 1931: Utowana expedition that took place between February 3 and May 4, 1931, itinerary is shown in Figure 13, and Thomas Barbour was its leader. Fairchild 1931–1932: Utowana expedition that took place between December 30, 1931 and April 2, 1932; David Fairchild was its leader. Fairchild 1933: Utowana expedition that took place between February 16 and April 7, 1933), itinerary is shown in Figure 15, and David Fairchild was its botanical leader. Kampong: private garden of David Fairchild is located in Coconut Grove, Miami, Florida.

[2] 1925 – 1927 Utowana expedition to the Old World. Material was shipped directly from West Africa to CBG.

[3] 1925 – 1927 Utowana expedition to the Old World. Material was shipped directly from Sri Lanka to CBG.

[4] Utowana expedition that visited CBG and delivered material to this botanic garden. See note 1 for expedition codes.

[5] Plant material collected during Utowana expeditions that was shipped to CBG from Harvard University, Kampong or USDA.

Table 3. Taxonomic diversity of plant material introduced in Cienfuegos Botanical Garden through Utowana expeditions.

Family	Number of species	Number of accessions	Family	Number of species	Number of accessions
Acanthaceae	1	1	Marantaceae	1	1
Achariaceae	1	1	Meliaceae	2	4
Amaryllidaceae	1	1	Moraceae	13	16
Annonaceae	3	3	Musaceae	1	1
Apocynaceae	8	9	Myristicaceae	1	1
Araceae	5	6	Myrtaceae	2	2
Arecaceae	52	60	Nyctaginaceae	1	1
Aristolochiaceae	1	1	Ochnaceae	1	1
Asparagaceae	6	6	Oleaceae	1	1
Begoniaceae	2	2	Orchidaceae	11	12
Bignoniaceae	3	3	Oxalidaceae	1	1
Boraginaceae	1	1	Passifloraceae	2	2
Bromeliaceae	2	2	Piperaceae	2	2
Cactaceae	3	3	Poaceae	4	4
Canellaceae	1	1	Polygonaceae	2	2
Capparaceae	1	1	Polypodiaceae	1	1
Celastraceae	1	1	Rhamnaceae	2	2
Clusiaceae	6	8	Rosaceae	1	1
Combretaceae	4	4	Rubiaceae	10	10
Costaceae	2	2	Rutaceae	1	1
Cupressaceae	1	1	Salicaceae	1	1
Dioscoriaceae	2	2	Sapotaceae	4	6
Ebenaceae	3	3	Solanaceae	1	1
Euphorbiaceae	2	2	Stegnospermataceae	1	1
Fabaceae	45	47	Talinaceae	1	1
Iridaceae	1	1	Urticaceae	1	1
Lamiaceae	4	4	Verbenaceae	1	1
Lauraceae	1	2	Vitaceae	1	1
Lecythidaceae	3	4	Zingiberaceae	3	3
Loganiaceae	1	1	Zygophyllaceae	1	1
Malpighiaceae	1	1	**TOTAL**	**254**	**278**
Malvaceae	11	11			

tannins; finally, 14 of these species were included in conservation projects or added to the living collections of the recipient institutes.

The 1925–1927 Utowana plant exploration expeditions to the Old World

The first voyage of David Fairchild on board the Utowana started in 1925, one year after he made his initial visit to Soledad (Fairchild 1924). During this expedition he sent seed samples of 14 species directly from Sri Lanka to Cienfuegos (Fairchild 1926); however, based on the CBG records only eight of these accessions appear to have reached its living collections (Table 2). Furthermore, in a letter that Fairchild sent to Grey from Cameroon, it is indicated that one sample of *Lasimorpha senegalensis* was sent from this country to CBG during this expedition (Fairchild 1927c).

Additional archival research confirmed that samples collected by David Fairchild during the 1925–1927 Utowana plant exploration expedition to the Old World were sent to CBG from USDA repositories in the United States (77 accessions representing 72 species). Among them, 63 accessions (62 species) were delivered through Utowana trips that visited Cienfuegos. Most of these accessions (61 accessions, 60 species) were brought by Dorsett during his 1928 trip to the Caribbean Basin (Table 2). The Utowana also delivered one of these Old-World accessions during the 1933 expedition that Fair-

Table 4. Biogeography of plant material introduced in Cienfuegos Botanical Garden through plant exploration expeditions on board the Utowana[1].

Region	Number of species	Number of accessions
Africa	47	54
Asia	39	42
Africa and Asia	8	8
Australasia and Pacific Basin	24	30
Caribbean Islands	21	21
Europe and Mediterranean Basin	2	2
Old World	8	8
New and Old World	16	17
New World	86	93
TOTAL	**251**	**275**

[1] Biogeographical regions could not be assigned to three species whose names were not found in the consulted taxonomic literature (i.e., *Bougainvillea warszewiczii* Hort., *Hibiscus collinsii* Hort., *Ficus waringiana* Hort.). They appear to refer to cultivars of unknown species.

child and Barbour led to the region. The rest of the Old-World samples (12 collections, 13 species) were not brought by this vessel, and it is likely that they were sent directly from the USDA through alternative paths.

The 1928–1933 Utowana plant exploration expeditions to the Caribbean

The first visit of the Utowana to Cienfuegos occurred in 1928, and 71 accessions (70 species) were introduced in Soledad (Table 2). All of them came from USDA repositories, the vast majority (62 accessions, 60 species) were collected during the 1925–1927 Utowana expedition to the Old World. Nine species (nine accessions) that came from other Utowana voyages were also carried to CBG by Dorsett during this trip. Only one collection did not belong to material that was obtained during an Utowana endeavor.

Barbour was apparently the only naturalist who joined the second Utowana expedition (year 1928) that stopped in Cienfuegos. During this trip, he introduced 22 collections (22 species) from Lancetilla Botanical Garden into CBG (Online Supplementary Table 1). This was the only material that this expedition brought to Soledad (Table 2).

In 1929 Barbour headed the next Utowana voyage that visited Cienfuegos. During this trip 25 accessions (25 species) were collected and carried to CBG. This material came from Trinidad and the Lesser Antilles. Two additional accessions were introduced into this garden through this expedition, but they have unknown provenance (Table 2).

Under the leadership of Barbour, the 1931 Utowana expedition brought only three accessions (three species) to Soledad (Table 2). None of them were collected during this voyage. One of these accessions came from the 1929 Utowana expedition to the Caribbean Islands, but the reminding two samples had an unknown origin and were not collected on previous Utowana voyages.

The last visit of the Utowana to Cienfuegos was in 1933, and the trip was led by Fairchild and Barbour. A wide array of collections was brought to Soledad during this journey (Table 2). Twenty of these samples (20 species) were collected during this expedition. Material from the 1925–1927 Utowana voyage to the Old World (two species) was also delivered. Interestingly, this 1933 trip also brought germplasm from the private gardens of Fairchild in Coconut Grove, Miami (eight collections, eight species). This site is known as The Kampong and is currently owned and operated by the National Tropical Botanical Garden. Finally, through the 1933 visit, material of unknown provenance or from the USDA collections was also introduced into Soledad (eight collections, eight species).

Utowana collections sent from USDA germplasm repositories and Harvard University

We found that 108 accessions (104 species) from Utowana expeditions were not brought to Soledad on board the Utowana, but they reached the garden through other channels (Table 2). This material was mailed directly, or personally carried by visitors or by members of the Atkins family from Harvard University, or the USDA germplasm repositories or The Kampong (Online Supplementary Table 1). Most of this material (83 accessions, 81 species) was collected during the 1931–1932 Utowana voyage to the Caribbean Islands and Guianas (Table 2). From the collection books of David Fairchild, we are certain that USDA facilities located in Miami (Chapman Field) and Washington DC were recipients of Utowana material; however, we have not found details of the precise USDA germplasm repositories that sourced the accessions that were sent to Soledad.

DISCUSSION

Following the 1898 Spanish-American war, the United States became the predominant political power in the Caribbean, and a new era dominated by neocolonialist

Table 5. Botanic gardens and research stations that provided material to Cienfuegos Botanical Garden through Utowana expeditions.

Botanic garden/research station provenance	Source of plant introduction[1]	Route of arrival of the material to CBG[1]	Number of species / accessions
Agricultural Experiment Station, Aburi, Ghana	1925–1927 Old World Expedition (Africa)	Dorsett 1928	2/2
Agricultural Experiment Station, Tortola	Fairchild 1933	Mailed from USDA	1/1
Antigua Botanic Garden	Fairchild 1933–1932	Mailed from USDA	1/1
Bath Botanic Garden, Jamaica	Fairchild 1931–1932	Mailed from USDA	1/1
Botanic Garden of Buitenzorg, Java	USDA germplasm repositories[2]	Dorsett 1928	3/3
Botanic Station of Scarborough, Tobago	Fairchild 1931–1932	Mailed from USDA	1/1
Castleton Garden, Jamaica	Fairchild 1933	Fairchild 1933	1/1
		Mailed from USDA	1/1
Dominica Botanic Garden	Barbour 1929	Barbour 1929	7/7
		Mailed from USDA	2/2
		Mailed from Harvard University	1/1
Grenada Botanic Garden	Fairchild 1931–1932	Mailed from USDA	5/5
Guyana Botanic Garden	Fairchild 1931–1932	Mailed from USDA	11/11
Hope Garden, Jamaica	Fairchild 1933	Fairchild 1933	4/4
		Mailed from USDA	1/1
Lancetilla, Tela. Honduras	Barbour 1928	Barbour 1928	22/22
		Mailed from Harvard University	1/1
Lloyd Botanic Garden, Darjeeling, India	USDA germplasm repository[2]	Dorsett 1928	1/1
Orotava Botanic Garden, Canary Islands	1925–1927 Old World Expedition (Macaronesia)	Dorsett 1928	1/1
Peradeniya Botanic Garden, Sri Lanka	1925–1927 Old World Expedition (Asia)	Dorsett 1928	7/7
		Mailed directly from Sri Lanka (*Utowana* Expedition)	7/7
		Mailed from USDA	2/2
Sibolangit Botanic Garden, Sumatra	1925–1927 Old World Expedition (Asia)	Dorsett 1928	1/1
Singapore Botanic Garden	1925–1927 Old World Expedition (Asia)	Mailed from USDA	1/1
St. Vincent Botanic Garden	Fairchild 1931–1932	Mailed from USDA	3/3
	Barbour 1929	Mailed from Harvard University	1/1
Summit Gardens, Panamá	Fairchild 1933	Fairchild 1933	2/2
Trinidad Botanic Garden	Barbour 1929	Barbour 1929	5/5
	Fairchild 1931–1932	Mailed from USDA	8/8
Victoria Botanic Garden, Cameroon	1925–1927 Old World Expedition (Africa)	Dorsett 1928	7/7
	1925–1927 Old World Expedition (Africa)	Fairchild 1933	1/1
	1925–1927 Old World Expedition (Africa)	Mailed from USDA	1/1
Total number of species / accessions	**113/113**		

[1] Utowana expeditions are coded in Table 1.

[2] Material was brought by Dorsett from USDA germplasm repositories but it was not originally collected during an Utowana expedition.

policies started in the region (Foner 1972). This was particularly relevant during the first third of the 20th century when the United States leased or added unincorporated territories to its jurisdiction. This included portions of land from Cuba (Strauss 2009) and Panama, both in 1903 (Major 1993). Furthermore, during this period American troops intervened in countries such as Cuba (between 1917 and 1922), Haiti (between 1915 and 1934), and the Dominican Republic (between 1916 and 1924), as reviewed by Pérez Jr. (1979), Renda (2001), and Cal-

Table 6. Material linked to Utowana expeditions that was sent from Cienfuegos Botanical Garden to other Cuban centers, farms, plant genetic resources stations or institutions.

Species[1]	Recipient / Province
Averrhoa bilimbi[2]	El Nicho fruit farm, Ministry of Agriculture / Cienfuegos
Bambusa blumeana[3,4]	Camagüey Botanical Garden / Camagüey
	Bamboo Project/ Holguín
	Bamboo germplasm bank of Topes de Collantes / Sancti Spiritus
Borassus flabellifer[3]	Camagüey Botanical Garden / Camagüey
Brownea coccinea[3,5]	Villa Clara Botanical Garden / Villa Clara
Brownea macrophylla[3,5]	Ingenito farm, owned by Ricardo Denis / Sancti Spiritus
	Villa Clara Botanical Garden / Villa Clara
Caryota mitis[3,5]	Villa Clara Botanical Garden / Villa Clara
Cassia grandis[3,6]	El Nicho Fruit Farm, Ministry of Agriculture / Cienfuegos
Dendrocalamus sikkimensis[4]	Bamboo Project/ Holguín
	Camagüey Botanical Garden / Camagüey
	Bamboo germplasm bank of Topes de Collantes / Sancti Spiritus.
Dialium guineense[2,3]	Forage and Fodder Experimental Station of Indio Hatuey / Mayabeque
	Ingenito farm, owned by Ricardo Denis / Sancti Spiritus
	Jovellanos fruit farm, owned by Héctor Correa / Matanzas
	Pinar del Río Botanical Garden / Pinar del Río
	Camagüey Botanical Garden / Camagüey
Elaeis guineensis[2,3,5]	El Nicho Fruit Farm, Ministry of Agriculture / Cienfuegos
	Jovellanos fruit farm, owned by Héctor Correa / Matanzas
	Camagüey Botanical Garden / Camagüey
	National Botanical Garden / La Habana[7]
	Jovellanos fruit farm, owned by Héctor Correa / Matanzas
Ficus sur[2,3]	Ingenito farm, owned by Ricardo Denis / Sancti Spiritus
	El Nicho Fruit Farm, Ministry of Agriculture / Cienfuegos
	Pinar del Río Botanical Garden / Pinar del Río
	Camagüey Botanical Garden / Camagüey
Garcinia dulcis[2,3]	Ingenito farm, owned by Ricardo Denis / Sancti Spiritus
	El Nicho Fruit Farm, Ministry of Agriculture / Cienfuegos
	Pinar del Río Botanical Garden / Pinar del Río
	Camagüey Botanical Garden / Camagüey
Guadua angustifolia[4]	Bamboo germplasm bank of Topes de Collantes / Sancti Spiritus
	Camagüey Botanical Garden / Camagüey
Lecythis minor[2,3]	El Nicho Fruit Farm, Ministry of Agriculture / Cienfuegos
	Pinar del Río Botanical Garden / Pinar del Río
	Camagüey Botanical Garden / Camagüey
Lecythis tuyrana[2,3]	Jovellanos fruit farm, owned by Héctor Correa / Matanzas
	Pinar del Río Botanical Garden / Pinar del Río
Payena leerii[5]	Topes de Collantes Arboretum/ Sancti Spiritus
Pericopsis mooniana[4,5,6]	Ingenito farm, owned by Ricardo Denis / Sancti Spiritus
Phoenix sp.[3]	Villa Clara Botanical Garden / Villa Clara
Ptychosperma macarthurii[5]	La Chata farm, owned by ex-president Carlos Prío / La Habana
	Quinta de Los Molinos / La Habana
Roystonea oleracea[3]	Villa Clara Botanical Garden / Villa Clara
Syderoxylon obovatum[2]	Ingenito farm, owned by Ricardo Denis / Sancti Spiritus
Syzygium grande[2]	El Nicho Fruit Farm, Ministry of Agriculture / Cienfuegos
	Jovellanos fruit farm, owned by Héctor Correa / Matanzas

[1] Accepted name is indicated.
[2] Collection was sent for food production projects.
[3] Material aimed ex situ conservation programs or enrichment of living collections of recipient.
[4] Germplasm targeted forestry program of recipient.
[5] Material was sent to develop plant ornamental initiatives.
[6] Collection was utilized in plant medicinal or tannin production activities of recipient.
[7] We believe that recipient received this material from BGC.

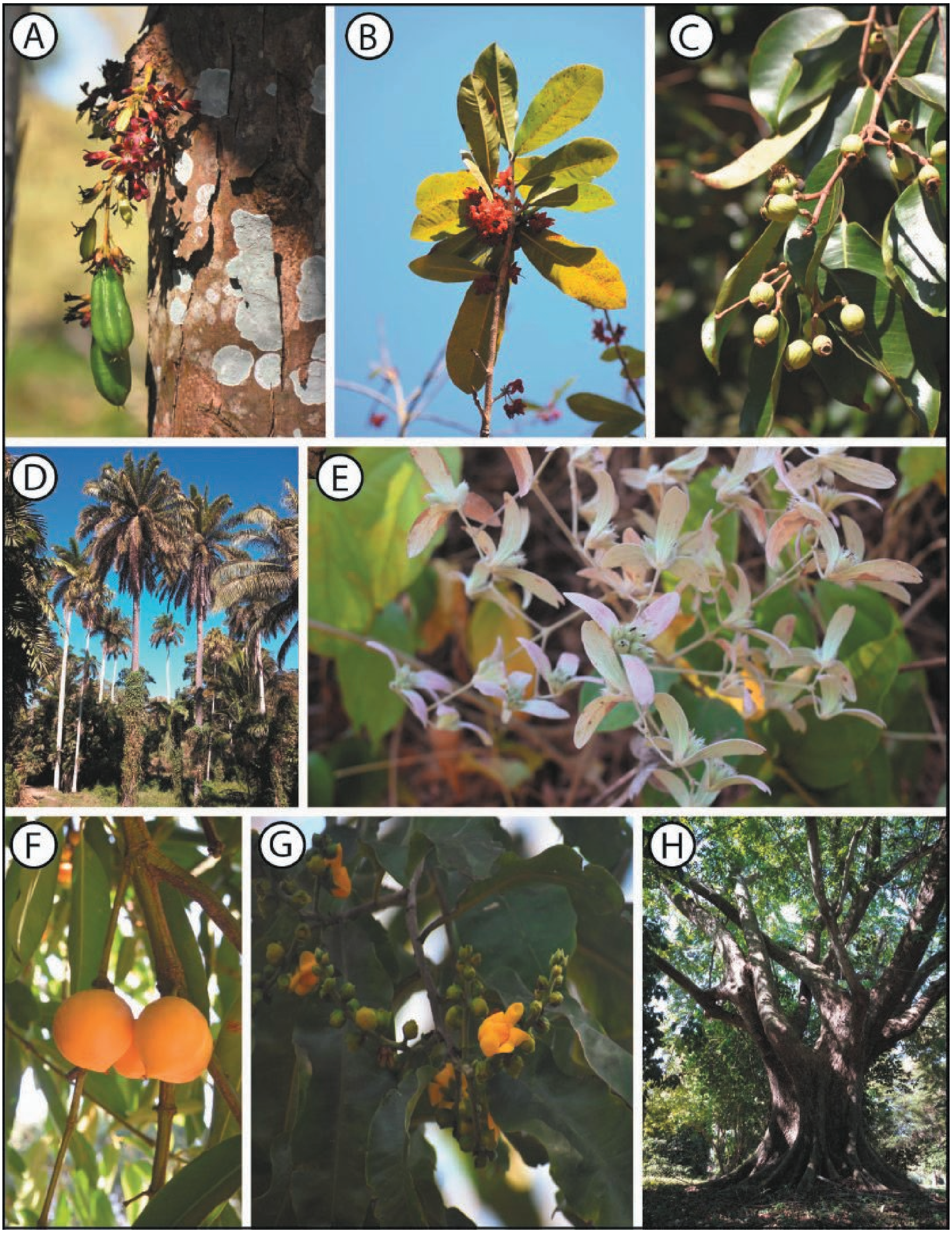


Figure 16. Species currently grown in the living collections of Cienfuegos Botanical Garden that were collected during Utowana expedition. USDA accession number or provenance is indicated inside parenthesis. (A) *Averrhoa bilimbi* (St. Vincent Botanic Garden). (B) *Ochna mossambicensis* (98870). (C) *Eugenia grandis* (70785). (D) *Elaeis guineensis* (73009). (E) *Congea tomentosa* (Dominica Botanic Garden). (F) *Garcinia dulcis* (58589 or 68028). (G) *Lecythis tuyrana* (102609). (H) *Pterocarpus indicus* (Lancetilla Botanic Garden). See additional details of these accessions in Online Supplementary Table 1. Photo credits: Rosalina Montes Espín (A, D, E, F, H), Mario A. Lima Cruz (B, C, G).

der (1988), respectively. United States companies, such as United Fruit, operated in the Caribbean and had major influence in the politics of this area, particularly in Central America (Bucheli 2008).

The political and economic role played by the United States in the Caribbean also had consequences pertinent to the advancement of natural history studies in the Neotropics (McCook 2002). Biological and ecological research led by several US museums, universities, and research institutes had Caribbean ecosystem and organisms as pivotal topics for many of their scientific studies. As indicated by Raby (2017: 8–14) this research movement led to the establishment of several tropical biological stations in the region that were owned and operated by US institutions (e.g., Barro Colorado Island in Panama, Cinchona Botanical Station in Jamaica, El Verde in Puerto Rico). They followed a model that was in many aspects originally implemented by the European powers in their colonies, particularly in the 18th and 19th centuries (Plucknett et al. 1987: 41–58). Colonial botanic gardens created by these European countries facilitated oversea botanical surveys and economic botany enterprises (Plucknett et al. 1987: 46, 50; Drayton 2000: 190–196). Perhaps the best example comes from Kew Gardens which supervised an extensive network of tropical botanic gardens in Africa, Asia, and the West Indies, that was also followed by other European institutions (Drayton 2000: 251–255).

Our research has implications regarding understanding the dynamics of the three US-operated botanic gardens from the Caribbean. We show that the USDA and its Utowana expeditions facilitated the movement of plant collections among them. Therefore, this was an active network in which both a federal government agency and two different private organizations developed joint botanical initiatives. This collaboration resulted in having duplicate germplasm accessions of tropical plants that could not be grown in most of the United States mainland. During this period, the USDA had a station in Puerto Rico which is currently known as the Tropical Agriculture Research Station. It was founded in San Juan in 1901, but one year later it was moved to Mayagüez (McCook 2002: 66). This USDA facility mostly focused on experimental agriculture and this could explain why Mayagüez was not a target for Utowana expeditions. A full study regarding movements of germplasm between Puerto Rico and the continental US is out of the scope of this study; however, we cannot rule out that future studies will find that some of the Utowana collections also reached this USDA site located in Mayagüez. Still, it is a mystery why neither the Utowana nor David Fairchild visited Puerto Rico, a US unincorporated territory in which plant exploration logistics were certainly much easier than in most of the other Caribbean Islands.

Our study centered on CBG confirms results presented by Elton (2017) and Ibáñez (2017) regarding the important role played by David Fairchild and Utowana endeavors to facilitate the growing of the living collection of Summit Gardens in Panama. Preliminary studies focusing on Fairchild Tropical Botanic Garden (Miami) show that shortly after this garden was founded (in 1938, Zuckerman 1988), there were also frequent exchanges of plant material with the botanic gardens of Lancetilla, Cienfuegos, and Summit (Francisco-Ortega et al. unpublished).

Another implication of our research concerns how the expeditions of the Utowana led to interactions between the three US botanic gardens located in the Caribbean and those run by Britain, the Netherlands, and Spain that were situated in Africa, Asia, or the West Indies. Many samples that reached CBG through Utowana expeditions were collected in colonial botanical gardens that were operated by European countries, and located in the Old or New World.

CONCLUDING REMARKS

Through this study we have found evidence that supports the ramifications of USDA plant hunting expeditions beyond the germplasm repositories of this federal agency. These collections provided building blocks for plant breeders working with major crops; however, they also included exotic material with gardening, biological, or ethnobotanical value. USDA plant exploration activities were flexible and targeted cultivated sites, natural areas, markets, and botanic gardens. The Utowana collections that reached CBG and other Caribbean botanic gardens had a wide-ranging scope and they included plant material from different sources with different horticulture interests. Clearly CBG benefited from the Utowana's collections; however, in our research we have shown that the material that reached Soledad had ramifications that involved other gardens from Cuba and the rest of the tropics.

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The genus *Salacia* (Celastraceae: Salaciodeae) in peninsular India

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Abstract. The genus *Salacia* (Celastraceae: Salaciodeae) in peninsular India is revised, wherein ten species are recognised. Eight species are endemic to the region. *Salacia macrophylla* and *S. reticulata* are excluded from the revision as occurrence of both the species is doubtful in mainland India. *Salacia macrosperma* exhibits great variation in leaf shape, flower number, pedicel length and fruit texture, hence the morphologically similar species *S. beddomei* and *S. vellaniana* are relegated to its synonymy. Descriptions, photographs, and pen and ink as well as colour drawings of all recognised *Salacia* species are provided with an artificial key, updated nomenclature, and synonymy. Distribution and IUCN Red list categories and criteria are also discussed. Seven binomials, *S. fruticosa*, *S. macrophylla*, *S. macrosperma, S. oblonga, S. ovalis*, *Tontelea prinoides* and *Johnia coromadeliana* are lectotypified.

Keywords: Hippocrateaceae, India, *Salacia*, taxonomy, Western Ghats.

INTRODUCTION

Celastraceae consists of 96 genera and about 1300 species (Mabberley 2017), distributed in tropical, subtropical and temperate parts of the world. In India, the family (including Hippocrateaceae) is represented by 15 genera and about 114 species (Ramamurthy and Naithani 2000). The classification of Celastraceae has undergone several revisions based on molecular evidence and it is now recognized with four subfamilies (Celastroideae, Stackhousioideae, Hippocrateoideae and Salacioideae). Subfamily Salacioideae consists of six genera and most of the species within this subfamily are lianas. *Cheiloclinium* Miers, *Peritassa* Miers and *Tontelea* Miers are confined to South America, *Salacighia* Loes. and *Thyrosalacia* Loes. are native to tropical Africa, whereas one of the largest genera, *Salacia* L., is distributed in both the Old and New World tropics (Simmons 2004). *Salacia* is perhaps best known as the source of salacinol, an antidiabetic compound (Yoshikawa et al. 1997).

Among the members of Celastraceae from India, the species of *Salacia* resembles those of *Loeseneriella* A.C. Sm. and *Reissantia* N. Hallé, but differs by their axillary or ramiflorous fascicles, thyrsiform or paniculate cymes, intra-staminal fleshy, annular-pulvinate or flattened disc (Figure 1A), 2 or 3

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Figure 1. Inflorescences and fruits in different genera of Indian Celastraceae. (A) *Salacia macrosperma* Wight: axillary fascicle and oblong petals. (B) *S. gambleana*: indehiscent berry-like or drupaceous fruit. (C) *Reissantia grahamii*: branched cymes with inconspicuous floral disc. (D) *Loeseneriella arnottiana*: branched cymes with conspicuous floral disc and involute petals. (E) *Reissantia indica*: dehiscent capsules.

inserted stamens from the pistil base, 2- or 3-celled, 1–8 ovulate ovary, drupaceous or baccate; mucilaginous (pulpy) or dry meso or endocarp, 1–8-seeded, indehiscent fruits (Figure 1B). *Reissantia* has entire-margined petals and an inconspicuous disc (Figure 1C), whereas *Loeseneriella* has involute petals and a conspicuous disc (Figure 1D). Moreover, both these latter genera possess axillary, dichotomously branched cymes, with or without supplementary branchlets in dichotomy, capsular, dehiscent fruit, and winged seeds (Figure 1E). Historically these three genera were often placed in Hippocrateaceae along with *Hippocratea* L. In more recent classifications, however, Hippocrateoideae and Salacioideae are included in Celastraceae as monophyletic groups representing different lineages. Fruits of Hippocrateoideae are dehiscent mericarps with winged seeds, whereas those of Salacioideae are indehiscent and drupaceous (Robson 1965; Ding Hou 1964; Robson et al. 1994; Simmons et al. 2001; Coughenour et al. 2010, 2011).

The genus *Salacia* consists of about 200 species worldwide (Mabberley 2017). The group is most diverse in tropical Africa with approximately 90 species (Hallé 1962); remaining taxa are distributed in southeast Asia with nearly 30 species (Ding Hou 1964; Pelser et al. 2016), and neotropics with 33 species (Smith 1940; Hedin 1999; Lombardi 2014). Ramamurthy and Naithani (2000) recognized 21 species of *Salacia* in India, 11 of which are endemic to the country. Subsequently three further species and one variety have been described from peninsular India (Udayan et al. 2012, 2013, 2014; Sujana et al. 2015, Page and Nandikar 2020).

Among the Indian species, *Salacia floribunda* Wight, *S. jenkinsii* Kurz and *S. khasiana* Purkay. are known from North East India, whereas *S. majumdarii* (Chakrab. & M.Gangop.) B.D. Naithani, *S. platyphylla* Kurz and *S. tortuosa* Griff. occurs on the Andaman and Nicobar Islands. *Salacia grandiflora* Kurz, *S. salacioides* (Roxb.) R.S.Rao & Hemadri and *S. verrucosa* Wight are common to North East India as well as the Andaman and Nicobar Islands. *S. chinensis* L. occurs throughout peninsular India and the Andaman Islands, whereas *S. oblonga* Wight & Arn. is restricted to the Western Ghats of India and Sri Lanka.

Salacia is more diverse in peninsular India than other parts of the country. Of the ten species recorded so far, eight are endemic to this part of the country: *S. agasthiamalana* Udayan, Yohannan & Pradeep, *S. brunoniana* Wight & Arn., *S. fruticosa* Heyne ex M.A.Lawson, *S. galmbleana* Whiting & Kaul, *S. macrosperma* Wight, *S. malabarica* Gamble, *S. megacarpa* N.V.Page & Nandikar and *S. wayanadica* Sujana, Nagaraju, M.K.R.Narayanan & Anil Kumar. *Salacia megacarpa* is the only species that has large, ridged, green mature fruit with a dry endocarp. *Salacia agasthiamalana* is unique in having small, elliptic, obovate leaves and fruits with a thin epicarp. *Salacia vellaniana* Udayan, Yohannan & Pradeep, wrongly synonymized under *S. gambleana* by Sasidharan & Anaz (2015), is considered conspecific to *S. macrosperma*. In *S. macrosperma*, the fruits have been described unclearly. In the protologue, fruits were given as irregularly ovate, and in illustration fruit vary from globose to obovoid to ellipsoid, smooth (Wight 1845). The original material (housed at K) has broadly ellipsoid-oblong fruit. Nevertheless, most collections of *S. macrosperma* from peninsular India also bears globose to oblong fruits with a smooth to sparsely tuberculate exocarp. Hence, taxonomic delimitation of *S. macrosperma* from its congeneric *S. beddomei* Gamble and *S. brunoniana* is often difficult. Incidentally, both the latter species were described without fruit. In the case of *S. beddomei*, it was found to be conspecific with *S. macrosperma* due to similarities in leaf shape, size, flowers. On the other hand, *S. brunoniana* is retained as distinct species, as it differs from *S. macrosperma* by having serrate leaves, and few-flowered fascicles.

The claimed occurrence of *S. macrophylla* and *S. reticulata* in peninsular India by Ramamurthy and Naithani (2000) is based on misidentifications. The former was identified based on the work of Ding Hou (1964), which was based on Dalzell's collection from Konkan. The present author had an opportunity to scrutinize Dalzell's collection of *S. oblonga* at K which is erroneously determined by Ding Hou as *S. macrophylla*. Similarly, *S. reticulata* Wight (1840) does not occur in India. It was based on a collection of Colonel Walker from Ceylon (Sri Lanka). In the protologue, Wight was uncertain about its distribution in India. Subsequently, Gamble (1918) incorrectly included this species based on a collection of Rao (*87440* at CAL), and misinterpreted the type specimen (*C.P. 2720* at CAL) of the Sri Lankan endemic *S. diandra* Thwaites as *S. reticulata* (see Udayan and Pradeep 2012).

Brief taxonomic history of Salacia in India

'Courondi' was the earliest recorded vernacular name for a species of *Salacia*, used by Van Rheede (1683) in his *Hortus Malabaricus* and later identified as *Salacia chinensis* (Ding Hou 1964, Nicolson and Suresh 1986), although it should rather be *S. fruticosa* (see the note under *S. fruticosa* in the present contribution). The name 'Courondi' was validated as a new genus *Courandi* Adanson (1763), but later rejected against the earlier Linnaean *Salacia* (Dandy 1969, Nicolson and Suresh 1986). Roxburgh (1820) in his *Hortus Bengalensis*, used the generic name *Johnia* for members of *Salacia* and subsequently applied it to *J. salacioides* Roxb. (= *Salacia salacioides*) and *J. coromandeliana* Roxb. (= *Salacia chinensis* L.) in his *Flora indica*.

Wight and Arnott (1834) described three *Salacia* species: *S. brunoniana*, *S. oblonga* and *S. oppositifolia* Wight & Arn., of which *S. oblonga* is distributed in peninsular India and Sri Lanka, whereas *S. brunoniana* is endemic to peninsular India. *Salacia oppositifolia* and *S. oblonga* are now found to be conspecific. Wight (1840, 1845) described four new species, *S. floribunda* Wight, *S. reticulata*, *S. verrucosa* and *S. macrosperma* Wight. Bentham and Hooker (1862) in *Genera Plantarum* reduced Hippocrateaceae to the tribes Celastreae and Hippocrateae. Kurz (1872, 1875) described *S. grandiflora* Kurz from Myanmar. *S. jenkinsii* Kurz and *S. platyphylla* Kurz were described from Assam and the Andaman and Nicobar Islands, respectively.

Lawson (1875) in the treatment of *Flora of British India*, placed *Salacia* in the tribe Hippocrateae and order Celastrineae. He recognised 20 species in the genus, with *Salacia latifolia* Wall. ex M.A.Lawson (=*S. chinensis*) considered as doubtful species, and *S. fruticosa* a new species based on Heyne's collection. Gamble (1916) described three species, *S. beddomei*, *S. malabarica* and *S. talbotii* Gamble from southern peninsular India. Purkayastha (1938) added *S. khasiana* from Assam.

Ding Hou (1964) revised the Malaysian Celastraceae and recorded 29 species, of which five species share a distribution with Andaman and Nicobar archipelago. With the addition of *S. korthalsiana* Miquel and *S. tortuosa* (Lakshminarasimhan and Srivastava 1993, Lakshminarasimhan and Ray 1994), the Andaman and Nicobar Islands now harbours seven *Salacia* species: *S. platyphylla*, *S. nicobarica*, *S. korthalsiana*, *S. chinensis, S. reticulata*, *S. salacioides* and *S. verrucosa*, with the first two endemic to these islands.

Biogeography and comparative morphology of Indian Salacia

Salacia chinensis, S. macrosperma and *S. oblonga* occur on the plateaus, along forest fringes and in undergrowth. *Salacia chinensis* also occurs in dryland, and riverine forests of peninsular India. *Salacia fruticosa* and *S. malabarica* grow along forest margins and in coastal scrubland forest. *Salacia gambleana* occurs along forest margins and often shares the habitat with *S. macrosperma*. *Salacia agasthiamalana* and *S. wayanadica* are known only from the type localities. The former grows on the slopes in evergreen grassland at an altitude of 900–1100 m and is narrowly distributed in Agasthiamala Biosphere Reserve and adjoining areas, whereas the latter has a sporadic distribution along the forest margin in Wayanad District, Kerala. Similarly, *S. megacarpa* is known from wet evergreen forests bordering Kerala and Karnataka. Except for its type collection from Nilgiris (Tamil Nadu), *S. brunoniana* is known only from evergreen forests of Palode, Thiruvananthapuram, Kerala.

Salacia agasthiamalana is a shrub or small shrub, whereas *S. chinensis* is often recorded as small tree to scandent shrub. All the other *Salacia* species grows either as scandent shrubs or lianas, straggling over small trees. Branchlets are usually grey to dark brown or black, smooth to lenticellate; rusty, abruptly yellow-striated in *S. oblonga* (Figure 2A–C). Leaf shape (Figure 2D) varies from obovate, oblanceolate, ovate to elliptic-oblong. *S. agasthiamalana* has small, elliptic to obovate leaves in comparison with the rest of the species in peninsular India. *S. gambleana* has distinct oblanceolate leaves. The leaf margin also varies from entire to serrate, cuneate, sinuate, undulate, whereas the leaf apex varies from acute to acuminate or obtuse. The midrib and lateral nerves are usually conspicuous, rarely inconspicuous as in *S. macrosperma*, with the lateral nerves varying from 6 to 12 pairs. Some of the African species are characterised by resinous or latex threads, particularly when breaking of leaves and petiole (Robson et al. 1994), which is absent in peninsular Indian *Salacia*. The inflorescence usually consists of solitary to many flowered ramiflorous and axillary fascicles (Figure 2E), whereas pedunculate cymes (Figure 2F) are characteristic of *S. fruticosa*, *S. oblonga* and *S. megacarpa*.

The flowers (Figure 3A–G) are moderately sized (7–15 mm in diam.), usually salver-shaped (urceolate in *S. oblonga*); pedicel length varies from 0.3 (*S. oblonga*) to 2 (*S. malabarica*) cm; bracts are often conspicuous and sepaloid; buds are usually globose, with calyptriform sepals, ovoid to conical in *S. chinensis*. The sepals are usually fused at the base, with the sepal lobes (Figure 4A–H) laciniate to fimbriate in *S. agasthiamalana, S. macrosperma*, and *S. gambleana*, glabrous or marginally or apically erose in *S. megacarpa, S. chinensis, S. oblonga* and *S. brunoniana*, sparsely ciliate in *S. malabarica*, apically bearded in *S. wayanadica,* inconspicuous, undulate, or crisp, white-margined in *S. fruticosa*. The petals are primarily green to pale green, elliptic to oblong, often with hyaline margins, revolute, obovate to oblanceolate in *S. chinensis* and *S. megacarpa*, orbicular and orange to ochreous in *S. fruticosa*. Disc shape, size and colour varies with flower maturity, oblate and green to pale green in *S. chinensis,* otherwise conical or lenticular, entire, or faintly lobed, green with orange shades or ochreous. There are three stamens, the filaments often becoming reflexed or revolute; anthers bi-thecate, globose to ellipsoid, thecae confluent by oblique slits in *S. megacarpa* (Figure 5A), longitudinal slits (Figure 5B) in *S. fruticosa* and *S. oblonga*. Ovoid, yellow to ochra-yellow anthers and thecae confluent by transverse slits (Figure 5C) are most common in the remaining species of peninsular India; pollen simple, tricolporate; ovary

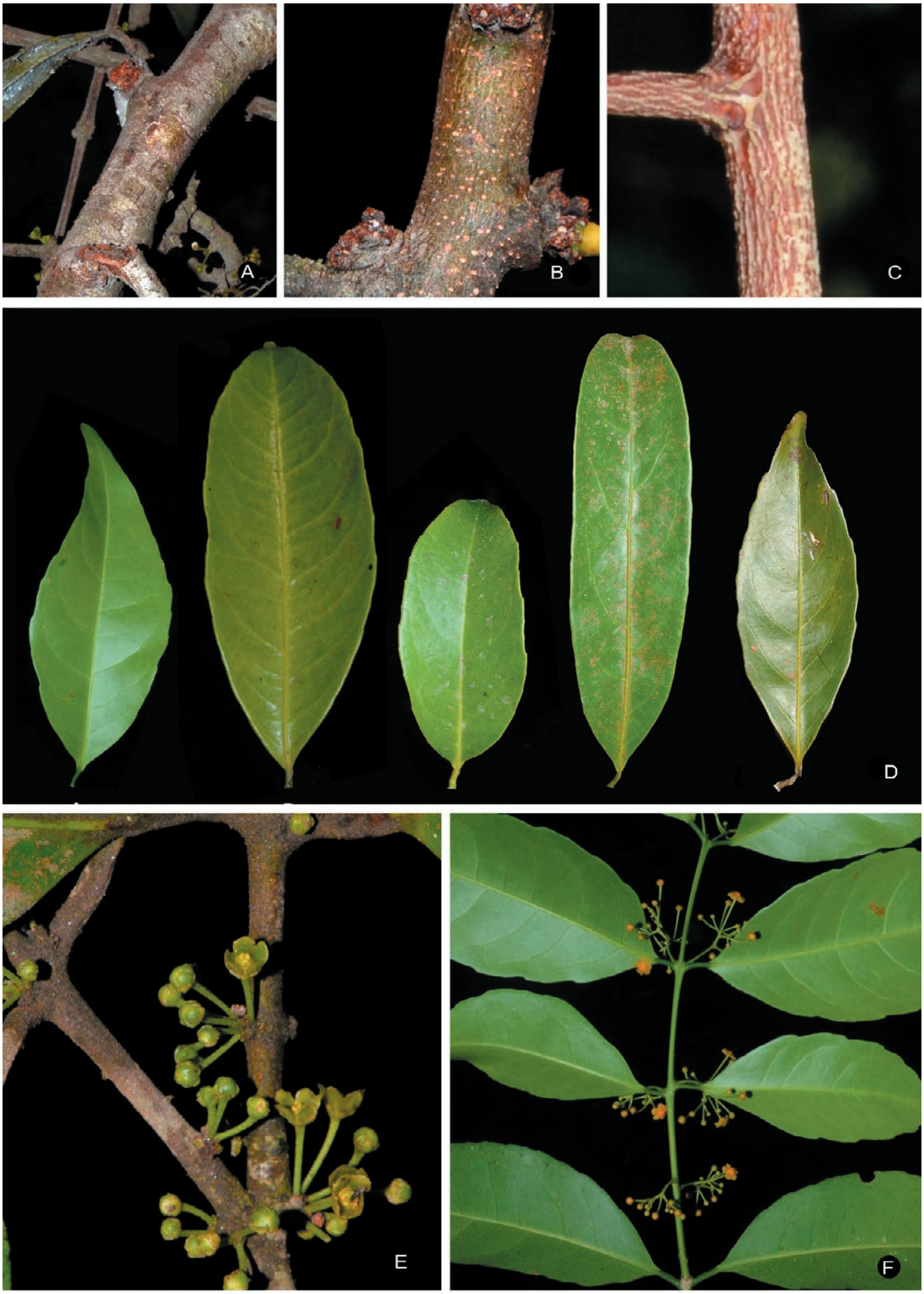

Figure 2. Lateral branches (A–C) and inflorescences (E–F) in species of *Salacia*. (A) *Salacia wayanadica*: smooth surfaces and hooked branches. (B) *S. macrosperma*: reticulate branches. (C) *S. oblonga*: irregularly corrugated. (D) Leaves (*S. fruticosa*: ovate to lanceolate, faintly crenate, acuminate; *S. macrosperma*: large, broadly elliptic, entire to faintly serrate, acute-obtuse; *S. chinensis*: small, elliptic, serrate; *S. oblonga*: large, oblong, entire, acute-obtuse; *S. brunoniana*: lanceolate, serrate-crenate, acuminate. (E) *S. wayanadica*: axillary and ramiflorous, 2–8-flowered fascicle. (F) *S. fruticosa*: axillary and ramiflorous, dichotomously branched, few-flowered cyme.

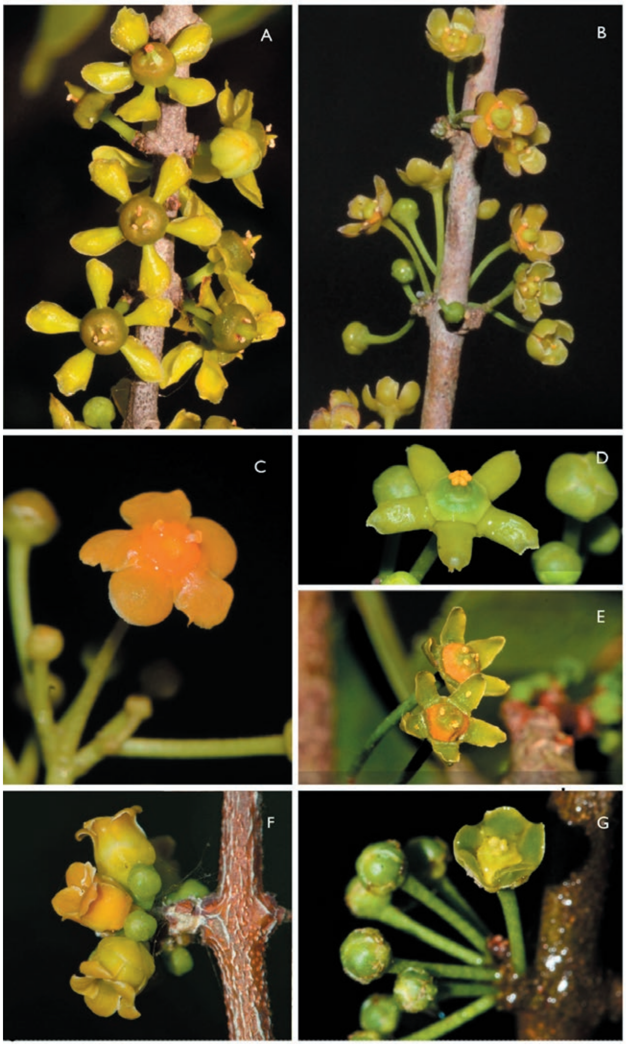

Figure 3. Flowers in species of *Salacia*. (A) *Salacia chinensis*: oblanceolate, pale green petals. (B) *S. brunoniana*: elliptic-oblong, ochreous petals with orange disc. (C) *S. fruticosa*: globose or orbicular, orange to ochreous petals, flattened, orange disc. (D) *S. megacarpa*: oblong, spreading, green petals with oblique anther cells. (E) *S. malabarica*: ovate to elliptic petals with orange disc. (F) *S. oblonga*: axillary, shortly pedunculate cymes, and urceolate flowers. (G). *S. wayanadica*, broadly elliptic-oblong petals.

immersed or embedded in the disc. Fruits (Figures 6, 7) usually a globose or ellipsoid berry, with pulpy meso- and endocarp and 1- (*S. chinensis*) to 8-seeded (dry indehiscent and prolate in *S. megacarpa*); exocarp smooth, or keeled, or verrucose, or tuberculate, thin (*S. chinensis*), otherwise leathery or tough; seeds ellipsoid to ovoid or oblate to obconical, usually dorsiventrally compressed, with surface smooth or reticulate.

MATERIALS AND METHODS

Multiple accessions of *Salacia* species were collected from different states of peninsular India. Photographs of habit, inflorescences, flowers, fruit, and seeds were taken using Nikon D7000 and Canon 700D digital cameras with different optics. Microscopic study was carried out with a Leica Stereo Microscope (DM500). Herbarium specimens were prepared based on the methods proposed by Forman and Bridson (1992). The processed and identified specimens were deposited in Naoroji Godrej Centre for Plant Research (NGCPR) Herbarium and duplicates presented to CAL and BSI. Existing herbarium specimens from the study area (peninsular India) were consulted at BSI, CAL, CALI, CMPR, FRLH, K, MH, PBL, RHT and TBGRI. Images of herbarium specimens were virtually consulted using JSTOR Global Plants (https://plants.jstor.org/) and herbaria webpages from A, BISH, BM, E, F, FR, G, GH, NY, P, U and US. The provisions of the ICN (Turland et al. 2018) was applied to update the nomenclature and for purposes of typification.

Descriptions were based on observation of morphology, study of type specimens, the protologue and herbarium specimens, whereas the descriptive terminology follows Ding Hou (1964) and Robson et al. (1994). The colour illustrations were prepared by the author from photographs, microscope images and herbarium specimens using water colour on hot press paper and processed in Adobe Photoshop 7.0. Conservation status was assigned, and threat assessment carried out for global level using IUCN Red list categories and criteria (IUCN 2019) based on population size, threats, and the estimation of the geographical range size (EOO and AOO), by using GeoCat (Moat 2007). The population trend and size data were produced from field observations, available literature, previous assessments and from information on herbarium specimen labels. Distribution maps were prepared for endemic species using DIVA GIS 7.5, with herbarium and field data being used to plot the distribution points.

TAXONOMIC TREATMENT

Key to the species of Salacia in peninsular India

1. Inflorescence pedunculate cymes; flowers subsessile to distinctly pedicellate; anther cells (thecae) ovoid, confluent by longitudinal or oblique slits; fruit smooth (sparsely tuberculate in *S. oblonga*)..2

1. Inflorescence sessile, fascicles or umbelliferous cymes; flowers distinctly pedicellate; anther cells (thecae) globose to

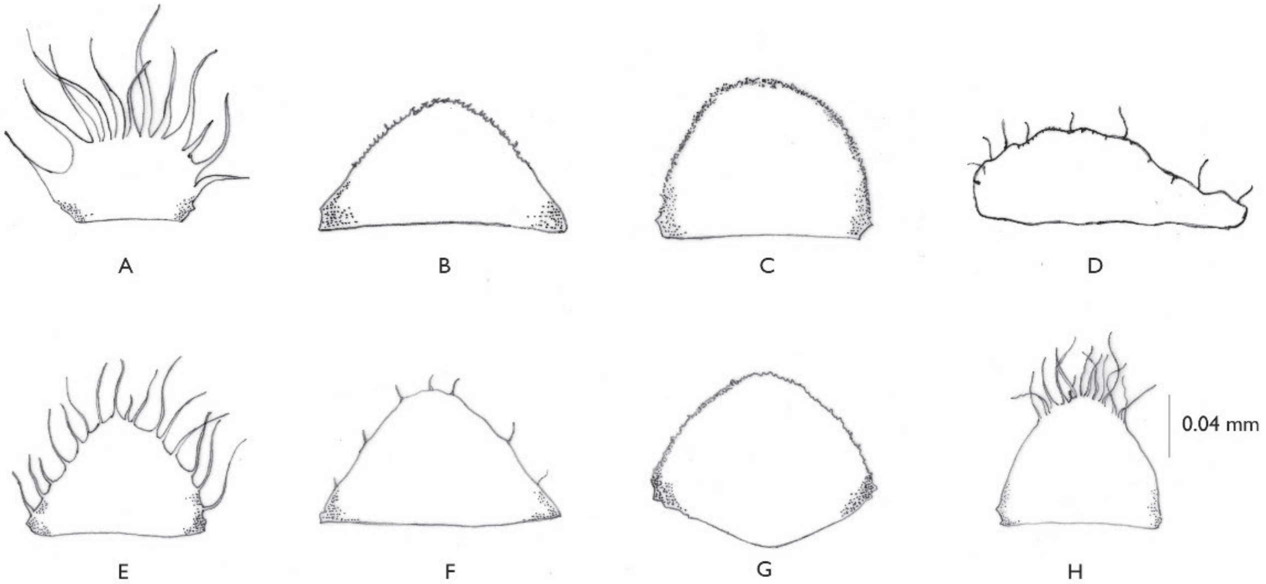

Figure 4. Sepal lobes in species of *Salacia*. (A) *Salacia agasthiamalana* (B) *S. brunoniana* (C) *S. chinensis*, *S. megacarpa* (D) *S. fruticosa* (E) *S. macrosperma*, *S. gambleana* (F) *S. malabarica* (G) *S. oblonga* (H) *S. wayanadica*

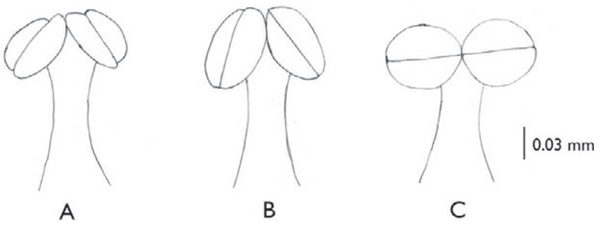

Figure 5. Stamens in species of *Salacia*. (A) Oblique anther cell (theca): *Salacia megacarpa* (B) longitudinal anther cell: *S. oblonga* (C) Globose, transverse anther cell: common in rest of *Salacia* in peninsular India.

ellipsoid, confluent by transverse slits; fruits smooth or smooth to tuberculate or verrucose 4

2. Young branchlets rusty, yellow-striated; leaves elliptic-oblong or oblanceolate, drying yellow; flowers urceolate; fruit globose to ovoid, smooth to faintly tuberculate .... ***S. oblonga***

2. Young branchlets grey to dark brown, smooth; leaves ovate-lanceolate or broadly ovate or elliptic-lanceolate, drying green or black; flowers with spreading petals; fruit globose to prolate to broadly ellipsoid, smooth, or ridged 3

3. Sepal lobes undulate, crisped, faintly ciliate; petals orbicular, ochreous; fruit globose, 2.5–3.5 × 2–3 cm, smooth with 2- or 3-seeded mucilaginous (pulpy) endocarp ..... ***S. fruticosa***

3. Sepal lobes entire, smooth to erose; petals elliptic-oblong or obovate, grey-green to yellowish green; fruit prolate to broadly ellipsoid, 7–10 × 4–6 cm, ridged or keeled with 5-seeded dry endocarp .... ***S. megacarpa***

4. Flower buds ovoid or conical; petals obovate to oblanceolate, margin revolute; disc oblate; berries 1-seeded, exocarp smooth, thin .... ***S. chinensis***

4. Flower buds globose; petals elliptic, ovate to oblong, margin undulate or crisped; disc conical or lenticular; berries 1–8-seeded, exocarp smooth to tuberculate, or smooth, or verrucose, leathery 5

5. Erect shrubs; petiole 4–7 mm long; berries smooth .... ***S. agasthiamalana***

5. Scandent shrubs, or lianas; petiole 8–20 mm long; berries smooth, or smooth to tuberculate or verrucose 6

6. Pedicel 1.5–2 (–2.5) cm long; sepals entire to sparsely ciliate .... ***S. malabarica***

6. Pedicel 0.8–1.2 cm long; sepals bearded, erose to laciniate or fimbriate 7

7. Leaf apex obtuse, margin entire; sepals bearded at apex with long cilia; petals oblong, pale green, tinged with orange .... ***S. wayanadica***

7. Leaf apex acute to acuminate, margin entire to undulate, or sinuate to crenate, or serrulate; sepals smooth to erose or laciniate; petals ovate to broadly elliptic, green to pale green 8

8. Leaves sinuate to cuneate, 4.6–7.5 × 2.7–4 cm; sepals inconspicuous, faintly erose at apex; petals oblong .... ***S. brunoniana***

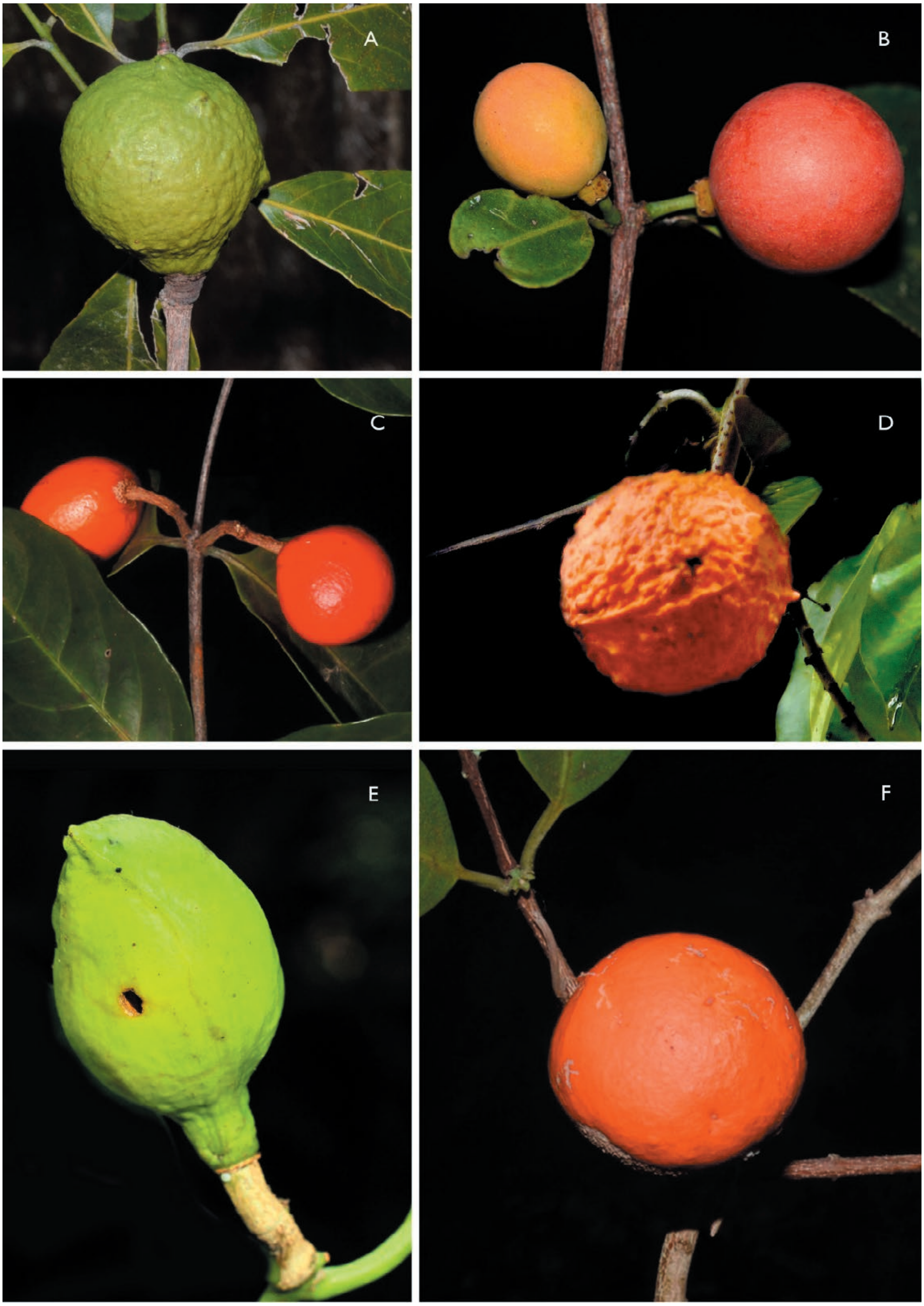

Figure 6. Fruits in species of *Salacia*. (A) *S. brunoniana*: immature, obovoid fruit with faintly tuberculate exocarp. (B) *S. chinensis*: smooth, globose, thin with pale orange exocarp with persistent disc base. (C) *S. fruticosa*: smooth, globose to ovoid, leathery, orange exocarp with distinct stalk. (D) *S. malabarica*: reticulate-verrucose, globose, orange exocarp. (E) *S. megacarpa*: immature, ovoid, faintly ridged fruit with distinct stalk. (F) *S. oblonga*: smooth, globose, orange exocarp.

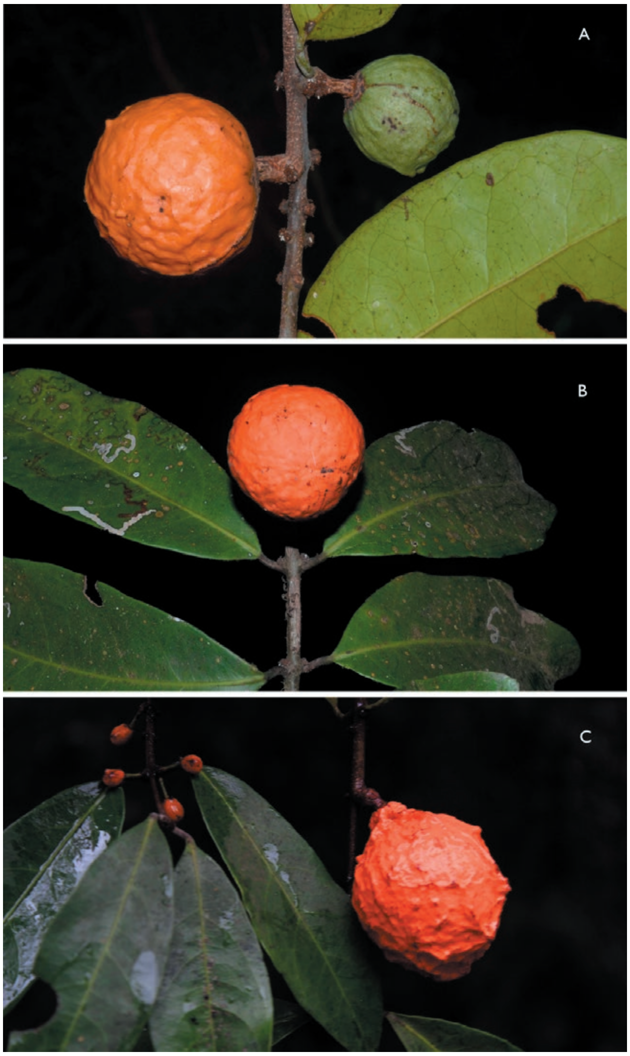

Figure 7. Exocarp variations from smooth to tuberculate (A–C) in *S. macrosperma*.

8. Leaves entire, undulate, serrate, 6–15 × 3–7 cm; sepals characteristically laciniate, or fringed; petals ovate to elliptic .. 9

9. Leaves usually oblanceolate, rarely elliptic-oblong, lateral nerves 6–8 pairs; berries smooth to verrucose or verrucose-tuberculate.. ***S. gambleana***

9. Leaves elliptic-oblong or obovate-elliptic, lateral nerves 6–12 pairs; berries smooth to tuberculate ....***S. macrosperma***

Salacia L. Mant., Pl. 2: 159. 1771. *nom. cons.*
Type: *Salacia chinensis* L.

Courondi Adans., Fam. Pl. 2: 446. 1763. *nom. rej.*
Type: 'Courondi' Rheede
Christmannia Dennst., Schlüssel Hortus Malab. 30: 1818.
Type: *Christmannia courondi* Dennst.
Johnia Roxb., Fl. Ind. 1: 172. 1820.
Type: *Johnia salacioides* Roxb.
Salacicratea Loes., Nova Guinea 8: 281. 1910.
Type: *Salacicratea papuana* Loes.

Description

Perennial scandent shrubs, lianas or woody climbers, rarely small trees or shrubs, distal branches scandent, glabrous throughout or essentially so; branchlets terete, often hooked, lenticellate, irregularly corrugated, swollen or somewhat flattened at nodes. Leaves opposite or sub-opposite, decussate, stipules inconspicuous or absent; petiole 4–15 mm; lamina ovate-elliptic, elliptic-lanceolate, or oblanceolate or oblong-lanceolate; margin crenate, serrate, or entire; lateral nerves 5–12, anastomosing. Inflorescences axillary or ramiflorous few to many flowered, tuberculate fascicle or branched cymes; pedicels 5–20 mm long; sepals 5(4) lobed, broadly ovate to orbicular, margin laciniate, or fringed or entire or erose or ciliate; petals 5 obovate to oblanceolate, elliptic to oblong, or ovate to elliptic-lanceolate, or orbicular or oblanceolate, often revolute; disk intra-staminal, fleshy, annular-pulvinate, sometimes conical or flattened, rarely cupular; stamens 3, inserted on disk, free or adnate with pistil, usually reflexed at anthesis, filaments subulate, broadened towards the base, anthers bilobed, thecae globose or ellipsoid or ovoid, confluent transversely or longitudinally or obliquely; ovary partly or completely immersed in the disk, 3-celled (locular), ovules 1(2)–8 in each cell; style short, simple, stigma simple. Fruit baccate, globose, broadly ellipsoid, or prolate, 3-celled, indehiscent, exocarp smooth to tuberculate, or smooth, verrucose or ridged; seeds 1 to several, embedded or not in mucilaginous (pulpy) endocarp, variously shaped, cotyledons massive, free or united.

General Distribution

About 200 species distributed in tropical and subtropical Africa, America and Asia, with few species in the temperate parts of Asia and America (Ding Hou 1963; Mabberley 2017). India with 21 species, ten of which are reported from peninsular India.

1. ***Salacia agasthiamalana*** Udayan, Yohannan & Pradeep in Edinburgh J. Bot. 69(2): 255. 2012. (Figure 8)

Type: India, Kerala, Thiruvananthapuram, Agasthiamala, 11 Apr. 2010 (flowering), *Udayan & Regy Yohan-*

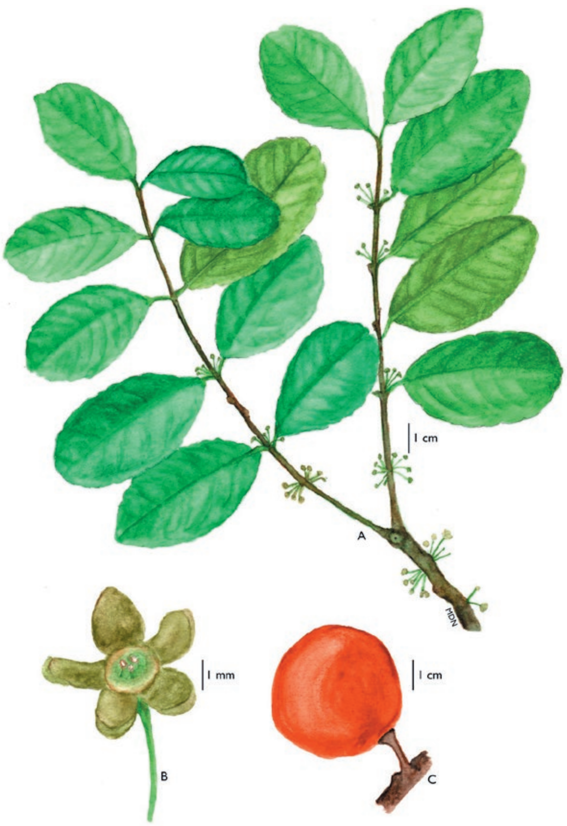

Figure 8. *Salacia agasthiamalana* (A) Flowering twig. (B) Flower. (C) Fruit.

nan S004 (holotype, MH *n.v.*; isotypes, K *n.v.*, SKC *n.v.*, SNCH *n.v.*).

Description

Erect shrubs; branchlets blackish lenticellate. Leaves opposite or subopposite, exstipulate; petiole 4–7 mm long; lamina broadly elliptic or obovate, 5–6 × 2–4 cm, apex acute or rounded-retuse, base acute or cuneate, margin serrate to crenate, coriaceous. Inflorescences axillary or ramiflorous, tuberculate, 2–8-flowered fascicles; pedicel 5–11 mm long; sepals fused at base, lobes oblong, c. 1 mm long, margin fimbriate; petals broadly elliptic, c. 2 × 1.5 mm; disk conical, c. 0.5 × 1 mm, tapering into a short style; stamens 3, rarely 4; anthers bi-lobed, globose, creamy-white with a brown tinge, thecae confluent transversely; filaments slightly spreading, broad at the base; ovary 3-celled, 1-ovulate; stigma simple, pale green. Fruits baccate, shortly stipitate, globose, exocarp smooth, leathery, 4–6 cm across, orange-red, 3-seeded; seeds slightly plano-convex, 1.5–2 × 1–1.5 cm.

Phenology

Flowers in March, fruits remain till June.

Distribution and habitat

Endemic to peninsular India, the species is known from two localities Pongalapara, Agasthiamalya, Thiruvananthapuram in Kerala and Peyaru to Panimalai, in Tirunelveli, Tamil Nadu (Figure 18). It grows on slopes of evergreen grassland at the altitudinal range of 900–1100 m (Udayan et al. 2012; Rajasekar et al. 2018).

IUCN status

Both the known locations of *Salacia agasthiamalana* are adjoining, Pongalapara is a protected area (part of Agasthiamala Biosphere Reserve), where no threat has been recorded so far. No information is available for the population at Panimalai. Hence, due to insufficient data on the population size and threat the species is assessed here as Data Deficient (DD).

Specimens examined

INDIA. **Kerala**, Thiruvananthapuram, Agasthiamala, Pongalapara, 11 Apr. 2011, *Udayan & Regy Yohannan 00S9* (MH).

Notes

S. agasthiamalana is similar to *S. macrosperma* Wight in being cauliflorous, with 1- to many-flowered fascicles, but differs in having a bushy habit, blackish, lenticellate branchlets, obovate, small, obtuse leaves and globose, smooth fruits. It also resembles *S. chinensis* in habit, leaf size and shape, however, shortly petiolate, obtuse leaves, broadly elliptic petals, 3-seeded, 4–6 cm large fruits distinguish *S. agasthiamalana*.

Type material of *S. agasthiamalana* at the herbaria listed in the protologue could not be traced. The specimen at MH (*Udayan & Regy Yohannan 00S9*), collected from the type locality, was used here to describe and illustrate the species (flower and fruits characters obtained from the protologue and Rajasekar et al. 2018).

2. *Salacia brunoniana* Wight & Arn., Prodr. Fl. Ind. Orient. 1: 105. 1834. (Figure 9)

Type: India, Peninsular, *s. d., Herb Wight 347* (lectotype, E! barcode E00174243), designated by Jadhav et al. (2016).

Description

Scandent shrubs or lianas up to 3(–5) m high; branches looped, branchlets terete, glabrous. Leaves

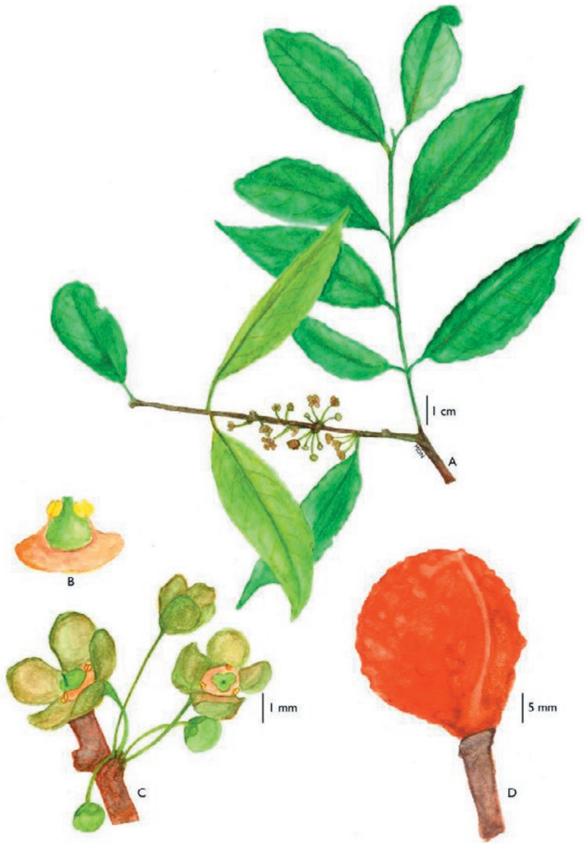

Figure 9. *Salacia brunoniana* (A) Flowering twig. (B) Disc. (C) Inflorescence. (D) Fruit.

opposite to sub-opposite or alternate, petiolate; petiole 0.8–1.5 cm long; lamina oblong or elliptic, 4.6–7.5 × 2.7–4 cm, apex acuminate, base acute or cuneate-attenuate, margin sinuate or crenate (rarely serrate), coriaceous, lateral nerves 5–8. Inflorescences axillary and ramiflorous, tuberculated, 2- to many-flowered fascicles; buds globose; pedicels 5–8 mm long; sepals fused at base, lobes ovate, inconspicuous, pale green, c. 1 mm long, adherent with the petals, faintly erose at apex; petals usually 5, rarely 4, oblong, c. 2.5 × 2.2 mm, coriaceous, incurved, margin hyaline, yellowish green; disk flat or annular, fleshy, ochreous; stamens 3, filaments 1 mm long, adnate to the disc or free, incurved, anthers bilobed, globose, pale ochreous, thecae confluent transversely; ovary oblate-globose, 2- or 3-celled, style c. 1 mm long, broad at base, tapering towards the apex, stigma inconspicuous. Fruit baccate, globose-obovoid, 2.5–4 × 2–4 cm, shortly stalked, exocarp tuberculate, orange-yellow at ripening, endocarp mucilaginous, 1–6-seeded; seeds ovoid to ellipsoid, 1–1.5 × 1 cm, brown.

Phenology

Flowers in January to March, fruiting remains till June.

Distribution and habitat

Endemic to the Western Ghats of Tamil Nadu and Kerala (Figure 18). Evergreen and fringing forest.

Specimens examined

INDIA. **Tamil Nadu**, Herb. *Wight 365*, Wall. Cat. no 4217E (K, K00069920); Nilgiris, 1884, *M. A. Lawson 0326* (MH). **Kerala**, Vittalapacha, 18 Feb. 1992, *A. Nazarudeen 13846* (TBGRI); *ibid*., 28 Feb. 2011, *S. M. Shareef 70649* (TBGRI); *ibid*, 20 Mar. 2014, *S. M. Shareef 79251* (TBGRI); Thiruvananthapuram, JNTBGRI, 13 Feb. 2014, *S. M. Shareef 79235* (TBGRI); JNTBGRI, Palode, 16 Feb. 2017, *D. C. Jadhav 1459* (NGCPR).

IUCN status

Salacia brunoniana is known from Tamil Nadu (Nilgiris), and Kerala (Thiruvananthapuram). At present there is no detailed information available on species distribution and population, therefore, considered here as Data Deficient (DD).

Notes

The distribution report of *S. brunoniana* in Maharashtra (Dalzell and Gibson 1861; Almeida 1996; Londhe 2000; Mishra and Singh 2001; Shareef and Kumar 2013) is an error. Dalzell's collection at K of *S. brunoniana* from Ram Ghat, Maharashtra is identified as *S. chinensis*. Nevertheless, I could not locate the collections by M.R. Almeida (*2292*: BNHS) and S.M. Almeida (*5204*: BLAT) (Almeida 1990) from Amboli, Sindhudurg Maharashtra. Similarly, its claimed occurrence in Odisha (Ramamurthy & Naithani 2000), is based on it being mistaken for *S. chinensis*. Perhaps, they have referred to *Panigrahi 23710* (CAL) labelled as *S. brunoniana,* which is an incomplete specimen of *S. chinensis*. Collections (*Nazarudeen 13846*, *Shareef 70649*: TBGRI) from Vittalapacha, Kerala well agrees with the protologue of *S. brunoniana* except in the number of flowers. *S. brunoniana* planted at JNTBGRI was originally brought from Vittalapacha, Kerala, which has distinctly sinuate, crenate, or serrate leaves, 2–8-flowered fascicle and broadly oblong-obovate petals. The species shares similarities in habit and flowering characters with *S. macrosperma* and *S. gambleana*, but these differs from *S. brunoniana* by characteristic laciniate, or fringed sepals and entire to serrate leaves.

3. *Salacia chinensis* L., Mant. Pl. Altera 293: 1771. *Tonsella chinensis* (L.) Spreng., Syst. Veg., ed. 16, 1: 177. 1824. (Figure 10)

Type: China, *Linn. Herb. No. 1066.1* (lectotype LINN! http://linnean-online.org/11292/), designated by Ding Hou (1963).

(=) *Tontelea prinoides* Willd., Neue Schriften Ges. Naturf. Freunde Berlin iv. 184: 1803.

Type: India, Orientalis, 1788, *Klein s.n.* ex herb. Willdenow (HAL! barcode HAL0118476), lectotype here designated.

(≡) *Salacia prinoides* (Willd.) DC., Prodr. [A. P. de Candolle] 1: 571. 1824.

(=) *Johnia coromandeliana* Roxb. in Fl. Ind., ed. Carey & Wall., 1: 173. 1820.
Type: India, Roxburgh *s.n.* (BR! barcode BR6985653), lectotype here designated.

Description

Climbing shrubs or small trees up to 2(–4) m high; much branched, branchlets angled, terete, often hooked, glabrous. Leaves opposite or subopposite, stipules deltoid; petiole 0.2–0.7 cm long; lamina oblong-lanceolate, elliptic to elliptic-lanceolate, obovate, or ovate-elliptic, 5–12 × 2–5 cm, apex acute to shortly acuminate, base cuneate or acute, margin entire, or faintly serrate-crenate, thin-coriaceous, lateral nerves 5–10 pairs. Inflorescences axillary and ramiflorous, tuberculate, 3–6-flowered fascicles; buds ovoid or conical; pedicel 5–7 mm long, glabrous; bract triangular or ovate, slightly erose; sepals fused at base, lobes ovate, sparsely erose; petals immersed from disk, obovate–oblanceolate, c. 3 × 4 mm, greenish yellow, margin revolute, often hyaline; disk annular-pulvinate, thick, oblate, often tapering into the short style; stamens 3, inserted on the disk, filament linear, subulate, 1 mm long, anthers bi-lobed, globose yellow, thecae confluent transversely; ovary 3-celled, 2-ovulate, style short, conical, stigma simple. Fruits baccate, shortly stipitate, globose, 0.8–1 cm in diameter, minutely apiculate, raised on persistent oblate disk, exocarp thin, smooth, orange-red to reddish brown at ripening, endocarp hyaline, mucilaginous, 1-seeded; seed globose, 5–8 mm in diameter, rusty.

Phenology

Flowers from January, fruits may last till June.

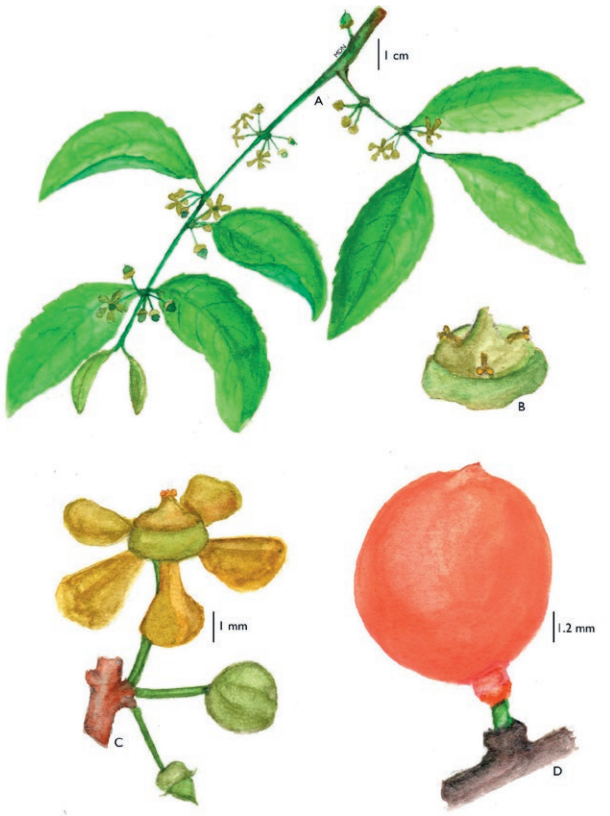

Figure 10. *Salacia chinensis* (A) Flowering twig. (B) Disc. (C) Inflorescence. (D) Fruit.

Distribution and habitat

Peninsular India, also in Andaman and Nicobar Islands, Assam, Odisha, and West Bengal; Sri Lanka and throughout southeast Asia. In open dryland forest, along the coastal lowland forest, as a small tree on open plateaus, in riverine forest and dense deciduous woodland.

Vernacular names

"madhu phal" (Bengali); "ekanaayakana beru" (Kannada); "cherukuranti" (Malayalam); "saptarangi", "nisul bondi" (Marathi); kadelanchi (Tamil); "saptachakra", "ekanayaka", "pitika" (Sanskrit); "nerani" (Telugu).

IUCN status

As the species has a wide distribution range from Indo-Malaya to China, it is classified here as Least Concern (LC). Rare occurrence of *S. chinensis* in semi-evergreen forests of the Western Ghats (Southern India and Sri Lanka) mentioned by Kamat et al. (2020) is an error; its status as Endangered by Majid et al. (2016) is also an error. However, some individuals in the field (Shimoga, Amba, and Amboli) were observed with cut marks which may indicate its use for medicinal purposes among the local inhabitants. *Salacia chinensis* is the preferred species for the extraction of salacinol, an important antidiabetic compound. Often, it is found growing in areas of human habitation resulting on it being impacted by human activities such as road clearing, road widening, and overharvesting of its edible fruits. Often well grown plants have been uprooted from the wild, mainly for the roots as a source of salacinol (Patwardhan et al. 2014), which is non-renewable. However, considering its wide distribution, these threats do not yet pose a significant risk to the sustenance of the species in the wild. A detailed ecological assessment is required, throughout its range of distribution, to understand the population, regeneration, and threat.

Specimens examined

INDIA: **Andaman and Nicobar Islands,** Great Cocos Island, 1890, *David Prain s. n.* (CAL); Andaman, 1884, *King s. n.* (K, CAL); Baradaug, 10 Feb. 1915, *C.E. Parkinson 290* (K); Ross Island, 29 Apr. *C.E. Parkinson 517* (K); *s. loc.,* 1884, *King s. n.* (K); *ibid, King s. n.* (K); South Nicobar, Navydera, 23 Oct. 1990, *P.V. Sreekumar 15368* (PBL); Middle Andaman, Mayabunder, 03 May 1974, *N. P. Balakrishnan 1306* (CAL); *ibid,* 29 Jan. 1959, *K. Thothathri 9142* (CAL). **Andhra Pradesh,** Vizag, Palkonda hills, Mar. 1884, *J.S. Gamble 14018* (K); *ibid*, *J.S. Gamble 13898* (K). **Assam,** Khasi hills, *s. d.*, *Jenkins 37* (CAL); Abor Hills, 30 Jan. 1912, *I. H. Burkill 36509* (CAL); Cachar**,** Jun. 1874, *R. L. Keenan s. n.* (K); Renjing, 28 Feb. 2012, *I. H. Burkill* 36739 (K). **Karnataka,** Karwar, 16 Feb. 1951, *Joseph Fernandes 2145* (A, CAL); Mangalore, *s. d.*, *R. F. Hohenacker 405* (K)**;** North Canara, 2 May 1995, *W. A. Talbot 1197* (K); Sirsi, Jan. 1867, *R. F. Hohenacker* 769 (K); Banglore, FRLHT campus, 24 Aug. 2016, *M. D. Nandikar 1458* (NGCPR); Shimoga, on the way to Honavar from Jog Fall, 21 Apr. 2017, *D.C. Jadhav 1473*; *ibid*, 2 Mar. 2018, *D. C. Jadhav & M.D. Nandikar 1481* (NGCPR). **Kerala,** Thiruvananthapuram, 16 Dec. 1893, *M. A. Lawson* 24 (K); Thiruvananthapuram, Palode, 5 Feb. 1996, *Parmar* 124 (K); Thiruvananthapuram, Pangappara, 10 May 1994, *A. Nazarudeen 18778*; JNTBGRI Medicinal Garden, 18 June 1996, *A. E. Shanawas 29704* (TBGRI); *ibid*, 16 Feb. 2017, *D. C. Jadhav 1463* (NGCPR). **Maharashtra**, Mumbai (Bombay), *s. d., Dalzell s. n.* (K); Ramghat, *s. d., Dalzell s. n.* (K); Sindhudurg, Amboli, 1 Dec. 1965, *B.G. Kulkarni 107992* (BSI); Way to Ramghat, Amboli, 20 May 1965, *R.D. Pataskar 105297* (BSI); *ibid*, 20 May 1965, *R. D. Pataskar 105293* (BSI); Mangaon forest near Akeri, 23 June 1965, *P. J. Cherian 102290* (BSI); Patgaon 5 miles from Ghotge, 27 Apr. 1966, *B. G. Kulkarni 108516* (BSI); Khanyle 5 miles from Bhedshi, 20 Feb. 1966, *M. Y. Ansari & B. G. Kulkarni 108455* (BSI); Parwad wadi near Ghotge, 11 Feb. 1966, *M. Y. Ansari & B. G. Kulkarni, 107829* (BSI); Bhadgoan 12 miles from Ghotge, 28 Apr. 1966, *B. G. Kulkarni 108538* (BSI); Parwadwadi, 2 miles from Ghotge, 26 Apr. 1966, *B. G. Kulkarni,* 108633 (BSI); Mahadevgad, Amboli, 30 Aug. 1967, *B. G. Kulkarni 108666* (BSI); Bhadgoan near Kudal, 12 Feb. 1966, *M. Y. Ansari 107866* (BSI); Songad, 36 km from Kankavli, 7 June 1970, *B. G. Kulkarni 121096* (BSI); Belachi Ravi 24 km from Kankavli, 7 Oct. 1970, *B.G. Kulkarni, 121528* (BSI); Mali 12 km from Kankavli, 13 Apr. 1971, *B. G. Kulkarni 121196* (BSI); Amboli, Chaukul Road, 20 Apr. 1971, *B. G. Kulkarni, 128829* (BSI); *ibid,* 29 Feb. 2016, *M. D. Nandikar, 1451* (NGCPR); Choukul, Amboli, 18 Apr. 2017, *D. C. Jadhav 1464* (NGCPR); Sawantwadi-Talkat road, 09 Apr. 2019, *M. D. Nandikar 2444* (NGCPR). **Odisha**, *s. loc.,* 1835, *Roxburgh s. n.* (K); Near Khurda, 5 Apr. 1917, *s. coll.* (K); Kuldhia, Tari, *s. d.*, *J.S. Gamble 9314* (K); Sambalpur, Kuldhia forest 29 Dec. 1943, *H. F. Mooney* 2379 (K); Kendrapara, Hukitola, 5 Feb. 1961, *G. Panigrahi 23710* (CAL); *ibid,* 1 Nov. 1972, *L. K. Banerjee 9425* (CAL); Mahanadi delta, Hetamunda, 16 June 1972, *L. K. Banerjee 8976* (CAL); Kendrapara, Bhitarkanika, 18 Feb. 1973, *L. K. Banerjee 10139,* (CAL); *ibid L. K. Banerjee 10124* (CAL); *ibid*, 05 Feb. 1961, *G. Panigrahi 23710* (ASSAM, CAL); Shores of Chilkha Lake, 30 Dec. 1915, *Haines 3899* (CAL). **Tamil Nadu**, *s. loc.,* 1867, *R. Wight 348* (K); *s. loc,* 1866, *R. Wight 468* (K); Ponparappu, 29 Apr. 1896, *s. coll., s. n.* (K); Vilupuram, Marakkananam, 23 Feb. 1972, *F. Blasco* 2243 (K); Pudukottai, Kulathur, Narthamalai, 22 Mar. 1980, *K. M. Matthew 27264* (K); Nagapattinam, Kodikerai, 5 Feb 1995, *H. S. Suresh & Rajan. J. 2719* (FRLH); Viluppuram, Vanur taluka, Marakkanam, 31 Jan. 1996, *W. F. Gastmans 2941* (FRLH); Salem, Attur, Periakalrayans Nagalur Forests, 10 Mar. 1980, *K. M. Matthew 26949*; *26933* (RHT); *ibid*, 05 July 1979, *K. M. Matthew 23568* (RHT); Salem, Attur, Periankalrayans, via Nagalur Reserve Forest to Kumakkal bridle path, 21 Sept. 1978, *N. Venugopal & C. Monoharan 17585* (RHT); Tiruchirappalli, Thuraiyur, Pachaimalais, top Sengattupatty Vengamudi path, 20 Mar. 1978, *K. M. Matthew 12507* (RHT; CAL); *ibid,* 19 Mar. 1978, *K. M. Matthew 12493* (CAL); *ibid,* 17 May 1976, *K. M. Matthew 12360* (CAL); South Arcot, Chidambaram, Killai, opposite to Karithurai, 07 Oct. 1976, *K. M. Matthew & V. A. A. Raj 4326* (RHT); Kanchipuram, Tambaram, MCC Campus, 12 Mar. 1999, *K. M. Matthew & K. T. Augustine 60626* (RHT); *ibid,* 05 Jan. 2001, *C. Livingstone 72082* (RHT); Dharmapuri District, Harur, Kottapatti, 16 May 1978, *K. M. Matthew 14125* (CAL). **Pondicherry,** Auroville, Marakkanam, 27 May 1999, *K.*

M. Matthew, K. T. Augustine & W. F. Gastmans 60778 (RHT). **West Bengal,** Sundarban, 26 Jan. 1894, *R. L. Heinig 22* (CAL); Midanpur, Tapoban, 07 May 1976, *Sudarran Maiji 6498* (CAL); Sagar Island, 01 May 1967, *A. K. Muk s. loc., s. d., V. Ball 177* (K).

Notes

The scandent habit of *S. chinensis* can often be seen along the riverbanks and the erect shrubby habit is abundant on the plateaus in Maharashtra, Karnataka, Kerala, and Tamil Nadu. It can be recognised by the few-flowered axillary and ramiflorous fascicles, smaller globose, 1-seeded fruit with thin exocarp and hyaline, pulpy endocarp.

Collections from the Andaman and Nicobar Islands are more likely to be of *S. platyphylla*, as the latter differs from *S. chinensis* in its broader leaves and 2-seeded berries. *Salacia chinensis* is similar to *S. megacarpa* in having obovate to oblanceolate petals, but the latter is clearly distinguished by its branched cymes and ellipsoid to prolate, ridged, dry fruits.

4. *Salacia fruticosa* Wall. ex M.A. Lawson in Fl. Brit. India 1(3): 628. 1875. (Figure 11)

Type: India, Karnataka, Wallich Cat. No. 4223, *Herb Heyne s.n.* (K! barcode K001038432) lectotype here designated; isolectotype CAL! barcode CAL87503).

(=) *Christmannia courondi* Dennst. ex Kostel. Allg. Med.-Pharm. Fl. 5: 2005. 1836. *nom. illeg.* (Nicolson and Suresh 1986).
Iconotype: 'Courondi' Rheede Hort. Malab. 4: t. 50. 1683.

Description

Scandent shrubs or lianas up to 2(–6) m high; stems terete, branched, branchlets looped, glabrous. Leaves opposite to sub-opposite, exstipulate; petioles 5–6 mm; lamina ovate–broadly elliptic, 4–10(–12) × 2–5 cm, apex acute–acuminate, base obtuse–cuneate, margin usually crenate, rarely entire, midrib distinct, lateral nerves 5 or 6 pairs. Inflorescences axillary and ramiflorous, pedunculate, peduncle 5–10 mm long, 10–14-flowered cymes; buds globose; pedicel 1–1.2 cm long, glabrous; bracts sepaloid; sepals fused, lobes oblong, 0.3–0.4 × 0.4 mm, undulate, crisped, white, faintly ciliate; petals orbicular, 1.5 × 1.5 mm, ochreous, margin faintly hyaline; disk flat to annular, fleshy, orange or ochreous; stamens 3, inserted on disk, filaments linear to clavate, white; anthers bilobed, ovoid, yellow, thecae confluent longitudinally; ovary globose, 3-celled, style short, stigma simple. Fruits baccate, shortly stipitate, globose, 2.5–3.5 × 2–3 cm, exocarp smooth, orange when ripening, endocarp mucilaginous, 2- or 3-seeded; seeds angular, ovoid, or ellipsoid, 1.5–2 × 1 cm, peach coloured.

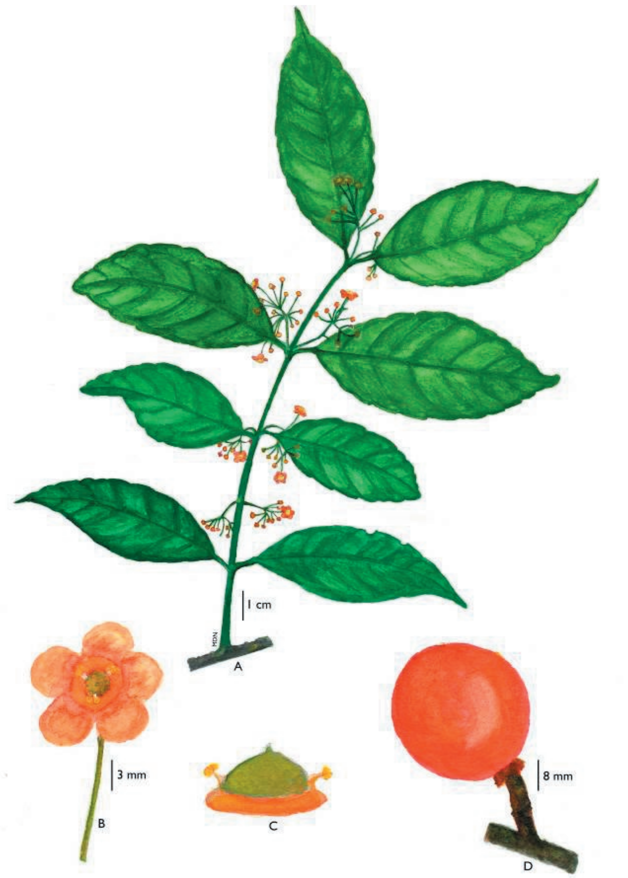

Figure 11. *Salacia fruticosa* (A) Flowering twig. (B) Flower. (C) Disc. (D) Fruit

Phenology

Flowers in January, fruits may remain till end of August, rarely till November.

Distribution and habitat

Endemic to the Western Ghats of Karnataka, Kerala, and Tamil Nadu (Figure 18). It prefers semi-evergreen to evergreen fringing forest, also known from coastal scrubland.

Vernacular name

"korandi" (Tamil, Malayalam)

IUCN status

S. fruticosa is recorded from several localities in the states of southern Western Ghats with strong and viable populations. Currently, no threats have been observed or recorded and no plausible future threats are recognised. Therefore, it is assessed as Least Concern (LC).

Specimens examined

INDIA. **Karnataka**, Coorg, Mar. 1817, Herb. Rottler ex *Heyne s.n.* (K [K000687001]); Mangalore, Jan. 1847, *Hohenacker s. n.* (K); Udupi, Brahmavara, 2 May 1980, *C.J. Saldanha 11366* (CAL); Dakshin Kannada, Vittala, 24 Mar. 2016, *D. C. Jadhav 1452* (NGCPR). **Kerala**, Quilon (Kollam), 1835, *R. Wight 467* (K); *s. loc.,* 5 Apr. 1895, *T. F. Bourdillon 570* (K); Wayanad, Thambarcheri Ghats, 21 Jan. 1903, *C. A. Barber 5679* (K); Kasargod, 22 Feb. 1913, *C. A. Barber 8810* (K); Thenmala, Ariyankavu, 9 Mar. 1980, *C. E. Ridsdale 540* (K); Kannur District, Kannoth R.F., 16 Feb. 1978, *s. coll. 54009* (CAL); Kannur, Aralam, 26 Feb. 1979, *V. S. Ramachandran 61928* (CAL); Kasargod, Panathur, 29 June 1980, *R. Ansari 67913* (CAL); Kasaragod, Sreekantapuram, 15 May 1982, *V. J. Nair 73097* (CAL); Pathanamthitta, Aryattukavu, Nilakkal, 26 Feb. 1988, *Anil Kumar 496* (CAL); Kasargod, Mulleria, 8 May 1982, *U. J. Nair 7105* (CALI); Idukki, Painavu, 27 Apr. 1984, *C. N. Mohanan 81637* (CALI); Palakkad, Panthenthode border, 8 May 1984, *T. Sabu 11444* (CALI); Malappuram, Calicut University Campus, 12 Feb. 1989, *Q. P. Elsie 43120* (CALI); Pathanamthitta, Moozhiyar forest, 8 June 1990, *R. Chandrasekaran 94010* (CMPR); Idukki, Elappara, 22 Sep. 2005, *P. S. Udayan 3629* (CMPR); Chandanathode, 20 Apr. 2010, *P. S. Udayan 6716* (CMPR); Kannur, Udayagiri 5 Jan. 2009, *P. S. Udayan 5377* (CMPR); Kollam, Kulathupuzha 7 Feb. 2008 *P. S. Udayan 4503* (CMPR); Kozhikkode, Koorachurdu, 19 May 2003, *P. S. Udayan 1671* (CMPR); Kozhikkode, Jeerakappra 22 July 1994 *A. Nazarudeen 22753* (TBGRI); Kottayam, Peringulam, 11 Apr. 2009, *A. J. Robi 5885* (CMPR); Ammayambalam pacha, 2 July 1992, *A. Nazarudeen 14345* (TBGRI); Kollam, Arienkavu, 24 Sep. 1993, *A. Nazarudeen 18060* (TBGRI); Kasargoad, Edaneer kavu, 12 Mar. 1993 *A. Nazarudeen 16418* (TBGRI); Malappuram, Kottakkal, CMPR Herbal Garden, 26 Mar. 2016, *D. C. Jadhav, 1453* (NGCPR); Pathanamthitta, Attathode, 20 Mar. 1994, *A. Nazarudeen 20302* (TBGRI); Kottavasal, 28 June 1994, *A. Nazarudeen 21796* (TBGRI); Pangappara, 10 May 1994 *A. Nazarudeen 18779* (TBGRI); Kollam, Thenmala, 25 Nov. 2004, *Geethakumary 55375* (TBGRI); Dharpakulam, 29 May 2012, *Deepthy & Usha 76215* (TBGRI); Thiruvananthapuram, Pallode, 15 Feb. 1996, *P. Chiranjit 126* (K); Trissur, Peechi, 16 Mar. 1996, *P. Chiranjit* 130 (K); Thiruvananthapuram, Palode, JNTBGRI garden, 21 Feb. 2014, *S. M. Shareef 79239* (TBGRI); Idukki, Lakshmi Estate, 30 Dec. 2014, *Deepthy & Jaya 76210* (TBGRI); Thiruvananthapuram, JNTBGRI Garden, Palode, 16 Feb. 2017, *D.C. Jadhav 1460* (NGCPR); Kozhikode, Kakkayam Ghat, 6 Mar. 2018, *D. C. Jadhav & M. D. Nandikar 1484* (NGCPR); KFRI Garden, Trissur, Aug. 2016, *K.C. Kishor s. n.* (NGCPR00509; NGCPR00510). **Tamil Nadu**, Annamalai Hills, 1885, *R.H. Beddome s. n.* (K); Kanyakumari, Lower Kodayar, Vallachithode, 28 Mar. 1981, *A. N. Henry 70665* (CAL); Karur, Devarmalai, 13 Aug. 1988, *R. Chandrasekaran 89205* (CAL); Kanyakumari, Kulasekaram, Pechiparai, 17 Mar. 1994, *S. P. Subramani 560* (FRLH).

Notes

Salacia fruticosa can be recognised in the field by its scandent habit, ovate-elliptic, crenate leaves, acute-acuminate apex, pedunculate dichotomously branched cymes, orbicular petals, and smooth, orange fruits. It was first described as *Tonsella fruticosa* in Wallich Catalogue (no. 4223), based on Heyne's collection and later validated by Lawson citing additional collections by *Rottler, Hoenacker*, and *Kurz*. The collection by *Heyne* here designated as lectotype was cited in Wallich Cat. 4223 and agrees with the protologue.

Rheede's (1683) 'Courondi' was previously attributed to *Salacia chinensis* (Ding Hou 1964, Nicolson & Suresh 1986). However, the branched cymes and orbicular petals illustrated by Rheede's artists agree more with *S. fruticosa* (a much more common species in the Malabar region) than *S. chinensis.*

5. ***Salacia gambleana*** Whiting & Kaul in Bull. Misc. Inform. Kew 1940(7): 300. 1941. (Figure 12)

(=) *Salacia talbotii* Gamble in Bull. Misc. Inform. Kew 1916(5): 133. 1916 *nom. illeg.*, *non* Baker Cat. Pl. Oban 19: 1913.

Type: India, Karnataka, North Canara, Anshi Ghat, 2 June 1885, *W. A. Talbot 1217* (lectotype K! barcode K000669981), designated by Jadhav et al. (2016).

Description

Scandent shrubs or spreading lianas up to 4(–7) m high; branchlets looped, lenticellate. Leaves simple, opposite to subopposite, exstipulate; petiole 1–1.5 cm long; lamina usually oblanceolate, rarely elliptic-oblong, 6–12 × 3–4 cm, apex abruptly acute, base attenuate, margin obscurely undulate, recurved, glabrous, lateral nerves 6–8-paired. Inflorescences axillary, ramiflorous, few to many-flowered, tuberculate fascicles; buds glo-

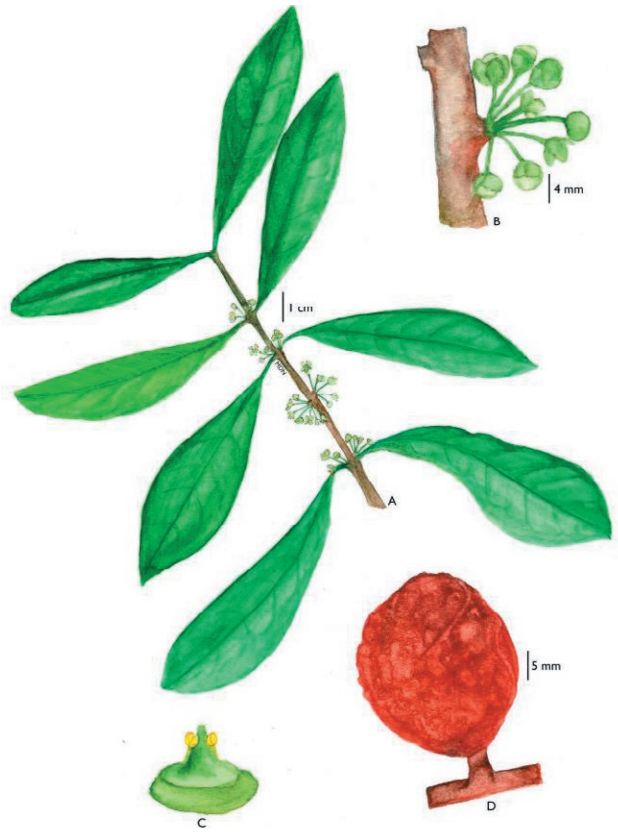

Figure 12. *Salacia gambleana* (A) Flowering twig. (B) Disc. (C) Inflorescence. (D) Fruit.

bose; pedicels glabrous, c. 8 mm long; sepals ovate, c. 1.5 mm long, margin laciniate to fimbriate, pale green; petals elliptic to ovate, c. 4 mm long, obtuse, coriaceous, pale yellow to green, margin hyaline; disk conical or annular, greenish yellow; stamens 3, inserted on inner margin of the disc, anthers bilobed, globose, yellow, thecae confluent transversely; ovary embedded in disc, 3-celled, style short, conical, exserted; stigma inconspicuous. Fruits baccate, globose to ellipsoid, 2–3 cm across, exocarp smooth to verrucose, often tuberculate, orange when ripen; endocarp mucilaginous, 2–5-seeded; seeds dorsiventrally compressed or discoid, oblong or ellipsoid, or oblate c. 10 × 7 mm, peach coloured.

Phenology

Flowers between January to April, fruits may remain till July.

Distribution and habitat

Endemic to the Western Ghats of Karnataka and Maharashtra (Figure 18). Evergreen forest, fringing forest, at 550 m a.s.l.

IUCN status

S. gambleana is occasionally found in the forests of north Karnataka and western Maharashtra. The species occurs at considerable number of localities and no threat is known at present. Hence, it is assessed here as List Concern (LC). However, more detailed study on population size and threats are needed to have precise IUCN status. Although the species was assessed as Vulnerable (VU) by Kamat et al. (2020), no data on population size and threat were provided by them to support their assessment.

Specimens examined

INDIA. **Karnataka**, North Canara, Anshi Ghat, 25 Jan. 1886, *W.A. Talbot 1361* (K, CAL); Agumbe, 15 May 1960, *R.S. Raghavan 62515* (CAL); Barakana, Agumbe, 13 June 1961, *R.S. Raghavan 74211* (CAL, BSI); Minhole, Agumbe, Shimoga, 19 Feb. 1963, *R.S. Raghavan 86353* (BSI); Agumbe, 28 Mar. 2016, *D.C. Jadhav 1456* (NGCPR); Basanbail village, 21 Apr. 2017, *D.C. Jadhav 1471* (NGCPR); *ibid, D.C. Jadhav 1472* (NGCPR); Shimoga, Sharavati River Valley viewpoint, 21 Apr. 2017, *D. C. Jadhav 1476* (NGCPR); Anshi Ghat, 20 Apr. 2017, *D.C. Jadhav 1468* (NGCPR). **Maharashtra**, Kolhapur, Dajipur, 3 Jul. 2016, *M.D. Nandikar 1457* (NGCPR).

Note

Salacia gambleana is mostly confused with *S. macrosperma* due to the similar habit and floral characters. However, the latter can be differentiated by its elliptic-oblong leaves, and 6–12-paired lateral nerves. I have examined several collections (from Maharashtra, Karnataka, and Kerala) at CAL, BSI, and MH that were wrongly identified as *S. macrosperma* and *S. beddomei*. The oblanceolate leaves and 6–8-paired lateral nerves are amongst the more reliable characters to separate *S. gambleana* from allied species. Most collections from Agumbe, Karnataka clearly belong to *S. gambleana*.

6. ***Salacia macrosperma*** Wight, Spicil. Neilgh. i. 28. t. 32. October 1845; Icon. Pl. Ind. Orient. 3(3): 5, t. 962. November 1845. (Figure 13)

Type: India, Kerala, Sispara peak, *s. d., Wight s. n.* (K! barcode K000669996), lectotype here designated.

(=) *Salacia beddomei* Gamble in Bull. Misc. Inform. Kew 1916(5): 133. 1916 **syn. nov.**
Type: India, Tamil Nadu, Coimbatore District, Annamalai hills, 1866, *R. A. Beddome s.n.* (lectotype K!

Figure 13. *Salacia macrosperma* (A) Flowering twig. (B) Disc. (C) Inflorescence. (D) Fruit.

barcode K000669921; isolectotype MH! barcode MH00001914), designated by Jadhav *et al.* (2016).

(=) *Salacia vellaniana* Udayan, Yohannan & Pradeep in Candollea 68(1): 148. 2013 **syn. nov.**
Type: India, Kerala, Thrissur District, Vellanipacha 26 Feb. 2011, *Udayan S005* (holotype CALI; isotypes MH, SKC, SNCH).

Description

Scandent shrubs or straggling lianas up to 2(–9) m high; branched, branchlets thick, grey to brown glabrous to lenticellate, distal branches spreading. Leaves opposite to sub-opposite, exstipulate, petiole 0.5–1 cm long; lamina elliptic-oblong or obovate-elliptic, 8–15 × 3–7 cm, apex acute to acuminate, base narrowly cuneate, rounded-obtuse, margin entire, rarely serrate to crenate, midrib distinct, venation anastomosing, lateral nerves 6–12 pairs. Inflorescences axillary, ramiflorous, 4(–7) to many-flowered, tuberculate fascicles; buds globose, flowers pedicellate, pedicel 5–9 mm long, glabrous; bract sepaloid; sepals fused at base, lobes ovate-oblong, 0.8–0.6 mm long, laciniate to fringed; petals ovate to elliptic, 1–1.9 × 1.2–1.3 mm, pale green-yellow, margin hyaline; disk flat, annular, pale-yellow; stamens 3, inserted on the disk, filaments short, broad at the base, anthers bi-lobed, globose, yellow, thecae transversely confluent; ovary 3-celled; style short, conical, c. 0.4 mm long; stigma simple. Fruits baccate, globose to ellipsoid, 2.5–4 × 2–3, exocarp orange when ripen, smooth to faintly tuberculate, or smooth, endocarp mucilaginous, 3–6-seeded; seeds ovoid, ellipsoid, often discoid, c. 2.5 × 1.5 cm, ochraceous.

Phenology

Flowers between February to April and fruits may remain till August.

Distribution and habitat

Endemic to the Western Ghats of Goa, Maharashtra, Karnataka, Kerala, and Tamil Nadu (Figure 19). Straggling over small trees in semi evergreen fringed forest, along roads, often grows as large shrubs with distal scandent branches along the edges of plateaus.

IUCN status

S. macrosperma is widely distributed in the Western Ghats, and a good and stable population trend was observed during the field surveys. Also, no major threats or future obstacles were detected. Hence, it is assessed here as Least Concern (LC).

Specimens examined

INDIA. **Goa,** Molem, Anomd Ghat (Karnataka Border), 19 Apr. 2017, *D. C. Jadhav 1466* (NGCPR); *ibid*, Anmod Ghat, *D. C. Jadhav 1467* (NGCPR). **Maharashtra,** Sindhudurg, Amboli, Mahadeogad, 4 Sep. 1968, *B. G. Kulkarni 108678* (BSI); Sindhudurg, Amboli, 22 Apr. 1971, *B. G. Kulkarni 128874* (BSI). **Karnataka,** Belgaum, Yadur village, 11 Feb. 1963, *R. Raghavan 86009* (BSI); Belgaum, Londa, Anmod Road, 22 May 1979, *C. J. Saldanha 7817* (CAL); Chorla Ghat, 31 June 2017, *M. D. Nandikar 1533* (NGCPR); Hassan, Between Devalkere & Devarunde, 19 Feb. 1972, *Ramamoorthy & K. N. Gandhi 2674* (K); *ibid,* 14 Apr. 1969, *C. J. Saldanha 13338* (K); Agumbe, Nishanigudda Road, 19 May 1960, *R. Raghavan 62737* (A); Agumbe, Ghatibagh, 15 May 1950, *R. Raghavan 80614* (BSI); Shimoga, Agumbe, Cattle shed, 17 May 1960, *R. Raghavan 62599* (CAL); Nallur, 7 Feb. 1961, *R. Raghavan 69442* (BSI); Kalmane, 19 May 1962, *R. Raghavan 80765* (BSI); *ibid*, 13 Feb.1963, *R. Raghavan 86225* (BSI); Shimoga, Agumbe Ghat, 28 Mar. 2016, *D. C. Jadhav 1456* (NGCPR); Yana Ghats, on the way to Vaddi village, 21 Apr. 2017, *D.C. Jadhav 1469* (NGCPR); Malemande, 21 Apr. 2017, *D. C. Jadhav 1475* (NGCPR); Thalacauvery, 04 Mar. 2018, *M. D. Nandikar & D. C. Jadhav 1482* (NGCPR); Devimane Ghats, 22 Apr. 2017, *D. C. Jadhav 1478* (NGCPR); Karikanamma, 22 Apr. 2017, *D. C. Jadhav 1477* (NGCPR); Basanbail, 02 March 2018, *D. C. Jadhav 1480* (NGCPR); Shimoga, Sharavathi River, Valley viewpoint, 21 Apr. 2017, *D. C. Jadhav 1474* (NGCPR); Chorla Ghat, 03 June 2017, *M. D. Nandikar 1532* (NGCPR); Yana Ghat, on the way to Vadi Village, 21 Apr. 2017, *D. C. Jadhav 1470* (NGCPR), **Kerala,** Kakkayam Dam Site, 06 Mar. 2018, *D. C. Jadhav & M. D. Nandikar 1486* (NGCPR); Malappuram, Calicut, 20 Feb. 2010, *M. S Devipriya & Regy Yohannan CNCHS3* (MH). *ibid*, 25 Jan. 2006, *P. S. Udayan 3978* (CMPR); Malappurum, Kottakkal, Herb Garden, 26 Mar. 2016, *D. C. Jadhav 1454* (NGCPR); Malappurum, Kottakkal, Herb Garden, 15 Jan. 2007, *P. S. Udayan 5026* (CMPR); *ibid*, 23 Jan. 2008, *P. S. Udayan 4380* (CMPR); Kozhikkode, Vellarimala, 1 Feb. 2008, *P. S. Udayan 4499* (CMPR); Kannur, Aralam, 23 Feb. 2008, *P. S. Udayan 4749* (CMPR); Malappuram, Anoli 4 Mar. 2009, *A. J. Robi. 5714* (CMPR); Kozhikode, Kakkayam, 5 June 2008, *P. S Udayan 5102* (CMPR); Palghat, Panthanthode to Dam site via old road, 3 Apr. 1983, *N. C. Nair* 77279 (K); *ibid* 3 Apr. 1983 *N. C. Nair 77282* (K); *ibid*, 3 Apr. 1983, *N. C. Nair 77279* (MH); Palghat, Silent valley, 8 Feb. 1995, *N. Sasidharan 10687B* (FRLH); Palode, 10 Apr. 1992, *A. Nazarudeen 14132* (TBGRI); Palode, 24 Feb. 1993, *A. Nazarudeen 16156* (TBGRI); Thiruvananthapuram, near damp site TBGRI, 30 Jan. 1996, *Jothish P. S. 27634* (TBGRI); Thiruvananthapuram, Vitalapacha, 18 Feb. 1992, *A. Nazarudeen 13846* (TBGRI); Palghat, Aruvappra 19 Nov. 1993, *A. Nazarudeen, 18722* (TBGRI); Kozhikkode, Jeerakappra, 22 July 1994, *A. Nazarudeen 22752* (TBGRI); Palakkad, Poochapara, 6 Mar. 2009, *A. J. Robi 5685* (CMPR); Palakkad, Mukkali forest, 7 Mar. 1975, *E. Vajravelu 49782* (CAL, MH); *ibid*, 18 July 1969, *E. Vajravelu 32184* (MH); *ibid*, 7 Mar.. 1975, *E. Vajravelu 46233* (MH); Panthenthode, 10 Apr. 1978, *N. C. Nair 56730* (MH); Kollam, Chandanathope, 30 Apr. 1979, *V. S. Ramachandran 61655* (MH); Mukkali forest, *E. Vajravelu, 33319* (MH); Kollam District, *s.l.* 18 Feb. 2010, *Devipriya M.S & Regy Yohannan, s.n.* (MH); Thrissur District, Vellanimala, 18 Apr. 1984, *N. Sasidharan 3079* (KFRI); *ibid*, 10 May 1985, *N. Sasidharan 3484* (KFRI); *ibid,* 13 Mar. 1987, *N. Sasidharan 3940* (KFRI); *ibid*, 11 Jan. 2013, *N. Sasidharan 27903* (KFRI); *ibid*, 23 Feb. 2005, *P.S. Udayan et al. 03371* (CMPR); *ibid*, 20 June 2009, *P.S. Udayan et al. 06121* (CMPR).

Note

In addition to *Salacia gambleana* (see the note under *S. gambleana*), *S. macrosperma* also resembles *S. salacioides* in having entire leaves, axillary fascicles and ovoid fruits. However, the latter differs by its drooping branches, stipulate, broadly lanceolate leaves and orbicular petals. *Salacia macrosperma* is an extremely variable species, particularly in its leaf size, number of lateral nerves, and smooth to faintly tuberculate fruits. Some variants earlier described as separate species have been compared based on their protologues, and live collections of *S. macrosperma* from Kerala. The analysis reveals the description of *S. macrosperma* to be a perfect match for *S. beddomei* and *S. vellaniana*. *Salacia beddomei* Gamble (1916) was described based on Beddome's collection from Anamalai Hills, Tamil Nadu. The species was differentiated from *S. macrosperma* by having larger leaves with prominent lateral nerves and reddish brown, fimbriate sepal margins. I had an opportunity to observe the original material of *S. beddomei* at K (K000669921) and MH (MH00001914), and to compare the type of *S. macrosperma*. After studying the protologue, illustration made by Gamble on the type sheet revealed that the characters used to describe *S. beddomei* matches those of *S. macrosperma*, hence it is here relegated to synonymy. Unfortunately, Gamble (1916) had not seen the fruits for *S. beddomei* and this might have led him to misinterpret the species. *Salacia vellaniana* from Vellanimala, Thrissur, Kerala (Udayan et al. 2013) is based on characters such as smaller leaves, short petiole, few-flowered cymes, colour of the petals and sepals, and warty fruits. All these characters are within the variation range for *S. macrosperma*.

7. ***Salacia malabarica*** Gamble in Bull. Misc. Inform. Kew 1916(5): 133. 1916. (Figure 14)

Type: India, Kerala, Kollam District, Travancore Hills, Nov. 1887 *T. F. Bourdillon 18* (MH! barcode MH00001913), lectotype designated by Jadhav et al. (2016).

Description

Scandent shrubs or lianas up to 2(–5) m high; branchlets purplish, terete, glabrous or lenticellate, grey to brown. Leaves opposite, exstipulate, petiole 1–1.2 cm long, lamina elliptic-oblong or obovate, 8–16 × 3.5–7 cm, apex obtuse–acute, base shortly attenuate or obtuse, margin distinctly serrate, lateral nerves 7–10 pairs. Inflorescences axillary, ramiflorous, 2–many-flowered, tuberculate fascicles; pedicel 1.5–2(–2.5) cm long, glabrous; sepals fused at base, lobes ovate, 3 mm long, entire to sparsely ciliate, pale green; petals elliptic-oblong, 5–7

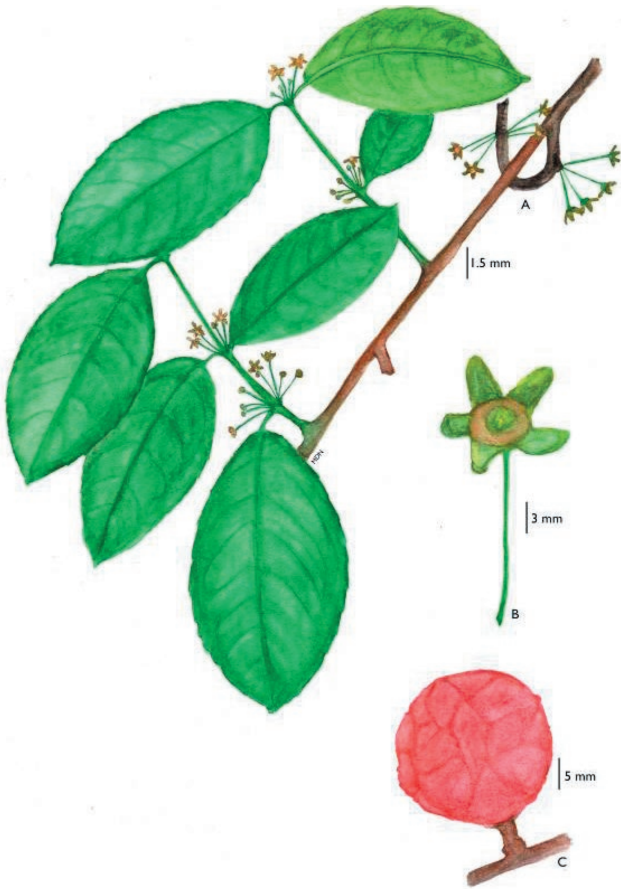

Figure 14. *Salacia malabarica* (A) Flowering twig. (B) Disc. (C) Fruit.

× 2–3 mm, green, margin greenish yellow; disc yellow-ochreous, conical, stamens inserted between lobes of disc, filaments usually recurved, rarely porrect, short, flattened, anthers globose, yellow, thecae transversely confluent; ovary embedded in the disc, 3-celled, style conical, stigma simple. Fruits baccate, globose, 1.5–2.5 cm in diameter, exocarp verrucose, orange at maturity, endocarp mucilaginous, 3–6-seeded; seeds ovoid, ochreous to brown.

Phenology

Flowers from November, peak in February and fruits may remain till June.

Distribution and habitat

Endemic to the Western Ghats of Karnataka and Kerala (Figure 19). It grows in evergreen and moist deciduous forest, coastline scrubland and fringing forest. Its occurrence in southeast Asia as recorded by Kamat et al. (2020) is wrong.

IUCN status

S. malabarica is sporadically distributed in coastal districts of Kerala and south Karnataka. The southernmost distribution is Kottoor Reserve Forests, whereas the northernmost distribution is known from Dakshin Kannada District. As much of the known populations falls within the Biosphere Reserves, hitherto no threat has been observed and the species is seemingly secured and protected. Hence, it is assessed here as Least Concern (LC). The IUCN status as Endangered (EN) by Kamat et al. (2020) is flawed and contradicts their remarks on the species' distribution.

Specimens examined

INDIA. **Kerala,** Palghat, Silent Valley, 25 Jun. 1976, *C. E. Ridsdale 285* (K); Kollam, Travancore Hills, Nov. 1887, *T. F. Bourdillon 18* (MH); *ibid*, 25 Nov. 1893 *T. F. Bourdillon s.n.* (MH [MH00001912], K [K000669995]); Kollam, Kattlapara to Choodal, Shendurney Wildlife Sanctuary, 7 Feb. 2008, *P. S. Udayan 4512* (CMPR); Wayanad, 13 Apr. 2009, *M. S. Devipriya & Regy Yohannan 171691* (MH); Wayanad, Kuruva Island, 5 Apr. 2009, *A. J. Robi 5835* (CMPR); Thiruvananthapuram, JNTBGRI, 17 Jan. 2014, *S. M. Shareef 79215* (TBGRI); *ibid*, 13 Feb. 2014, *S. M. Shareef 79227* (TBGRI); Agasthyavanam, Kottur Reserve Forest, 3 Apr. 1973, *J. Joseph 44010* (MH); JNTBGRI, Palode, 16 Feb. 2017, *D. C. Jadhav 1461* (NGCPR). **Karnataka,** South Canara, *s.d.*, *Beddome s. n.* (MH); South Canara, Subramanya, 25 Feb. 1997, *S. R. Ramesh 9925* (FRLH).

Note

S. malabarica can be recognised by its elliptic-oblong or obovate, distinctly serrate leaves, 2–12, pedicellate (1.5–2 cm long) flowers on axillary, ramiflorous, tuberculate, fascicles. It shares similarities with *S. gambleana* and *S. macrosperma* but differs in having broadly elliptic to oblong, serrate leaves and long pedicellate flowers. *Udayan 04512* (CMPR) from Shendurney Wildlife Sanctuary, has entire to faintly serrate leaves, and c. 2.5 cm long fruiting pedicel, but it appears to agree with *S. malabarica* in most of the other diagnostic characters of the species.

8. ***Salacia megacarpa*** N.V.Page & Nandikar in Nordic J. Bot. 38(4)-e02647: 2. 2020. (Figure 15)

Type: India, Karnataka, Abailu Antipoaching Camp, Bramhagiri Wildlife Sanctuary, Virajpeth Taluk, Kodagu District, 850 m. a.s.l., 23 Jan. 2016, *N.V. Page 22201* (holotype: MH, isotypes: JCB, WII, NGCPR).

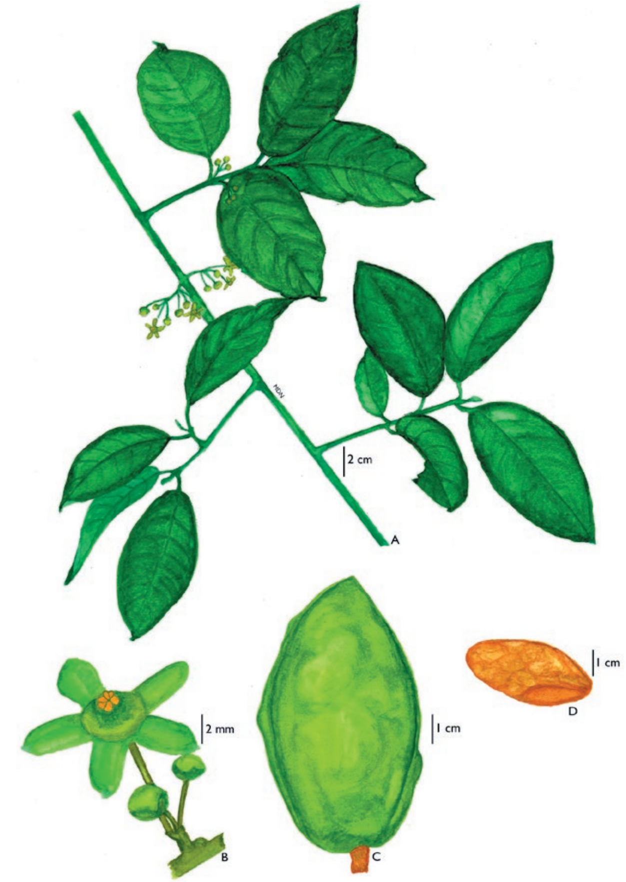

Figure 15. *Salacia megacarpa* (A) Flowering twig. (B) Inflorescence. (C) Fruit. (D) Seed

Description

Scandent shrubs or spreading lianas up to 2(–4) m high; branches slender, hooked, glabrous, sparsely lenticellate. Leaves opposite, stipules inconspicuous or absent; petiole 1–1.5 cm long, lamina broadly elliptic-ovate, oblong, 9–17 × 3.5–8 cm, apex rounded to obtuse or acute, base cuneate or rounded, margin entire or faintly crenate, coriaceous, surface glabrous, adaxial dark green and abaxial light green; midrib and lateral nerves 6–10 in pairs and prominent with brown after drying. Inflorescences axillary and ramiflorous, 3–6 flowered cymes, peduncle c. 5 mm long. Flower buds spherical or globose, citrine, with calyptriform sepals; flowers c. 10 mm wide, dark greenish yellow, pedicel 3–5 mm long, sparsely puberulous, bracts minute, pedicel base with 1 or 2 inconspicuous rudimentary flowers with 2–4 petal whorls; sepals fused at base, lobes ovate, c. 1 × 1 mm, margin sparsely erose; petals elliptic-oblong, 3–4 × 2 mm, grey-green to yellowish green; apex rounded or acute, hyaline or erose, margin entire, hyaline, often revolute; disc pentagonous, pulvinate, c. 2 mm high, carnose, yellowish green; stamens 3, recurved, erect at anthesis, filaments short, c. 0.7 mm in length, with dilated bases; anthers bilobed, saffron or lemon, ovoid, thecae confluent obliquely; pistil pyramid shaped, cleft into 3, stamens emerging from each cleft of pistil; style c. 0.6 mm long; stigma simple; ovary embedded in disk, tri-locular. Fruits baccate, shortly stipitate, prolate to broadly ellipsoid, or ovoid, 7–10 × 4–6 cm, distinctly 2- or 3-keeled, apex acute, greenish yellow, exocarp thin, endocarp dry, 5–8-seeded; seeds triangular to ovoid or ellipsoid, truncate (on hilum side), c. 3 × 2 cm, without mucilaginous pulp, ochreous, surface glabrous and with faint reticular meshes, hilum linear, sericeous.

Phenology

Flowers between January March, followed by fruiting till June.

Distribution and habitat

Endemic to the Western Ghats of Karnataka and Kerala (Figure 19). It grows in open and semi evergreen forest, fringing forest, along the perennial streams.

ICUN status

The conservation status is assessed as Least Concern (LC). At present the species is known from two localities in Karnataka and Kerala. No threats have been observed as both the locations are well protected and forms part of a Biosphere Reserve.

Specimens examined

INDIA. **Kerala**, Kozhikode, Malabar Wildlife Sanctuary, Kakkayam Dam, 6 Mar. 2018, *D. C. Jadhav & M. D. Nandikar 1485* (NGCPR, BSI). **Karnataka**, Kodagu, Virajpeth, Abailu Antipoaching Camp, Bramhagiri Wildlife Sanctuary, 16 May 2017, *N.V. Page 22201B* (WII, fruit: spirit collection).

Note

Lack of mucilaginous or fleshy seeds or endocarp in the fruits of *Salacia megacarpa* makes its distinct among its congeners. All the *Salacia* species in the study area have orange-ochreous, tawny fruits at the maturity, except the present species in which the fruits remain are green or greenish yellow at maturity. One of the largest fruits (c. 6 cm long) in the genus was described from the Malaysian *S. maingayi* M.A. Lawson (Ding Hou 1964). However, *S. megacarpa* fruits are claimed to be the largest in *Salacia* and is also distinct due to the presence of three keels running along the longitudinal axis of the fruit.

Salacia megacarpa is similar to *S. fruticosa* with respect to its habit and inflorescence but the later differs in having crenate leaf margins, orbicular petals and 2- or 3-seeded, orange berries and mucilaginous pulpy seeds. *Salacia oblonga* also has axillary and ramiflorous, dichotomously branched cymes. The latter can, however, be easily differentiated from the species described here by having subsessile, urceolate flowers, globose and orange-red fruit. The Indo-Malaysian *S. korthalsiana* also has similar branched cymes but can be distinguished based on single-seeded fruits. The Southeast Asian *S. maingayi* is the only other species which has comparable sized large fruits; however, it can be distinguished based on 1 or 2 axillary flowers.

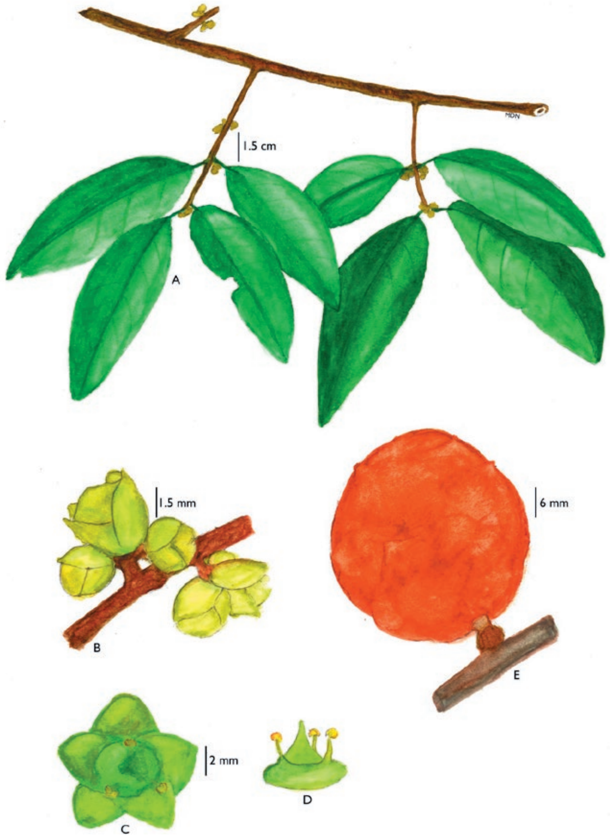

Figure 16. *Salacia oblonga* (A) flowering twig. (B) Inflorescence. (C) Flower. (D) Disc. (E) Fruit.

9. *Salacia oblonga* Wall. ex Wight & Arn., Prodr. Fl. Ind. Orient. 1: 106. 1834. (Figure 16)

Type: India, Wallich Cat. no. 4226, *Herb Wight 351* (E! barcode E00174247), lectotype here designated.

(=) *Salacia oppositifolia* Rottler ex Wight & Arn. Prodr. Fl. Ind. Orient. 1: 106. 1834 *pro syn., nom. inval.*
(=) *Salacia oblonga*. var. *kakkayamana* Udayan & Raghu in Int. J. Pl. Anim. Environm. Sci. 4(3): 100. 2014. **syn. nov.**
Type: India, Kerala, Kozhikkode, Malabar Wildlife Sanctuary, Kakkayam, 12 Mar. 2012, *P.S. Udayan, A.V. Raghu & E.M. Muraleedharan 27802* (holotype CAL; isotypes MH, CALI, SKC, KFRI).

Salacia pomifera Wallich Numer. List no. 4227. 1831. *nom. nud.*

Description

Climbing or straggling shrubs or small trees up to 1(–3) m high; young branchlets terete, rusty, abruptly yellow-corrugated. Leaves opposite or sub-opposite, petioles c. 1 cm long, lamina elliptic-oblong, rarely, oblanceolate, 7–12.5 × 2.5–3.2 cm, apex obtusely acuminate, base obtuse, margin entire, coriaceous, adaxial surface emerald, abaxial surface citrine, drying yellow, midrib distinct, venation anastomosing, lateral nerves 5–6 in pairs. Inflorescences axillary, ramiflorous branched, subsessile (peduncle c. 5 mm long) , 5- or 6-flowered cymes; flowers urceolate; sepals fused at base, lobes ovate to orbicular, c. 2 × 2 mm, apex rounded, margin sparsely erose; petals 5, free, oblong, c. 4 × 3 mm, yellowish green, apex rounded, margin entire, chartaceous; disk conical, pale green; stamens 3, inserted in the disk, filaments broad at base, c. 1.5 mm long, anthers bilobed, pale yellow, ovoid to ellipsoid, thecae confluent longitudinally; ovary embedded in disc, 3-celled, style short, conical. Fruits baccate, globose or sub-globose, 2–5 cm in diameter, supported on persistent calyx, smooth, rarely uneven or tuberculate, exocarp bright orange-red when ripe, endocarp mucilaginous, 2–8-seeded; seeds 2–8, angular, deltoid, c. 2.7 × 1.5 cm, ochreous or brown.

Phenology

Flowers between January to March, fruits may remain till end of July.

Distribution and habitat

Peninsular India (Goa, Karnataka, Kerala, Maharashtra, and Tamil Nadu) and Sri Lanka. Semi-evergreen forest, fringing forest, undergrowth forest, along the plateaux borders. The species occurrence in southeast Asia by Kamat et al. (2020) is erroneous.

Vernacular name

"ponkoranti" (Malayalam).

IUCN status

Though the species is fairly widely distributed in peninsular India and Sri Lanka, an IUCN Red list category of Vulnerable (VU) [A2cd] is assigned to it (Ved et al. 2015), mainly due to decline in area, extend and habitat quality caused by over exploitation, agricultural invasion, and road construction. Nevertheless, the species needs to be reassessed based on the precise data on population and threat for the Sri Lankan part of its distribution. The Endangered (EN) category assessed by Kamat et al. (2020) is not supported. This is one of the most exploited species from the wild due to its use as an antidiabetic medicine. As the root are richer in the active compound, salacinol, mature plants are often uprooted from the wild. *Salacia oblonga* is in need of harvest management to ensure sustainability, as well as a mass cultivation programme as an immediate conservation measure.

Specimens examined

INDIA. **Karnataka,** North Kanara, Mundele, May 1853, *Ritchie 1653* (K); North Kanara District, Anshi Ghats, 30 Jan. 1886, *W. A. Talbot 1378* (K, CAL); *ibid*, *s. d.*, *W. A. Talbot 2931* (BSI); *ibid*, 22 Dec. 1892 *s. coll. 2932* (BSI); *ibid*, *s.dat.*, *W. A. Talbot 2933* (BSI); *ibid*, 1889, *W. A. Talbot 2934* (BSI); Shimoga, Agumbe, Jogi Gundi Falls, 21 Feb. 1963, *R. Raghavan 86431* (BSI); Agumbe, 26 Apr. 1997, *K. Ravikumar, S. P. Subramani & P. S. Udayan 11898* (FRLH); North Kanara, *s. loc.* June 1883, *W. A. Talbot 1241* (CAL); North Kanara, Supa, May, *T. D. Bell 6043* (CAL); Coorg, Thalacavary, 13 May 2010, *P. S. Udayan et al. 6834* (CMPR). **Goa,** *s. l.*, 29 May 1905, *R. K. Bhide s. n.* (BSI); Caranzol, 17 Apr. 1966, *P. J. Cherian 107165* (BSI); Valpoi, 22 May 1964, *K. C. Kanodia 96401* (BSI). Malachi Rai, 22 Mar. 1964, *K. C. Kanodia 96401* (CAL); Molem, 19 Apr. 2017, *D.C. Jadhav 1465* (NGCPR). **Kerala,** Kozhikode, Moodadi, 14 Mar. 1996, *P. Chiranjit 129* (K); Thiruvananthapuram, on the way to Thekkumalai, 13 Apr. 2009, *Devipriya M.S. & Regy Yohannan 55* (MH); Thrissur, Vellanipacha, 4 Apr. 2004, *P. S. Udayan, 2519* (CMPR); Vellanipacha, 23 Feb. 2007, *P. S. Udayan et al. 00104* (CMPR); *ibid*, 3 Apr. 2004, *P. S. Udayan et al. 2489, 2490* (CMPR); *ibid*, 23 Feb. 2005, *P. S. Udayan et al. 3373* (CMPR); *ibid*, 21 Jan. 2006, *P. S. Udayan et al. 3973* (CMPR); *ibid*, 23 Feb. 2007, *P. S. Udayan et al. 4944* (CMPR); Kozhikode, Kakkayam, 26 Mar. 2008 *P. S. Udayan 4900* (CMPR); Malappuram, Kottakkal, Herb Garden, 15 Jan. 2007, *P. S. Udayan et al. 5029* (CMPR); *ibid*, 26 Mar. 2016, *D. C. Jadhav 1455* (NGCPR); Kollam, Ventilakara, 7 May 2015, *G. Ravikumar 72842* (TBGRI); Thiruvananthapuram, Palode, 28 Dec. 2011, *S. M. Shareef 70672* (TBGRI); JNTBGRI Garden, 13 Feb. 2014, *S.M. Shareef 79228* (TBGRI); *ibid,* 16 Feb. 2017, *D.C. Jadhav 1462* (NGCPR). **Maharashtra,** Bombay, *s. l.*, *N. A. Dalzell s. n.* (K); North Concan, *s. loc.*, *Law s. n.* (K). **Tamil Nadu,** Wallich Cat. no. 4227, *Herb Wight s.n.* (K [K0001038436]; CAL [sheet no. 87592]); Tirunelveli Ghats, Dec. 1871, *R. H. Beddome 202* (K); Courtallum, July 1835, *R. Wight 464* (K); Nilgiris, Kallar, Oct. 1889, *J. S. Gamble 21457* (K); Kanyakumari, on the way to Thekkumalai Estate to Courtallum Forest, 20 Feb. 1983, *E. Vajravelu, 76587* (MH); *ibid*, 9 Oct. 2002, *C. Murgan, 114184* (MH); Way to Pothigaimalai, 20 Apr. 1992, *R. Gopalan 99346* (MH); Tirunelveli, on the way to Kongupatty to Puliyara, 10 Oct. 2002, *C. Murgan, 114189* (MH); Tirunelveli District, Courtallam, Honey Fall, *K. Subramanyam 5606* (MH); Courtallam, *s.d.*, *R. H. Beddome 2177* (MH); Tirunelveli, Nellai Kattabomman, 8 Mar. 1994, *S. P. Subramani 00320* (FRLH); Tirunelveli, Courtallum, 3 Dec. 2015, *M. Alister 88251* (TBGRI). SRI LANKA. Trincomalee, *s.d., Herb Wight s.n.* (MH [MH1915]); Jaffna, Northern Province, Ampan, 12 Sep. 1974, *L. H. Cramer 4336* (MH).

Note

Udayan et al. (2014) described *S. oblonga* var. *kakkayamana* Udayan & Raghu, but I failed to locate the type of this intraspecific taxon at CAL and MH (*Udayan et al. 27802*). The specimen collected at the type locality (*Udayan et al. 110820*: FRLH) has a fruit that matches that of *S. oblonga*. Hence this variety is here treated as conspecific with *S. oblonga*, which it also resembles in other characters such as a woody scandent habit, subsessile urceolate flowers in axillary branched cymes, elliptic-oblong or oblanceolate leaves, oblong petals, flat disk, globose and bright orange red or yellowish orange fruits.

Londhe (2000) in *Flora Maharashtra* listed *S. oblonga* from Sindhudurg District, but during the present study I could not locate the specimens on which this distribution is based. Instead, I saw Wight, Dalzell, Law and Ritchie's collections of *S. oblonga* from Tamil Nadu (the then Madras Presidency), Karnataka and Maharashtra (the then Bombay Presidency). These were misidentified as *S. macrophylla* by Ding Hou (1964).

Jadhav 1462 (NGCPR) from the TBGRI campus, Kerala, differs from the rest of the Indian material seen in having noticeably pentamerous and almost sessile flowers.

10. ***Salacia wayanadica*** Sujana, Nagaraju, Ratheesh & Anil Kumar in Taiwania 60(2): 91. 2015. (Figure 17)

Type: India, Kerala, Wayanad, Periya, Chandanathode, evergreen forests, 853m, 28 Feb. 2011, *K. A. Sujana 0401* (holotype CAL! barcode CAL0000025311; isotype MH).

Description

Straggling shrub or spreading liana up to 2(–5) m high; branches terete, coiled, lenticellate to smooth. Leaves opposite, exstipulate, petiolate; petiole 0.8–1 cm long; lamina oblong-elliptic, 8–18 × 3–6 cm, apex obtuse, base cuneate to rounded, margin entire, coriaceous, glaucous, lateral nerves 8–12 pairs. Inflorescences axillary or ramiflorous, 2–12-flowered, tuberculate fascicle; pedicels 10–12 mm long, terete, pruinose; bracts inconspicuous, ovate, sepaloid; sepals fused at base, lobes ovate, c. 0.5 × 1 mm, apex densely bearded, otherwise glabrous; petals c. 2 × 1.5 mm, oblong, apex acute to hooded, pale green tinged with orange, margin hyaline to yellowish, glabrous; disk annular, pulvinate at base, yellowish orange; stamens 3, incurved (before anthesis); filaments short, anthers bi-lobed, globose, yellow, thecae confluent longitudinally; style raised on the disc, stigma inconspicuous, ovary 3-celled. Fruits baccate, globose to ovoid, 2–5 × 2–3 5–6, exocarp orange, thick, tuberculate, endocarp mucilaginous, 3- or 4-seeded; seeds discoid or ovoid, c. 2 × 1.5 cm, ochraceous.

Phenology

Flowers and fruit collected from January to August.

Distribution and habitat

Endemic to the Western Ghats of Kerala (Figure 19). Climbing over small trees in semi evergreen forest, fringing forest, and along roads.

Specimens examined

INDIA. **Kerala**, Wayanad, Chandanthode, 04 Apr. 2018, *D. C. Jadhav & M. D. Nandikar* 1483 (NGCPR); *ibid*, 20 Mar. 1980, *V. S. Ramachandran 66831* (MH); *ibid*, 12 Aug. 1979, *V. S. Ramachandran 63921* (MH); *ibid*, *V. S. Ramachandran 63920* (CAL); Wayanad, on the way Periya to Chandanthode, 16 June 1979, *V. S. Ramachandran 626321* (CAL); Valady, Periya, Mananthavady, Wayanad, 27 May 1995, *Bija & Joy 10237* (FRLH).

IUCN status

The species is recorded from only two localities in Wayanad District. Both the localities are adjacent to places of human habitation and threatened by habitat degradation. Few plants were found damaged, perhaps due to road clearing and widening, also confirmed by Sujana et al. (2015). The restricted AOO and EOO, continuing decline (observed) of quality of habitat and continuing decline (inferred) in the number of mature individuals suggests an assessment of Critically Endangered (CR) for this species [B1+2ab(iii,v); D].

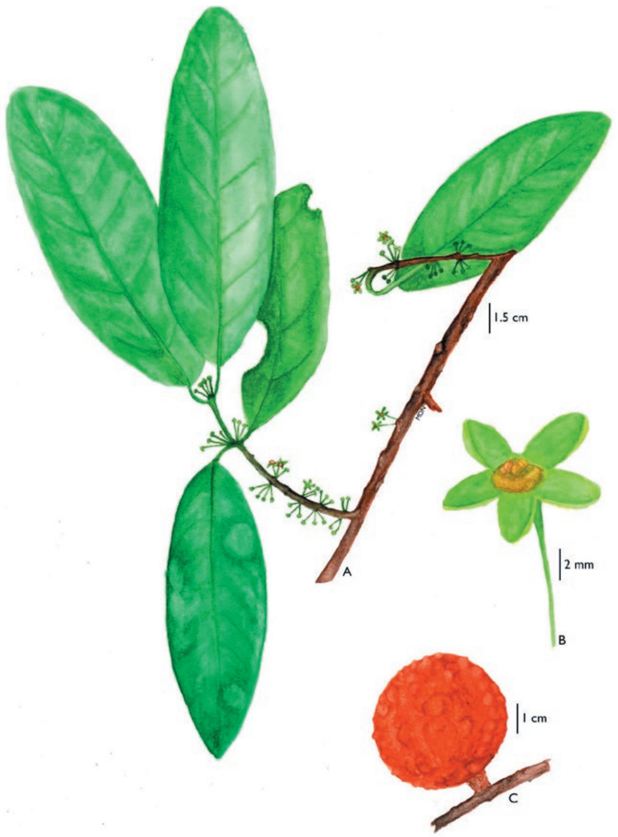

Figure 17. *S. wayanadica* (A) Flowering twig. (B) Flower. (C) Fruit.

Note

S. wayanadica shares a similar habit and inflorescence with *S. macrosperma*, *S. gambleana* and *S. malabarica*. However, *S. macrosperma* differs by having acute to acuminate leaves, laciniate to fimbriate sepals and ovate to broadly elliptic petals. Similarly, *S. gambleana* differs by having oblanceolate leaves, whereas *S. malabarica* has serrate leaves, much longer pedicels, and glabrous sepals.

EXCLUDED SPECIES

1. ***Salacia macrophylla*** Blume, Bijdr. Fl. Ned. Ind. 5: 221. 1825.

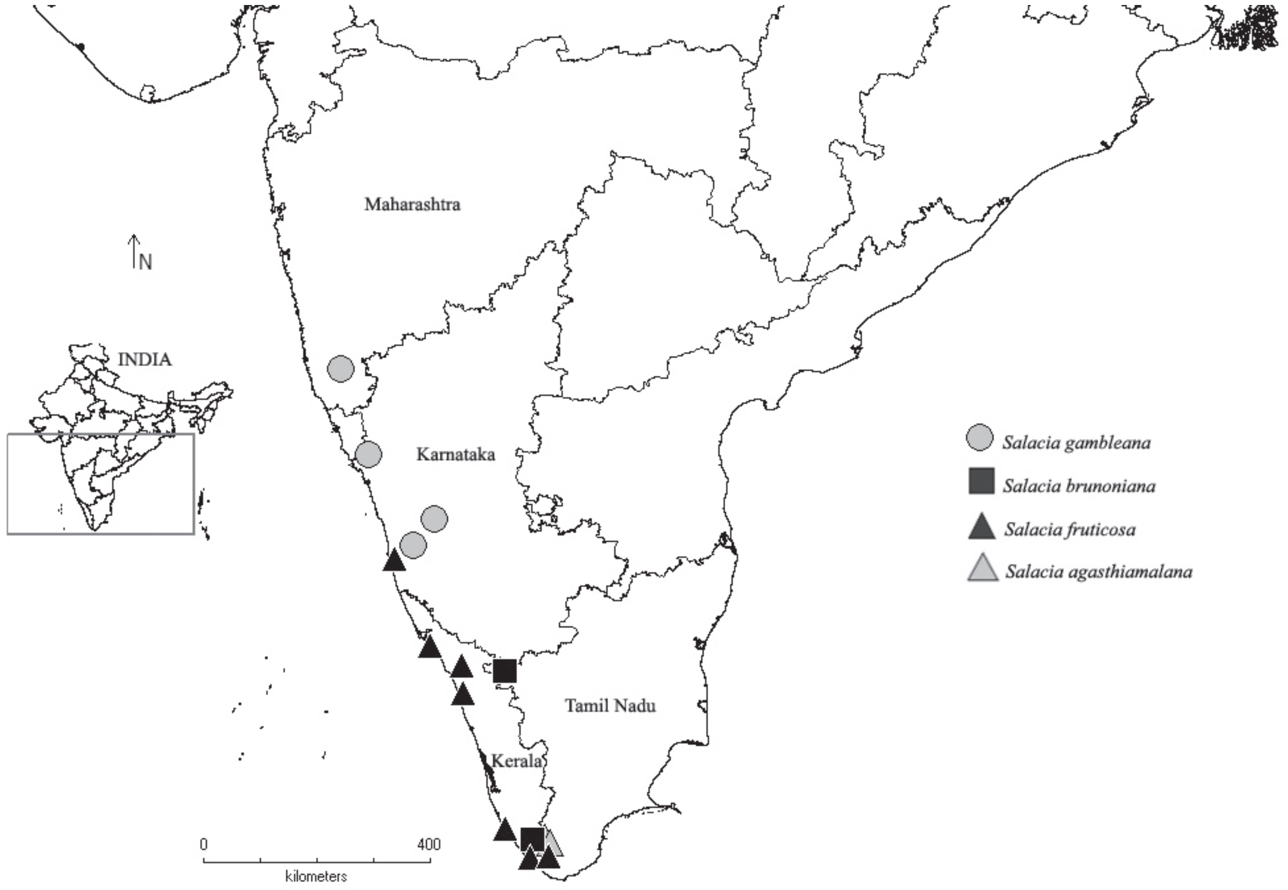

Figure 18. Distribution map of *Salacia* species endemic to peninsular India.

Type: Indonesia, Java, *s.loc. s.d.,* Herb. Lugd. Bat., *Blume 1699* (L! barcode L0015423), lectotype here designated.

(=) *Salacia ovalis* M.A. Lawson in Fl. Brit. India 1(3): 627. 1875. non Korthals, Flora 31: 579. 1848.
Type: Malaysia, Malacca, *s. loc*., *s. d*., *A.C. Maingay, 400* (lectotype K! barcode K000669976; isolectoype CAL! barcode CAL0000007497), designated here.

Distribution and habitat

India (Andaman and Nicobar Islands), Cambodia, Thailand, Hainan. Low land coastline forest.

Note

Blume (1825) described the species from Indonesia. Later, Ding Hou (1964) erroneously reported the occurrence of this species in peninsular India. It seems he misidentified the collections of *S. oblonga* (from Maharashtra and Karnataka, the then Bombay Presidency) by *Dalzell*, *Law* and *Ritchie* that are available at K. Subsequent authors, Ramamurthy & Naithani (2000) and Londhe (2000) included the taxon in Maharashtra following Ding Hou (1964). I could not locate any specimen of *S. macrophylla* to support its occurrence in mainland India. The original material collected by *Blume* and *Maingay* of *S. macrophylla* and *S. ovalis* is housed at L, K and CAL. For both the names there is no precise indication of type and hence warrant typification. Comparing the original material with protologue, the best specimen is designated here as lectotype following ICN Art. 9.3 (Turland et al. 2018).

2. ***Salacia reticulata*** Wight, Ill. Ind. Bot. 1: 134. 1838.

Type: Sri Lanka, *s. loc., s. d., Colonel Walker s. n*. (K! barcode K000669988), lectotype designated by Wadhwa (1996).

Distribution and habitat

India (Andaman and Nicobar Islands) and Sri Lanka. Evergreen forest.

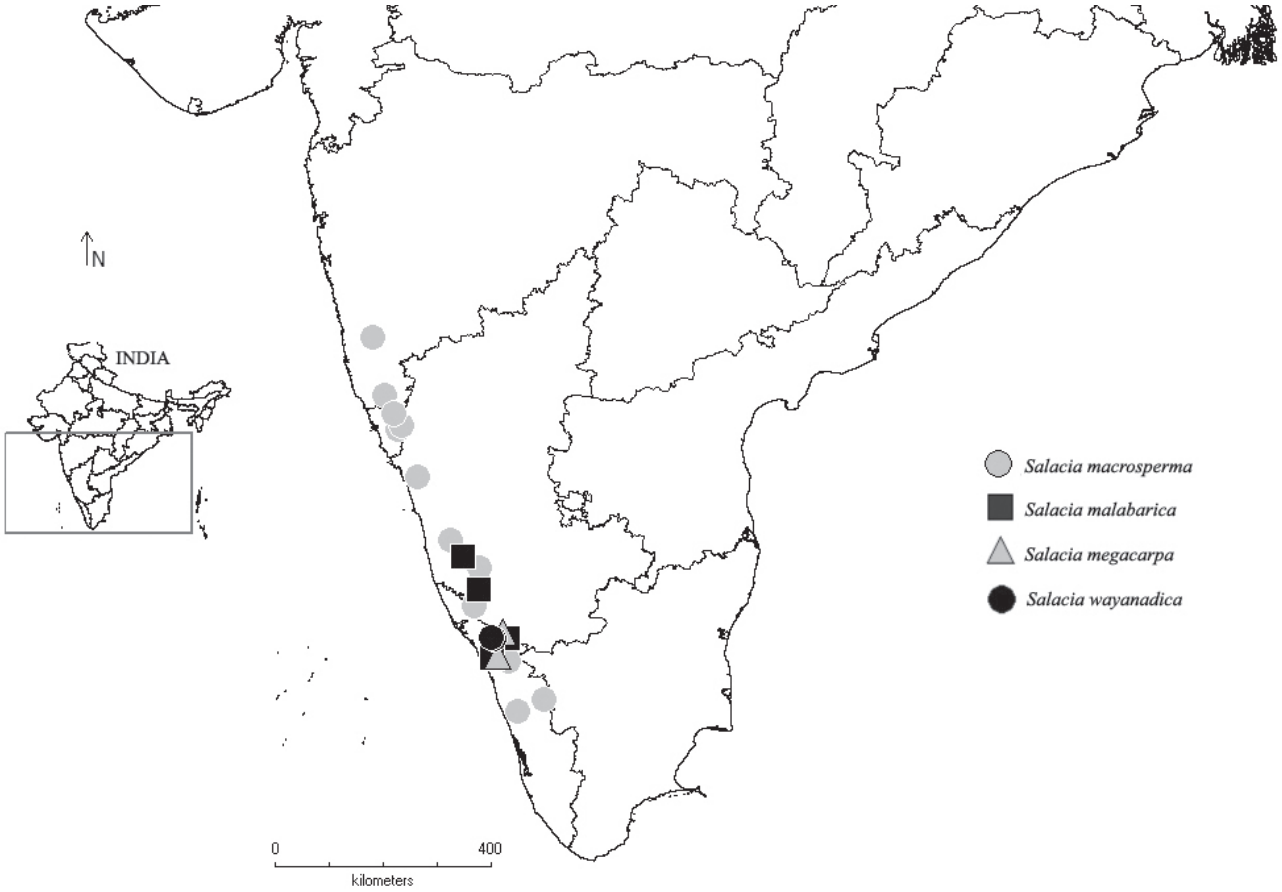

Figure 19. Distribution map of *Salacia* species endemic to peninsular India.

Note

Wight (1838) described the species based on Walker's collection from Sri Lanka. He was not certain about its occurrence in Malabar of South India. In the protologue, he mentioned that "the identity of the Malabar specimen is doubtful as flowers were not seen, leaves are less distinctly reticulate" and added characters of the fruit is doubtful. Gamble (1918) listed *S. reticulata* in Madras Presidency based on Rama Rao's collection (*CAL 87440*). Further details on the doubtful occurrence of *S. reticulata* in India and misapplication of *S. reticulata* to different elements by various authors in India can be found in Udayan and Pradeep (2012). The occurrence recorded in peninsular India by Kamat et al. (2020) is an error.

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Hedyotis hamiguitanensis (Rubiaceae: Spermacoceae), a new species from Mt. Hamiguitan, Davao Oriental, Philippines and its systematic position in *Hedyotis*

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Abstract. *Hedyotis hamiguitanensis*, from Mt. Hamiguitan, Davao Oriental, Philippines, is described, illustrated, and compared with two similar species, *H. whiteheadii* and *H. schlechteri*. This species is distinguished from congeneric Philippine species by its 5–12 cm long, compound, umbellate inflorescences, pendulous flowers, lanceolate to oblanceolate, thick, scabrid leaf blades with revolute margins. Its phylogenetic systematic position within the tribe Spermococeae is determined with a phylogenetic analysis using chloroplast (rps16, petD) and nuclear ribosomal (ITS, ETS) nucleotide sequence data.

Keywords: *Hedyotis*, Rubiaceae, Philippines, taxonomy.

INTRODUCTION

Hedyotis Linnaeus (1753: 101) is part of the *Hedyotis-Oldenlandia* complex, a taxonomically confusing group that was formerly placed in the tribe Hedyotideae, which is now part of tribe Spermacoceae (Bremer 1996; Andersson and Rova 1999; Bremer and Manen 2000). The genus has long been controversial because of the lack of taxonomic delimitation and molecular data (Terrell and Robinson 2003). Recent phylogenetic analyses based on nuclear and plastid sequences of Asian-Pacific taxa from this group have identified 13 well-supported monophyletic genera (Neupane et al., 2015). Diagnostic characters such as habit, fruit type, seed form, and pollen type were compared to the phylogeny for characterizing the clades (Kårehed et al 2008; Groeninckx et al. 2009; Guo et al. B 2013; Wikström et al. 2013; Neupane et al. 2015). In the latest revision (Neupane et al. 2015), members of *Hedyotis* s.str. included species from Sri Lanka, India, SE China, Indo-Chi-

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na, Malesia, Papuasia, Northwest Pacific, and Australia. The recent studies lack *Hedyotis* species occurring in the Philippines . *Hedyotis* is characterized by its habit –suffrutescent herbs, shrubs, or small trees –, its capsules with apex not protruding beyond the calyx lobes, the septicidal dehiscence usually followed by a partial apical loculicidal dehiscence that sometimes results in two semi-split valves and, the dorsiventrally compressed seeds (Wikström et al. 2013). The flowers have a pubescent corolla tube and pollen with 3 -4 ecto-apertures, endoapertures shaped as an endocingulum and a tectum with a double reticulum pattern (Neupane et al. 2015). There are approximately 180 species in *Hedyotis* (Neupane et al. 2015), 36 of which occur in the Philippines (Pelser et al. 2011).

During fieldwork of the Thomasian Angiosperm Phylogeny and Barcoding Group (TAPBG) on Mt. Hamiguitan, Davao Oriental, Philippines, an interesting taxon was discovered. Two populations were observed, one in mossy forests and the other in pygmy forests on the same mountain. The collected material is morphologically similar to *Hedyotis whiteheadii* Merrill (1907: 303) and *H. schlechteri* Merrill & Perry (1945: 1), but detailed comparison showed that these two species differ from the newly collected material by their vegetative and inflorescence morphology. Therefore, a new *Hedyotis* species is here described and illustrated. We also included the new species in a maximum likelihood and Bayesian phylogenetic analysis of *Hedyotis* s.str. (sensu Neupane et al. 2015) based on chloroplast (rps16, petD) and nuclear ribosomal (ITS, ETS) nucleotide sequence data to elucidate its position within the genus.

MATERIAL AND METHODS

Hedyotis specimens were collected in the forests of Mt. Hamiguitan, Davao Oriental, Philippines, on 15 April 2017. Measurements, colors and other details given in the descriptions are based on field observations, herbarium specimens and reproductive parts preserved in 70% ethanol. Microscopic features were analyzed using a dissecting microscope (Olympus SZ2-ILST). Measurements were obtained using a metric vernier caliper. Character state terminology is based on Beentje (2010). *Hedyotis* specimens from different herbaria (A, CAHUP, K, PNH, PUH US, and USTH) were compared to our specimens. Additional specimens were examined on JSTOR Global Plants (https://plants.jstor. org/, accessed 18 May 2021). Herbarium specimens were deposited in USTH.

For the molecular data, DNA was extracted from silica gel-dried leaves using the DNeasy Plant Mini Kit (Qiagen, Germany) following the manufacturer's protocol. The amplification protocol for nuclear and chloroplast regions follows Kårehed et al. (2008: 845) and Groeninckx et al. (2009: 111), respectively. The alignment file was downloaded from the supplementary data provided by Neupane et al. (2015). A total of 293 accessions were analyzed with the addition of 2 samples from this study, *H. hamiguitanensis* CB177051 and CB17036. The new sequences from plastid (rps16, petD) and nuclear (ITS) regions of H. hamiguitanensis produced during our investigation were deposited in Genbank (Genbank accession numbers MZ407950, MZ435801, MZ435799 for USTH016306 MZ407951, MZ435802, MZ435800 for USTH016305 respectively) Sequences were edited and pre-aligned using CodonCode Aligner v.4.0.4 (CodonCode Corporation, Dedham, MA) and subsequently aligned using MAFFT v.7 (Katoh and Standley, 2013). The alignment was manually adjusted using SeaView Sequence Aligner V.4 (Guoy et al., 2010). ML tree search was performed in RaxML-HPC Blackbox v. 8.2.12. while Bayesian inference was performed using MrBayes v.3.2 (Ronquist et al. 2012) with 15 million MCMC iterations. Mrbayes and RaxML searches were conducted on the CIPRES Portal (Miller et al. 2010).

TAXONOMY

Hedyotis hamiguitanensis Santor, Santiago & Alejandro, **sp. nov.** (Figures 1, 2).

Type: Philippines, Davao Oriental, Pygmy forest in Mt. Hamiguitan, 16.7400° N, 1600 m, 126.1817° E, 15 Apr 2017, *Ordas, Alfeche & Zamudio CB17051* (holotype, Accession numbers from USTH:USTH016306.1; isotypes: USTH016306.2, USTH016306.3).

Diagnosis

Hedyotis hamiguitanensis is similar to *H. whiteheadii* and *H. schlechteri* because of general leaf size ranging from 1.5-4 cm with 3—4 lateral nerves, densely hirsute petioles, and compound peduncled inflorescence, from which it can be distinguished by its lanceolate to oblanceolate, relatively thick leaves, scabrid surface, margins that are entire and revolute, stems, stipules, peduncle, pedicels with hirsute indumentum, inflorescence a compound, 5–12 cm long, umbel, and by the pendulous, 8–11 mm long flowers.

Description

Shrub 0.5–2 m tall. Stems terete, about 1–2 mm in diameter, olive green with maroon coloration on some

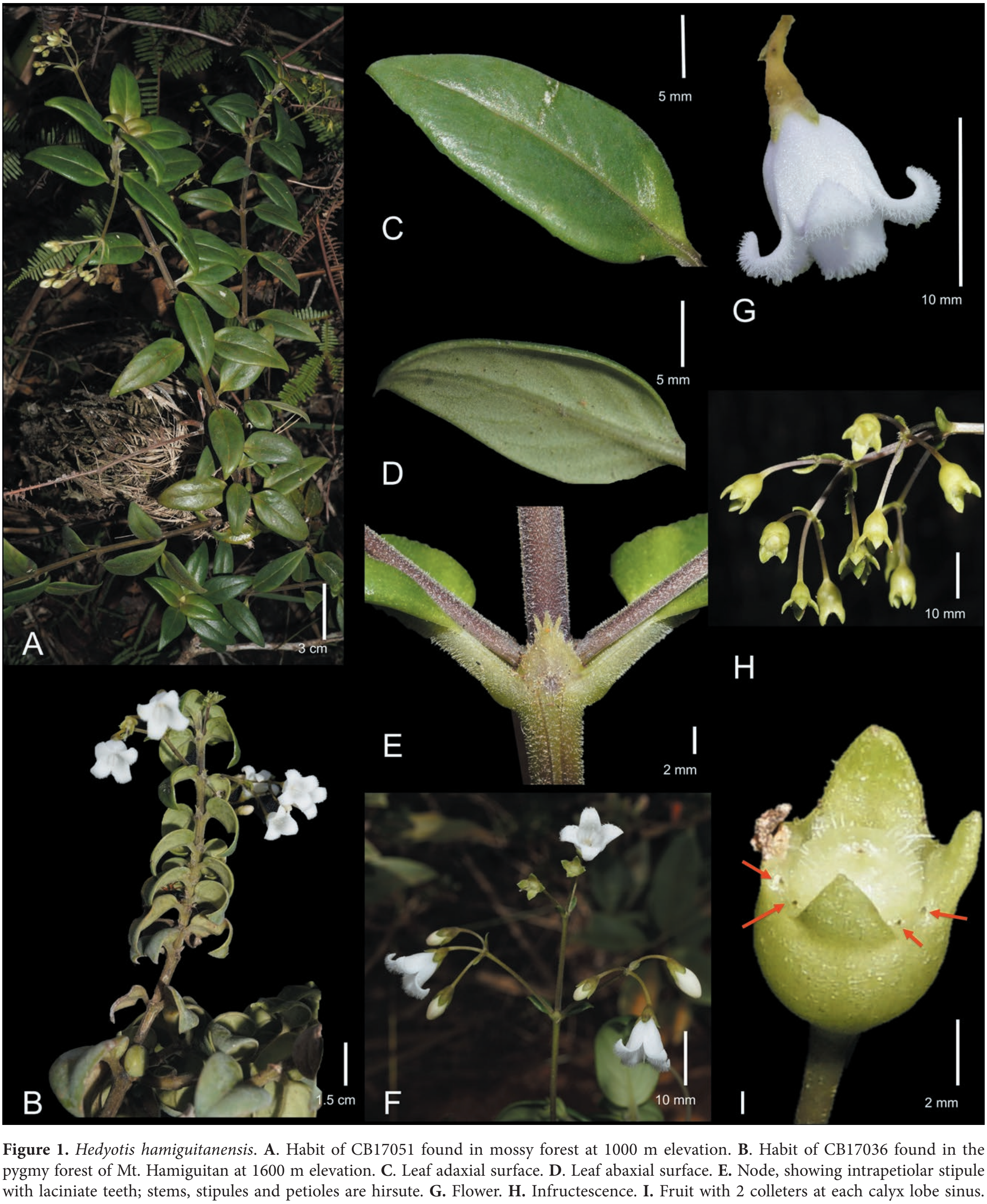

Figure 1. *Hedyotis hamiguitanensis*. **A**. Habit of CB17051 found in mossy forest at 1000 m elevation. **B**. Habit of CB17036 found in the pygmy forest of Mt. Hamiguitan at 1600 m elevation. **C**. Leaf adaxial surface. **D**. Leaf abaxial surface. **E.** Node, showing intrapetiolar stipule with laciniate teeth; stems, stipules and petioles are hirsute. **G.** Flower. **H.** Infructescence. **I.** Fruit with 2 colleters at each calyx lobe sinus. Photos by N.K. Alfeche.

Figure 2. *Hedyotis hamiguitanensis.* **A.** Flowering and fruiting branch. **B.** Stipules. **C.** Inflorescence. **D.** Flower, lateral view. **E.** Flower, top view. **F.** Calyx and style. **G.** Opened Corolla showing stamens. **H.** Capsule. **I.** Dissected capsule showing the 2 locules. **J.** Seed. Illustrated by P.J.R. Santor.

parts, densely hirsute; internodes 1–5 cm long; branchlets sulcate, 1–2 mm in diameter. Stipules interpetiolar, triangular ovate, 2–4 × 3–4 mm, with 9–11 lacinia, hirsute. Leaves with petioles 1–5 mm long, subsessile in populations above 1600 m elevation, densely hirsute; blades lanceolate to broadly ovate, 1.5–3 × 0.8–1.5 cm, thinner leaves with margins recurved, thicker leaves with entire lamina recurved from the midrib; lamina scabrid on both surfaces, abaxial surface may appear densely hirsute on younger leaves, coriaceous, yellow-green to green on the adaxial surface, abaxial surface pale green when fresh, olive green to dark brown and brittle when dry, base subcordate to obtuse, apex attenuate to acute, lamina scabrid on both surfaces, abaxial surface may appear densely hirsute on younger leaves, thinner leaves with margins revolute; margins of thicker leaves revolute from the midrib; midrib distinct, canaliculate, sparsely to densely scabrid on the adaxial surface, sparsely scabrid on the abaxial surface; secondary veins 3 or 4 on each side of the midrib, obscure on thicker leaves, evident in thin leaves, tertiary venation not prominent. Inflorescence axillary, a compound umbel, 6–12 cm long in populations above 1000 m elevation, or 5–6.5 cm long in populations above 1600 m elevation, pendulous, hirsute; peduncle terete, 2–9 cm long, 0.2–0.5 mm in diam., hirsute; bracts ovate to lanceolate, 3–6 × 2-4 mm, apex attenuate, scabrid on the adaxial surface, hirsute or with bullate configuration on the abaxial surface, margins flat or revolute. Inflorescence cymose, 3(4)-flowered, 1–3 cm long, 3–5 mm in diameter, sparsely hirsute to glabrous; bracteoles ovate to lanceolate, 2–3 × 0.5–1.5 mm, apices acute. Pedicels terete, 10-30 mm long. Flowers 4–merous, pendulous, cupuliform, 8–11 mm long, white; . *Calyx* subcampanulate, 2–4 mm long, 3 mm in diameter; tube bell–shaped with constricted base, 1–1.5 mm long, sparsely hirsute to glabrous; lobes 1–2.5 mm long, apex attenuate, puberulous, 2-3 clavate indumentum located in the margin in between each calyx lobe. Corolla 6–11 mm long, glabrous, white; tube 4–6 mm long, pubescent inside; lobes lanceolate, 2–5 mm long, apex acute. Stamens 2.5–4.2 mm long, included, inserted at 2 mm; filaments 1–2 mm long, glabrous; anthers oblong, 1–2 mm long, dorsifixed. Style 6–7 mm long, glabrous, exerted 1.5–2.5 mm beyond corolla mouth. Capsules urceolate to ovoid, 3–4 × 2 mm, septicidal; calyx lobes persistent, 1.5 mm long. Seeds numerous, angular, dorsiventrally compressed, 0.5–0.7 mm long, black.

Etymology

The specific epithet is based on the type locality, Mt. Hamiguitan, Davao Oriental, Philippines.

Distribution and habitat

This new species is currently known only from its type localities. *Hedyotis hamiguitanensis* occurs in the mossy forest of Mt. Hamiguitan at c. 1000 m elevation, and in pygmy forest on Mt. Hamiguitan at c. 1600 m elevation.

Phenology

Hedyotis hamiguitanensis was observed flowering and fruiting in April.

Provisional IUCN Conservation assessment

This species was only collected at the type localities. Although two populations were found, few individuals were observed in the mossy and pygmy forest. The distribution range of this species remains unknown. Thus, the conservation status of *H. hamiguitanensis* is Data Deficient (DD) based on the IUCN (2019) categories.

Additional Specimens examined (paratypes)

PHILIPPINES. Davao Oriental: Mossy forest in Mt. Hamiguitan, 6.7400° N, 1000 m, 126.1817° E, 15 Apr 2017, *Ordas, Alfeche & Zamudio CB17036* (USTH016305.1, USTH016305.2, USTH016305.3).

Phylogenetic Analysis

The phylogenetic analysis (Fig. 3) based on the combined nuclear (ITS, ETS) and plastid (*petD*, *rps16*) data revealed that *H. hamiguitanensis* is embedded within the *Hedyotis s str.* clade (Neupane et al. 2015) and is sister to a clade consisting of *H. schlechteri* and *H. valetoniana* (BS=90, BPP=0.97), both from New Guinea. Although the two populations observed CB17051 and CB17036 showed differences in leaf size and thickness (Figure 1A&B), phylogenetic analysis revealed that both populations formed a monophyletic group (BS=100, BPP=1.00), supporting the view that these two populations belong to the same species and the morphological differences may be due to adaptation to environmental conditions (Fig. 3).

Discussion

Two samples representing *Hedyotis hamiguitanensis* Santor, Santiago & Alejandro were collected and analyzed. Field sample CB17051 *Ordas, Alfeche & Zamudio* was collected on the peak of Mt. Hamiguitan, Davao Oriental, at c. 1600 m elevation, while CB17036 *Ordas, Alfeche & Zamudio* was collected in the mossy forest at c. 1000 m elevation. The two collections have similar morphology in their vegetative and floral characters, but were different in terms of size, including plant height, leaf

Figure 3. ML tree showing phylogenetic relationships in the genus *Hedyotis* using the combined nuclear (ITS, ETS) and plastid (*petD*, *rps16*) data of Neupane et al. (2015) and the two gatherings of *Hedyotis hamiguitanensis*. Values above the nodes represent bootstrap support (BS) while values in parenthesis are Bayesian Posterior Probabilities (BPP). The field collection number after the taxon indicates different populations or individuals. **A.** Shows the collapsed tree with the established major clades (collapsed). **B.** Phylogenetic relationships in the *Hedyotis* clade.

Table 1. Comparative morphology between *H. hamiguitanensis* (CB177051, CB17036), *H. whiteheadii* and *H. schlechteri*

Characters	*H. hamiguitanensis*	*H. whitehedii*	*H. schlechteri*
Leaf			
shape	lanceolate to oblanceolate	broadly ovate	broadly ovate
length (cm)	1.5-3	1.5–3	2–4
width (cm)	0.8–1.5	1–1.8	1–1.5
surface	adaxial: scabrid abaxial: scabrid/hirsute	glabrous on both surfaces	scabrid on both surfaces
lateral veins	obsolete	obscure	prominent
margin	revolute	revolute	planar
Petiole			
length (mm)	(0-) 1–5	1.5–2	5
Stipules			
surface	hirsute	hirsute	scabrid
Inflorescence			
type	compound umbel	compound cyme	compound cyme
length (cm)	5–12	2–3	5–6.5
Flowers			
direction	pendulous	erect	erect
flower length (mm)	8–11	5–6	5–7
Adaxial corolla lobe surface	hirsute	hirsute	glabrous

dimensions, degree of curvature of the leaf blade margins, petiole length, inflorescence length, and flower size. The size differences of the two samples can be attributed to different environmental conditions - elevation, amount of sunlight and availability of nutrients in the soil.

Hedyotis hamiguitanensis shares features with the allied species *H. whiteheadii*, notably the leaf blade 1.5–3 × 0.8–1.5 cm, the lamina thickness, the obscure lateral veins, revolute margins, and the hirsute stipules. However, *H. hamiguitanensis* found at c. 1000 m. altitude differs from *H. whiteheadii* in its lanceolate to oblanceolate leaves (vs. broadly ovate), scabrid leaf surfaces (vs. glabrous), compound umbels 5–12 cm long (vs. compound cymes 2–3 cm long), and significantly larger flowers 8–11 mm (vs. 5-6 mm). *Hedyotis hamiguitanensis* found at c. 1600 m. altitude also shares similar features with *H. schlechteri* with its scabrid leaf texture, inflorescences 5–6.5 cm long, and flowers up to 7 mm long. However, *H. hamiguitanensis* differs from *H. schlechteri* in the lanceolate to oblanceolate leaf blades (vs. broadly ovate), obscure lateral veins (vs. prominent), planar lead margin (vs. revolute), hirsute stipules (vs. scabrid), 5–12 cm long inflorescences (vs. 5–6.5 cm), and larger flowers that are 8–11 mm long (vs. 5–7 mm).

Although the flower orientation was not mentioned in the protologue descriptions of *H. whiteheadii* and *H. schlechteri*, the type specimens of *H. whiteheadii, E.D.Merill 5783* (US 00137449 [image!] and *H. schlechteri, R.Schlechter 19761*, (K000760468 [image!], K000760467 [image!] exhibit an upward flower orientation. *Hedyotis hamiguitanensis* flowers, on the other hand, are pendulous. Table 1 provides a summary of the morphological differences between *H. hamiguitanensis, H. whiteheadii* and *H. schlechteri.*

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You 'Sau' Me! A new species and a rediscovery in the genus *Saurauia* (Actinidiaceae) from Zamboanga Peninsula, Mindanao Island, Philippines

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Abstract. A new species and a rediscovery in the genus *Saurauia* (Actinidiaceae) from Zamboanga Peninsula, Mindanao island, Philippines are presented here. The new species, *Saurauia abbreviata*, closely resembles *Saurauia lanaensis* Merr. but can be differentiated by having longer petioles, uniformly setose adaxial leaf surface, longer and wider leaves, more lateral veins, 3 styles, and a 3(–4)-locular ovary. This discovery raises the current number of recognized *Saurauia* in the Philippines to 57 following an 87-year gap in the taxonomic study of this genus in the country. *S. longipedicellata* Merr. is also rediscovered after almost a century. A lectotype is here assigned for this name selected among the syntypes. Photographs, ecological notes, and an amended description are also provided to aid taxonomic identification.

Abstrak. Usa ka bag-ong species ug nadiskobrehan pag-usab sa genus nga *Saurauia* (Actinidiaceae) gikan sa Zamboanga Peninsula, isla sa Mindanao, Philippines ang gipresentar dinhi. Ang bag-ong species, *Saurauia abbreviata*, nahisama pag-ayo sa *Saurauia lanaensis* Merr. apan ang bag-ong species adunay labi ka taas nga mga petioles, uniformly setose ang ilalom nga dahon, mas taas ug mas lapad nga dahon, labi pang mga lateral veins, 3 styles, ug 3(–4)-locular nga obaryo. Ang nadiskobrehan nagdugang sa kadaghanon sa mga giila nga *Saurauia* sa Pilipinas ngadto sa 57 human sa 87 ka tuig nga gintang sa taxonomic nga pagtuon sa kini nga genus sa nasud. Ang *Saurauia longipedicellata* Merr. nadiskobrehan usab pagkahuman sa hapit usa ka gatus ka tuig. Ang tipipikasyon gihimo dinhi aron mapalig-og ang ngalan. Mga litrato, mga notang ekolohikal, ug giusab nga hulagway alang sa maong species makita usab dinhi.

Keywords: Actinidia, Actinidiaceae, endemism, Philippines, taxonomy.

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INTRODUCTION

Saurauia Willd. is a large genus currently composed of ca. 300 species distributed in the tropical and sub-tropical areas of both the old and new worlds (Briggs 2015). Together with the genera *Actinidia* Lindl. and *Clematoclethra* (Franch.) Maxim., *Saurauia* is currently included in the family Actinidiaceae Engl. & Gilg (POWO 2019). Advancement in the taxonomy of *Saurauia* has been hampered due to the extent of morphological variation within species being largely undetermined. This has made species delineation difficult, and recognizing undescribed taxa very challenging (Conn & Damas 2013), especially in the Malesian Region where a great diversity of this taxon is largely unknown up to date.

The first species of *Saurauia* described for the Philippines, *S. latibractea* Choisy, was based on a collection by Hugh Cuming, who collected natural history collections there from 1836 to 1839 (van Welzen 2017). Elmer Drew Merrill continued the advancement in the study of this genus during the American occupation of the Philippines with 6 species published in the Govt. Lab. Publ. 35 (Merrill 1906). He likewise mentioned 48 species in his Enum. Philipp. Flow. Plants (EPFP) III (1923) and EPFP IV (1925). Moreover, *S. gigantifolia* Quisumb. and *S. knemifolia* Quisumb. were added to the list in 1944. Leonard Co updated the species checklist containing 56 taxon [excluding *S. cordata* Quisumb., the name however is accepted in the current checklist (Pelser et al. 2011 onwards)]. His unfinished manuscript laid the foundation of Co's Digital Flora of the Philippines (philippineplants.org) (Barcelona et al. 2013), an updated checklist of Philippine vascular plants (Pelser et al. 2011 onwards). This online database currently recognizes 56 species of

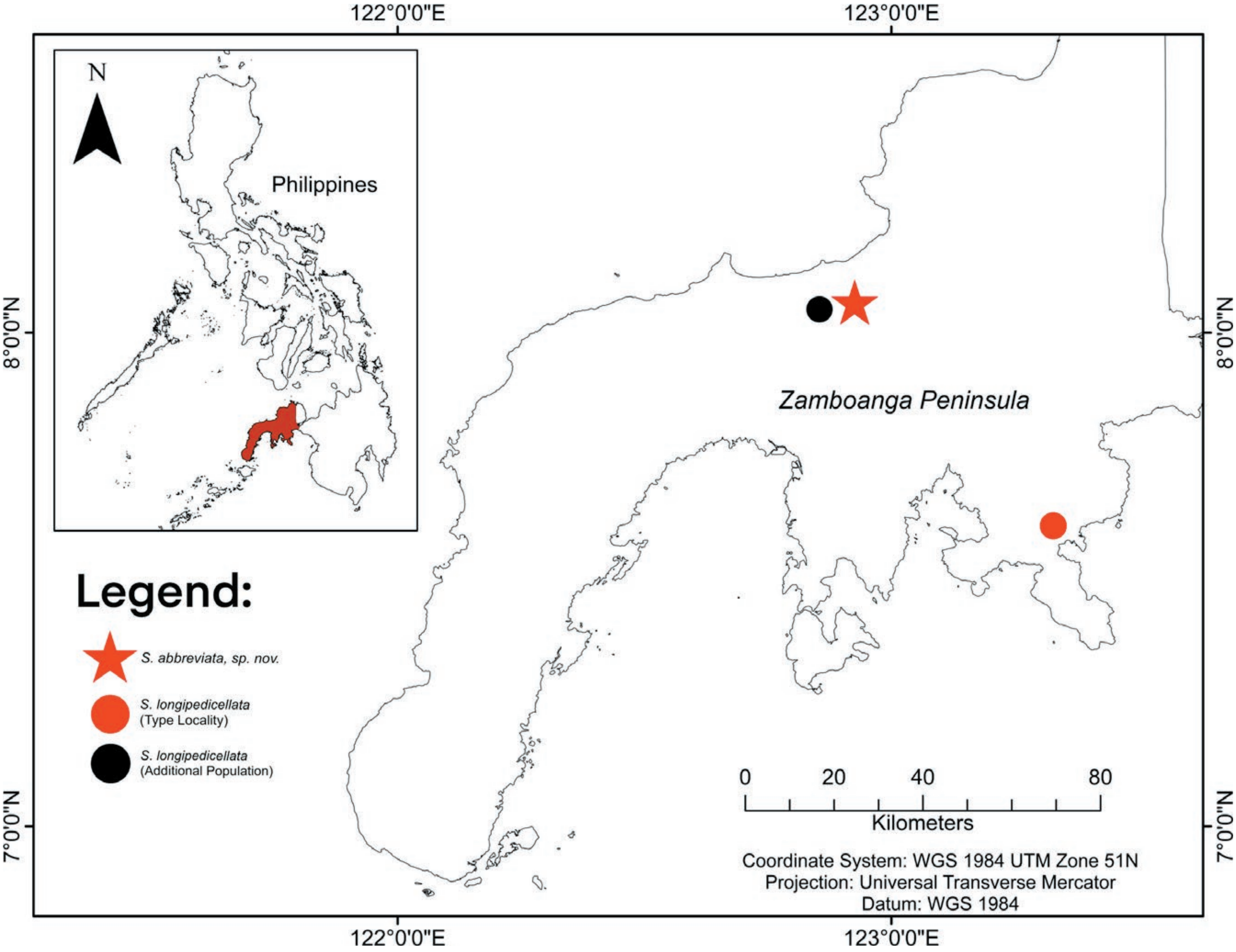

Figure 1. Map of Zamboanga peninsula showing the type locality of *S. abbreviata* denoted by (star); type locality of *S. longipedicellata* denoted by (red dot); additional population denoted by (black dot). Map created by Kean Roe Mazo.

Saurauia. There are currently 20 species recorded on the island of Mindanao.

The Zamboanga peninsula (Fig. 1) in Mindanao island comprises 3 provinces: Zamboanga del Norte, Zamboanga del Sur, and Zamboanga Sibugay. This region is regarded as one of the cultural and ecological centers of the island. Historically, Zamboanga flora had been extensively studied through various expeditions in the 1900s. These expeditions generated specimens of a number of narrowly endemic species—many of which are yet to be rediscovered in the wild. Some noteworthy endemic plants are *Aeschynanthus zamboangensis* Kraenzl., *Begonia zamboangensis* Merr., *Cymboglossum zamboangense* (Ames) Ormerod & Cootes, and *Pandanus zamboangensis* Martelli.

During fieldwork in the Municipality of Leon B. Postigo in Zamboanga del Norte, the first author documented an interesting *Saurauia* species bearing small, few-flowered axillary cymes. The plant was initially identified as *S. lanaensis* Merr. because of its abaxially setose leaves and very short inflorescences. However, review of literature, comparison with protologues and herbarium specimens in JSTOR proved that the specimen represents an undescribed taxon. Thus, we here formally describe and name this new species as *Saurauia abbreviata* K.R.Mazo. This discovery is the latest addition to the genus after an 87-year gap in knowledge in studying this taxon of Actinidiaceae in the Philippines. It further raises the number of recognized endemic species of *Saurauia* in the country to 57. Moreover, *Saurauia longipedicellata* Merr. is also rediscovered almost a century since it was first described. Following the International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2017) (ICN), we here assign a lectotype among its syntypes to stabilize this name. Photos, taxonomical and ecological notes, including and an amended description, are also provided.

MATERIALS AND METHODS

Initial description of the plants were done *in situ*. Further description was made using dried herbarium and spirit specimens. Botanical illustrations of the new species and *S. longipedicellata* were created from photographs of living plants and specimens preserved in spirit. Morphological comparisons to similar species were made using herbarium specimens. Images of type specimens deposited in JSTOR Global Plants (continuously updated) were likewise analyzed. All vegetative characters were observed and recorded in the field and reproductive characters were based on fresh and preserved material. The amended description of *S. longipedicellata* was based on the original description and supplemented by the specimen vouchered by the first author. All specimens were vouchered using the Wildlife Gratuitous Permit: G.P. No. R-IX-03-2021 (New) granted by the Department of Environment and Natural Resources (DENR) Region IX. Herbaria abbreviations follow Thiers et al. 2020 (continuously updated).

TAXONOMIC TREATMENT

Saurauia abbreviata K.R.Mazo, **sp. nov.** (Figures 2, 3)

Type: Philippines: Mindanao: Zamboanga Del Norte Province, Municipality of Leon B. Postigo, Barangay Tinuyop, secondary lowland forest, 8° 4’ 27” N, 122°56’25” E, ca. 331 masl elevation, 06 February 2021, *KRM 0014* (holotype: PNH; isotype: CMUH).

Diagnosis

Saurauia abbreviata closely resembles *Saurauia lanaensis* Merr. by having densely setose branchlets, abaxially setose leaves, small, axillary, cymose inflorescence; setaceous sepals; short sepals and petals. However, the new species can be differentiated by having longer petioles (1.5–4.0 cm *vs.* 1.0–1.5 cm), uniformly setose adaxial leaf surface (*vs.* glabrous), longer and wider leaves (20–42 cm long × 9.5–17 cm wide *vs.* 11–20 cm long × 3.0–6.0 cm wide), more lateral veins (14–25 pairs *vs.* 10–12 pairs). In terms of floral characters, *S. lanaensis* has slightly larger petals and sepals vs. *S. abbreviata*. Notably, the older inflorescences in *S. abbreviata* forms a slightly thick woody rachis from which new flowers emerge after the senescence of the older ones—a characteristic not known to occur in *S. lanaensis*.

Description

Habit: small terrestrial tree, ca. 3.5 m high, 10–15 cm (diameter at breast height), bark color grayish to brown, lenticels sparse. Branchlets terete, brown-green, densely setose (hairs 0.5–3.7 mm) when old; larger setae lanceolate, antrorse, the smaller ones ciliate or reduced setae. Leaves alternate, simple, blade oblanceolate to obovate, chartaceous, 20–42 cm long × 9.5–17 cm wide, apex cuspidate, base sub-oblique to cuneate, margin entire, setae (1.0–2.0 mm) antrorse, curved, uniformly distributed on the margin; adaxial surface green, uniformly setose (hairs 1.5–2.7 mm long), setae thin, erect, pale green or brown, distributed on the midrib, veins, and reticulations; typically denser at the midrib; abaxial surface pale green, pubescent, ascending on the mid-

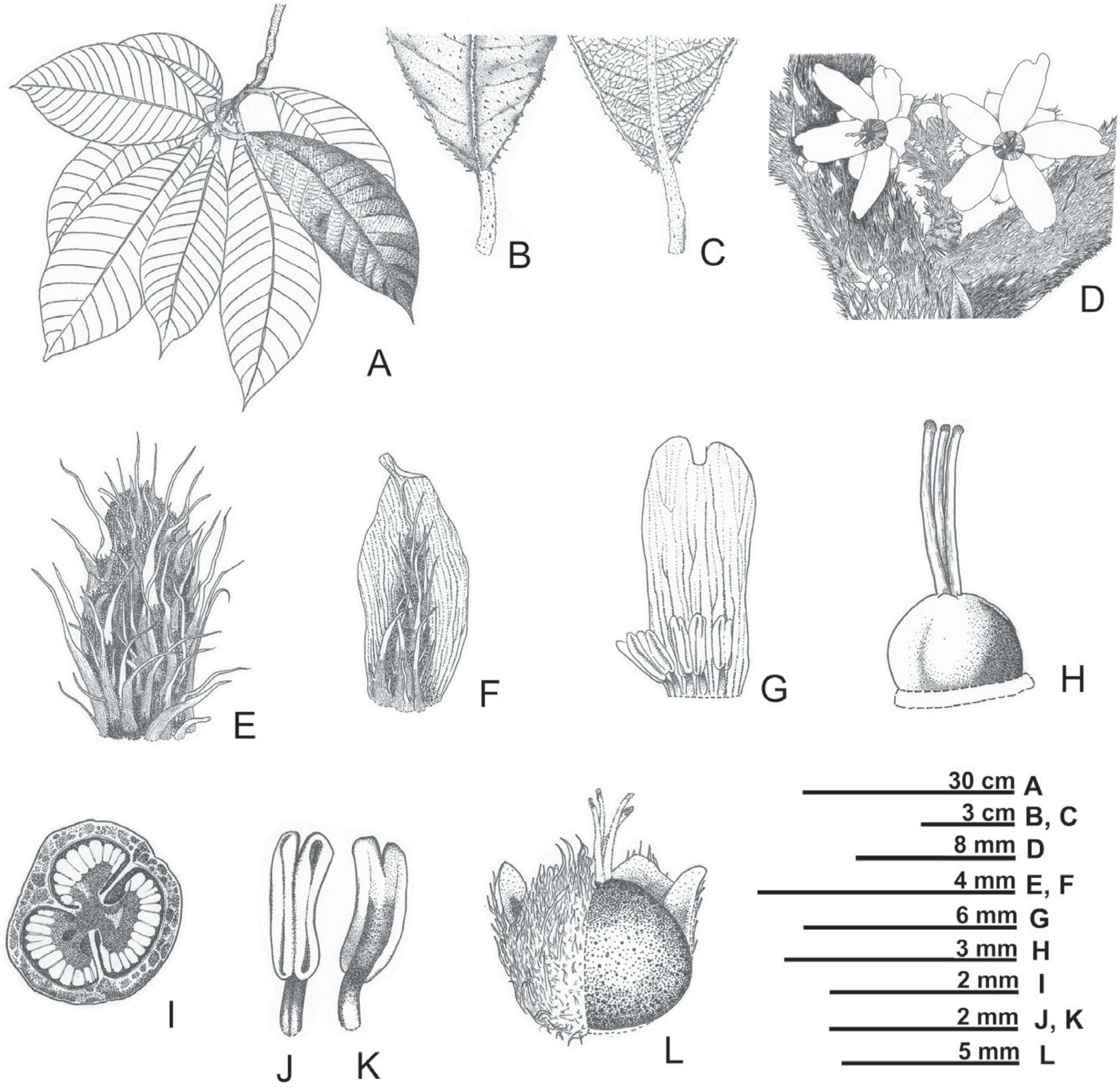

Figure 2. *Saurauia abbreviata* K.R.Mazo sp. nov. A. Habit; B. Leaf (adaxial view); C. Leaf (abaxial view); D. Inflorescence; E. Outer sepal; F. Inner sepal; G. Petal and stamens; H. Pistil; I. Cross section of the ovary; J. Stamen (anterior view); K. Stamen (posterior view); L. Fruit (remnant sepal removed). Illustrated by Jayson Mansibang.

rib, including the veins, and reticulations; midrib with sparse lanceolate setae with aristate tips, appressed, antrorse; lateral veins 14–25 pairs, reticulate veined, slightly arching and anastomosing towards leaf margin, secondary veins less prominent, slightly canaliculate adaxially, raised abaxially; submarginal veins 1.0–3.0 mm apart from the margin; petiole terete, green, 1.5–4.0 cm long × 0.18–0.36 cm wide, densely setose (hairs 1–2.5 mm long), larger setae lanceolate with aristate tips, appressed, antrorse, smaller ones ciliate or reduced setae. Inflorescences short, axillary, solitary or short fascicle-cymose, 1.5–2.0 cm long, older inflorescence forms a short woody rachis, 5.0 mm long × 3.0 mm wide, 3–5 flowered, lustrous white, few in anthesis at a time. Bracts 2, linear lanceolate, 2.5–3.0 mm long, both bracts and bracteoles densely setose (hairs 1.0–2.0 mm long), larger

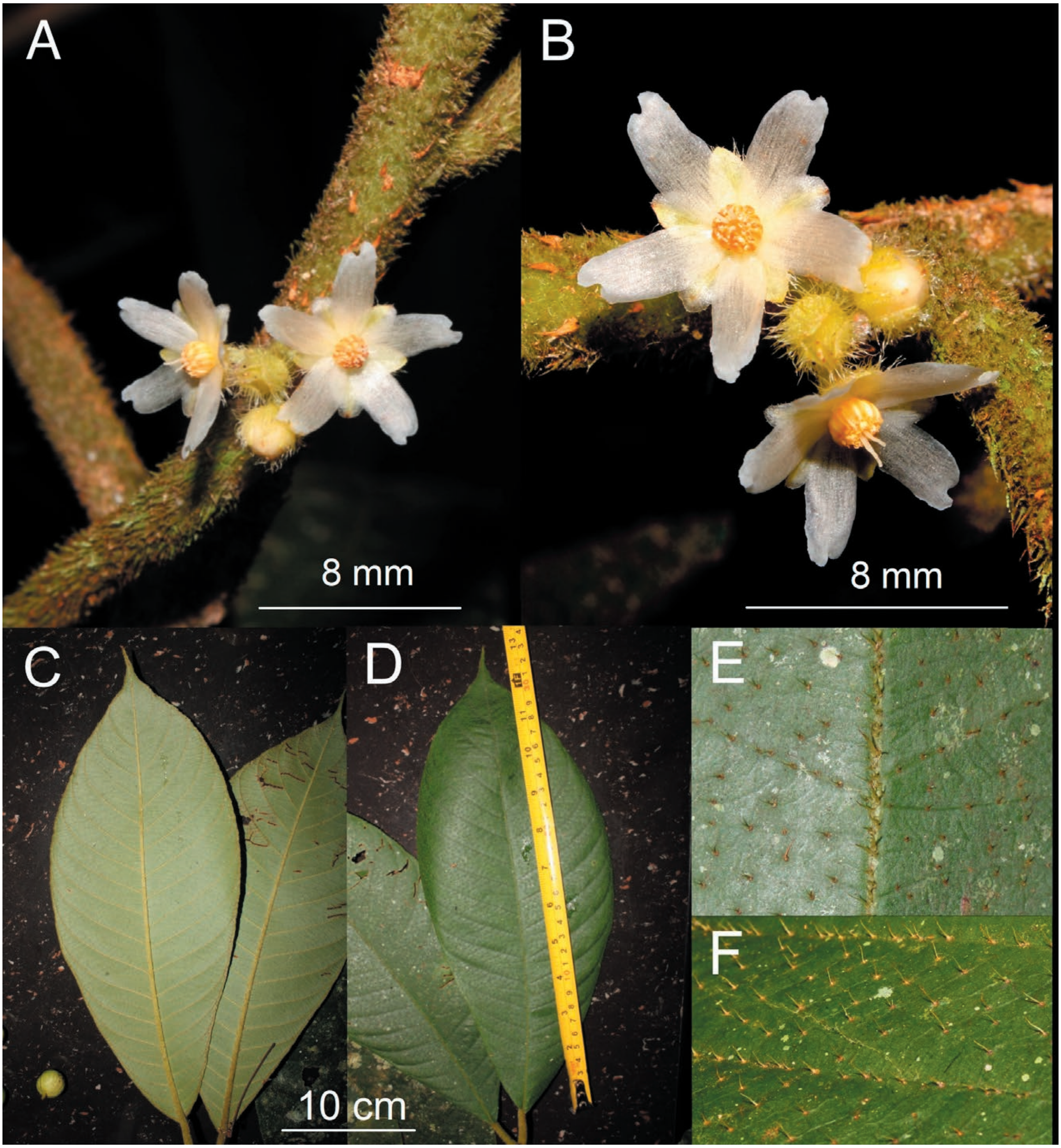

Figure 3. *Saurauia abbreviata*, sp. nov. A & B. Inflorescence; C. Leaf (abaxial view); D. Leaf (adaxial view); E. Abaxial leaf setae (close up); F. Adaxial leaf setae (close up). Photos by Kean Roe Mazo.

setae appressed, slenderly lanceolate with apiculate tips; peduncle 3.0–7.0 mm long, pale green, densely setose (hairs 0.5–1.0 mm long); bracteoles 2, linear lanceolate, 1.0–2.0 mm long, smaller than bracts. Pedicels 3.0–4.0 mm long, pale green, densely setose (hairs 0.5–1.0 mm long). Sepals 5-merous, almost equal in size, pale green, entire, ovate-lanceolate, 3.5–4.0 mm long (excluding setae) × 2.0–2.5 mm wide, apex bluntly acute-obtuse, outer and inner sepals adaxially glabrous; outer sepals abaxially densely setose (hairs 0.5–3.0 mm) throughout the surface, larger setae slenderly lanceolate with apiculate tips; inner sepals abaxially densely setose but only at the median portion (glabrous at the margins). Petals 5-merous, lustrous white, narrowly oblong, 6.0 mm × 2.0–3.0 mm, apex notched, sinus 0.5–0.7 mm long, glabrous. Stamens 20–30, yellow, in two series, adnate to the corolla, filaments 0.5–0.6 mm long, glabrous; anthers 1.2–1.5 mm long × ca. 0.5 mm wide, oblong, dorsifixed, longitudinally dehiscent, apex divided into 2 lobes, 0.2–0.3 mm long, inner stamens slightly smaller than outer one. Ovary ca. 2.0 mm long × 2.0–3.2 mm wide, globose, glabrous, pale green-white; locules 3(–4), placentation axile, ovules numerous. Styles 2.5–2.7 mm long, 3(–4), filiform, terete, pale green-white, united at the base for 0.1–0.2 mm, upper arms free, stigma capitate, minutely corniculate. Fruits a berry, globose, glabrous, dark olive-green, 4.0–5.0 mm long × 5.0–7.0 mm wide (styles excluded), solitary or a few per infructescence, styles caducous or nearly so, sepals persistent at base, apically splitting. Seeds black, numerous, not embedded on mucilaginous matrix.

Etymology

The specific epithet *abbreviata* is derived from the Latin word *"brevis"* (short) in reference to the very short or shortened inflorescences and flower dimensions of the new species—character combinations which are very rarely observed among Philippine *Saurauia* species.

Distribution and Habitat

Saurauia abbreviata is only known from the type locality, inhabiting secondary tropical lowland evergreen rainforest at ca. 331 masl composed of trees such as *Shorea contorta* S.Vidal, *S. squamata* (Turcz.) Benth. & Hook. with epiphytes such as *Freycinetia* Gaudich. species. The understory comprises *Zingiber* Boehm. sp., *Syzygium angulatum* (C.B.Rob.) Merr., and weak herbs including *Alocasia sanderiana* W. Bull, *Begonia oblongata* Merr., and *Elatostema zamboangense* Merr. All individuals were observed growing near streams, in partially to fully shaded areas.

Phenology

Flowering from July to August; fruiting from January to February.

Proposed Conservation Status

There were only around 20–30 individuals seen in the type locality, along the stream. There is an adjacent forested area, but it has not yet been fully explored. Considering the sampling limitations and the lack of concrete data to establish a putative assessment, we propose it to be listed under the Data Deficient (DD) category (IUCN Standards and Petitions Committee 2019).

Notes

S. abbreviata bears some similar characters to *S. bakeri* Merr. and *S. clementis* Merr. in terms of its dense indumentum in its branchlets, abaxial lamina, inflorescence, sepals, and locule-style number (*S. clementis* also has a uniformly distributed setae on its adaxial surface). However, both *S. bakeri* and *S. clementis* are clearly distinct from *S. abbreviata* by bearing smaller leaves, fewer lateral nerves, distinctly long peduncled inflorescence, and larger flowers. Likewise, the new species is somewhat close to *S. elmeri* Merr. by its much-reduced inflorescence, however the leaf and flower characters of the new species cannot be mistaken.

The knowledge gap, not only about the Zamboanga region but also the Philippine flora, is not yet fully resolved and many genera still need urgent taxonomic attention. Majority are still only known from one or two collections (including *S. lanaensis*). Amending the description and finding the type population is integral to this step. Unfortunately, threat of habitat destruction, armed conflict, and climate change hinders conservation and taxonomic efforts. The habitat of the new species is likewise within the ancestral land of the indigenous people in Zamboanga. The Subanen people call *S. abbreviata 'himag-puti'* and is traditionally used as an ointment for wounds along with other *Saurauia* species found in the type locality.

Rediscovery and lectotypification of Saurauia longipedicellata Merr.

Saurauia longipedicellata Merr. is rediscovered after almost a century from the forest of the Municipality of Leon B. Postigo, growing sympatrically with *S. abbreviata sp. nov.* As part of the study towards a revision and improving the species definition of Philippine *Saurauia*, an amended description of the species is provided here. Moreover, no holotype had been assigned in the protologue of *S. longipedicellata*. Thus, we assume that all extant specimens bearing the collection *BS 36897 Ramos & Edaño* are syntypes. The specimen deposited at K in our opinion matches the current circumscription of this species and best represents this taxon. We therefore assign it as the lectotype following the ICN (Turland et al. 2017). The specimen from K shows consistent diagnostic characters with respect to the rediscovered population as vouchered by KRFM (*KRM 0016*) and the original description (i.e. glabrous branchlets and leaves, axillary and cauline positioned inflorescences with very long pedicels). All the remaining extant specimens with the same collection number of this species are therefore treated as isolectotypes.

Saurauia longipedicellata Merr., Philipp. J. Sci. 20, 1922: 407 (Figures 4, 5).

Type: Malangas, Zamboanga Sibugay, Mindanao, Philippines, in forest along streams at low altitudes, November 1919. *BS 36897 Ramos & Edaño*. Lectotype here designated: K000761737! (Fig. 6); isolectotype: US1264759!.

Description

Habit small tree, ca. 7 m high, 8.8 cm (diameter at breast height), bark color rufous brown–beige. Branchlets terete, about 5.0 mm in diameter, green when young, brown when old, entirely glabrous with sparse minute warts and scales on branchlets. Leaves alternate, simple; blade oblanceolate, chartaceous-subcoriaceous, 11–20 cm long × 4.0–5.5 cm wide, apex rather abruptly and shortly acuminate, base cuneate, sub-oblique, margin entire from the base to the lower half or upper two-thirds, the upper half or a third to the apex denticulate; brown when dry, slightly shiny, adaxial surface green, entirely glabrous or with sparse minute warts at the midrib; abaxial surface pale, glabrous with sparse minute warts and scales on the midrib, lateral veins, and reticulations; lateral veins pinnate, (14–16 pairs), abruptly curved and ascending, raised abaxially; secondary veins less prominent, slightly canaliculate adaxially. Inflorescences axillary or cauliflorous, fascicled, 1.0–1.8 cm wide, on the trunk and larger branches, few flowers in anthesis at a time; each pedicel is attached to a lignified tubercle, individual rachis 2.6 mm long × 2.0 mm wide with pairs of linear–triangular scales subtending the pedicel attachment (scales 0.6–0.8 mm long × 0.5–1.0 mm wide). Bracts 2, lanceolate, 1.0–3.0 mm long × 0.6 mm wide, located at or near the middle of the pedicel, glabrous, appressed to the pedicel. Pedicels glabrous, terete, red-pink, slender, (3–)4–5 cm long. Sepals 5-merous, pinkish white; outer 2 sepals elliptic-ovate, 2.0–3.5 mm long × 1.78–2.0 mm wide, glabrous on both surface; inner sepals petaloid, quite rigid only at the median portion, orbicular-elliptic, 4.0–5.0 mm long × 3.7–5.0 mm wide, broadly rounded, glabrous on both surfaces. Petals 5-merous, pinkish, broadly oblong, 7–8 mm long × 4–6 mm wide, entire, apex notched, sinus 1.4–2.0 mm long, glabrous on both surfaces. Stamens 15–20, in one series, adnate to the corolla; filaments 2.0–2.3 mm long, glabrous; anthers 1.9–2.5 mm long × 0.7–1.2 mm wide, oblong, dorsifixed, longitudinally dehiscent, apex divided into 2 lobes, 0.2–0.4 mm long. Ovary globose, glabrous, white, 1.6 mm long × 2.2 mm wide; locules 3(–4), placentation axile, ovules many. Styles (2.7–4.0 mm long) 3(–4), filiform, terete, white, united only at the point of attachment, upper arms free, stigma capitate, corniculate. Fruit berry, few per infructescence, globose-ovoid, glabrous, pink-white, ca. 9.0 mm long × 6.0–9.0 mm wide (styles excluded); styles quite persistent or nearly so, sepals persistent at base, apically splitting. Seeds black, embedded in mucilaginous matrix, numerous.

Notes

S. longipedicellata is unique and strongly characterized by being entirely glabrous (Merrill 1922). The specific epithet pertains to its long pedicels—the strongest diagnostic characteristic of the taxon. However, upon closer examination, it appears that there are (very) sparse minute warts and/or scales present in localized areas of the plant (at least for the vouchered specimens). But these sparse minute warts or scales needs a magnifying tool to confirm presence and cannot be easily discerned especially in fresh specimens.

Notably, these sparse minute warts and scales present in localized areas of the plant may have been a derived character from the reduction of the setae. The sparse warts are more visible abaxially as compared adaxially on leaves. The pedicels of cauliflorous fascicle are attached to lignified tubercles. The outer sepals are thicker and more rigid compared to the inner sepals which are somewhat petaloid. The style and locule number is 3 (very rarely 4). Nevertheless, all other characters mentioned in the protologue especially that of the long pedicels of both the inflorescence and infructescence of *S. longipedicellata* is similar for the Zamboanga population.

S. longipedicellata was noted by Merrill (1922) to be closest to *S. trunciflora* Merr. However, *S. longipedicellata* can be readily differentiated by the absence of well-developed setae on the ultimate branchlets, fewer lateral veins (14–16 pairs *vs.* 15–20 pairs), inflorescence position (axillary and cauliflorous *vs.* strictly cauliflorous), and longer pedicels [(3–)4–5 cm long *vs.* 2–3.5 cm long)].

Ecology

The newly rediscovered population of *S. longipedicellata* Merr. was found in the same locality as *S. abbreviata,* sp. nov. Merrill noted that the type population of this taxon was collected in Zamboanga, district of Malangas, lowland forest along streams. Similarly, the rediscovered population of *Saurauia* collected by the first author were

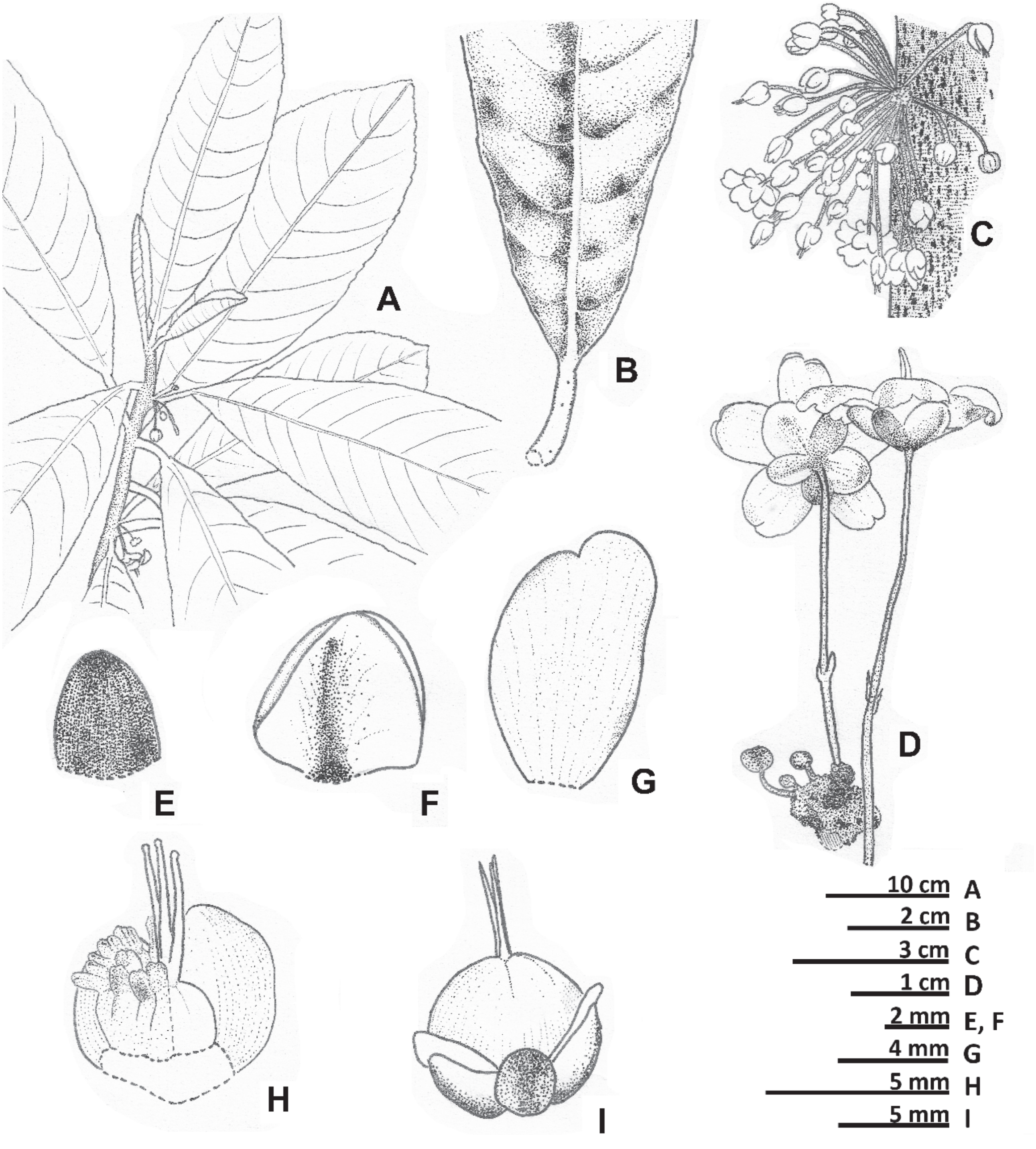

Figure 4. *Saurauia longipedicellata* Merr. A. Habit; B. Leaf (adaxial view); C. Cauliflorous inflorescence; D. Detail of the flower and tubercle; E. Outer sepal; F. Inner sepal; G. Petal; H. Flower (with portions of corolla and stamens removed). I. Fruit. Illustrated by Jayson Mansibang.

growing in the same ecological conditions, and it has been observed that all other species of *Saurauia* present in the area prefer the same habitat. At present the habitat preference and ecology of *Saurauia* species in the Philippines is not well understood. Thus, a comprehensive ecological study for *Saurauia* is recommended to aid future research in this poorly studied genus.

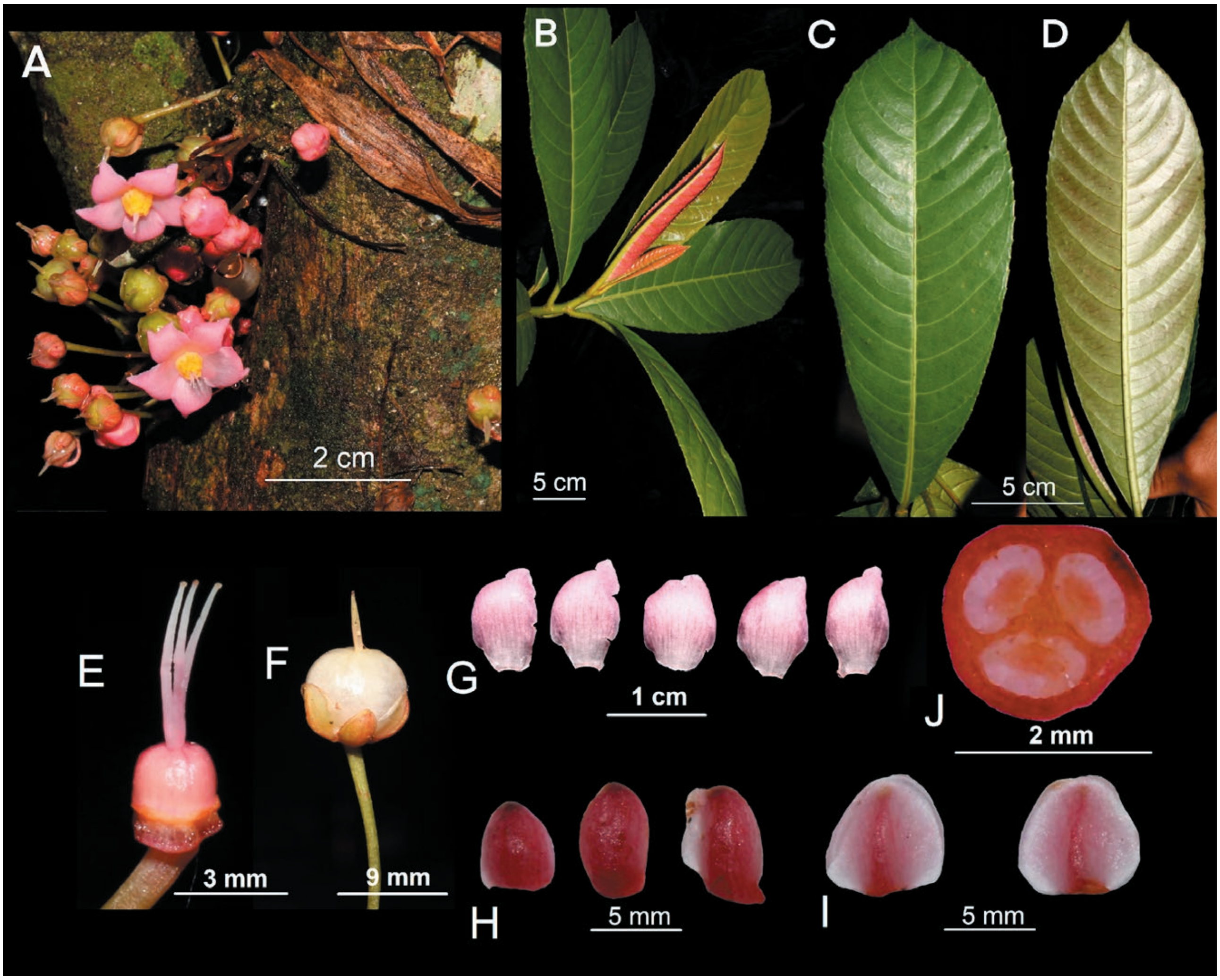

Figure 5. *Saurauia longipedicellata* Merr. A. Cauline inflorescence; B. Branchlet; C. Leaf (adaxial view); D. Leaf (abaxial view); E. Pistil (perianth removed); F. Fruit; G. Petals; H. External sepals; I. Internal sepals; J. Ovary cross-section. Photos by Kean Roe Mazo.

Proposed Conservation Status

Though endemic, the difficulty to conduct fieldwork in the areas of extant populations cannot confidently designate a putative conservation status of this species. We thus temporarily assign it as Data Deficient (DD) (IUCN Standards and Petitions Committee, 2019).

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Figure 6. Lectotype of *Saurauia longipedicellata* Merr. K000761737. Copyright of the Board of Trustees of the Royal Botanic Gardens, Kew (http://specimens.kew.org/herbarium/K000761737).

ers involved in this study. We also thank the comments and suggestions of the reviewers that contributed to the improvement of this manuscript.

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Matelea tarrazuana (Apocynaceae, Asclepiadoideae), a new critically endangered ocellate species from Central Pacific of Costa Rica

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Abstract. *Matelea tarrazuana*, a new species endemic to Costa Rica, is described and illustrated. It is similar to *M. pusilliflora*, a vine from Yucatan Peninsula because of its green flowers with a reflective white spot in the apex at the apex of each lobe, but differs from that species by its longer pedicels, larger corolla lobes, staminal corona purple (vs. orange), gynostegium with the style apex purple (vs. green) and inhabiting premontane forests of Costa Rica. Data on its distribution and habitat, phenology, conservation status and taxonomy are included, as well as photographs of the living plant, and a key to identify the five related species in Mesoamerica.

Keywords: Endemic, floristics, Milkweed, premontane forest, Tarrazú.

INTRODUCTION

Matelea Aub. (Asclepiadoideae) is one of the largest genera within Apocynaceae comprising approximately 225 species worldwide (McDonnell 2014). It comprises herbaceous or woody neotropical vines (Stevens 2009, Cortez *et al*. 2018, Morales & Stevens 2020), and is the largest genus in the New World subtribe Gonolobinae (G. Don.) Liede. (McDonnell 2014). It has been suggested that it has two centers of diversity: one includes southern Mexico-Guatemala, and the other in the north of South America (Spellman and Dwyer 1973, Villaseñor 2016).

Molecular studies have suggested that *Matelea* sensu Woodson (1941) is morphologically heterogeneous and not monophyletic (Krings et al. 2008; Morillo 2015). Here we follow the concept of the genus *Matelea* according to Stevens (2009). Traditionally, *Matelea* has a mixed indumentum of long, short and glandular hairs, the glandular always colored, extra-axillary inflorescences, rotate or campanulate corollas, staminal corona fused to the base of the corolla or the gynostegium, and horizontal or subhorizontal pollinia laterally excavated and sterile near the union with the caudicle (Stevens 2009).

Matelea has been studied twice recently in Costa Rica. Stevens (2009) suggest that the genus has 13 species, whereas Morales & Stevens (2020) recognized 15 species. Because of this, it was unexpected to find a new species of this group. This taxon is unusual and conspicuously different in floral morphology from the other related species of *Matelea* in Mesoamerica, and belongs to a the "ocellate complex" (Krings 2012) characterized by its small-flowered species held together primarily by having a bright white reflective ocellus at the tip of each corolla lobe. Stevens and Arbelaez (2014) discusses the rarity of this group, and this new species reinforces the discussion and make the discovery more expected.

MATERIALS AND METHODS

The study area is located in the Zona de los Santos region (Tarrazú canton) in the Central Pacific of Costa Rica. The material was processed and incorporated into CR and USJ. The acronyms of herbaria mentioned in this work follow Thiers (2021). The description and illustration were based on live and dried material. Stevens (2009) and Cortez et al. (2018) were followed for the morphological terminology. Ecological life zone is described according to Holdridge et al. (1971). The assessments of the conservation status were made based on the guidelines of the International Union for Conservation of Nature (IUCN 2001), using parameters such as number of locations, extent of occurrence (criterion B1) and area of occupancy (criterion B2). Map was made using Photoshop.

TAXONOMIC TREATMENT

Matelea tarrazuana J.E.Jiménez & J.E.Hidalgo-Mora, **sp. nov.** (Figures 1, 2).

Type: Costa Rica: San José, Tarrazú, San Lorenzo, San Joaquín, bosque a la par del río San Joaquín a 50 m aguas arriba del puente que lo atraviesa. Este río se convierte en el Río Naranjillo pocos metros aguas abajo cuando se une con la quebrada Pirranga, bosque primario intervenido, 1200–1300 m, 9°34'52.86'' N, 83°58'48.90'' W, 28 Mar. 2020 (fl.), *J.E. Jiménez & J. Hidalgo-Mora 5058* (holotype: USJ!, isotype: CR!).

Diagnosis

Similar to *Matelea pusilliflora* L.O. Williams in having leaves ovate with the base slightly cordate or truncate, inflorescences racemose and congested and flowers green with a reflective white spot in the apex of each lobe, but differs from that species by its pedicels 0.4‑0.6 cm long (vs. 0.1‑0.2 cm long), corolla lobes as long as wide, 0.4–0.5 cm long (vs. wider than long, 0.2–0.3 cm long), staminal corona purple (vs. orange), and gynostegium with the style apex and stigma purple (vs. green).

Description

Twining herbaceous vines**,** latex colorless. *Stems* cylindrical, slightly suberose and glabrescent with age, young branchlets puberulent to sericeous with translucent trichomes less than 0.1 cm long, old branchelets and main stems glabrous to puberulent. *Leaves* opposite-decussate in orthotropic stems and opposite-distichous in plagiotropic stems, increasing progressively in size in the plagiotropic stems from the proximal to distal nodes, yellow when withered; petioles 0.8‑1 cm long, puberulent with translucent trichomes less than 0.1 cm long; leaf blades 2.5‑6.5 x 1.2–3.5 cm, ovate, the apex acuminate to long-acuminate, the base cordate to slightly truncate, with a sinus of 0‑0.5 cm, leaves scarcely puberulent on adaxial side, with few trichomes less than 0.1 cm long and sparse to densely puberulent on the midveins and secondary veins abaxially; brochidodromous venation, with 4–6 pair of secondary veins; colleters at the base of the midrib on the adaxial side, 4–6, ca. 1 mm long. Inflorescences extra-axillary, one per node, condensed-racemiform, 0.1‑0.7 cm long, with straight disperse trichomes less than 0.1 cm long; peduncles 0.3–0.4 cm long; pedicels 0.4–0.6 cm long; bracts lanceolate, 0.2‑0.3 × ca. 0.1 cm, margin ciliate with trichomes less than 0.1 cm. Calyx lobes ovate-lanceolate, 0.4–0.5 × 0.1–0.3 cm, erect, puberulous. Corolla rotate, green to brownish green, with inconspicuous reticulate light green venation, with a bright white spot at the tip of each lobe, glabrous, tube 0.2 cm long, lobes ovate to nearly orbicular, flat and patent, 0.4–0.5 × 0.4–0.5 cm, apex obliquely acuminate to obtuse; staminal corona rounded-pentagonal surrounding gynostegium, purple to dark-purple, fleshy, with five semicircular wings folded in front of each anther. Gynostegium with a cylindrical stipe 0.1–0.2 cm tall covering by the corona, pentagonal, style apex rounded-pentagonal, convex in natural form, 10–15 mm wide, with a gray margin. Pollinaria ca. 15 × 12–10 mm, corpuscle brown, slightly clavate; lamellar claudicle 10–12 mm long, pollinia oblong, ca. 10 × 03–05 mm, laterally excavated, oriented towards the posterior part of the anther. *Follicles* and seeds unknown.

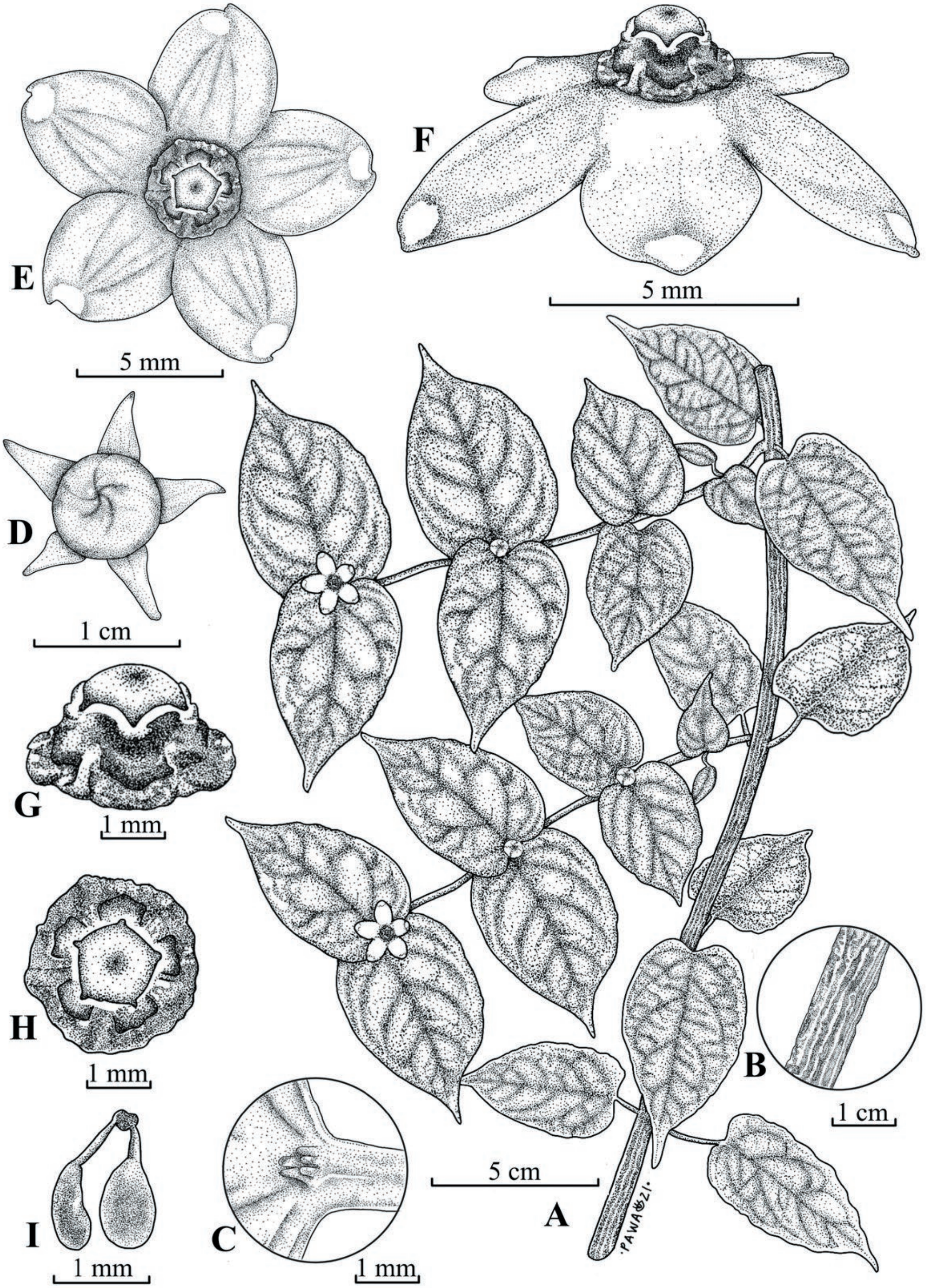

Figure 1. *Matelea tarrazuana*. A. Flowering branch. Notice orthotropic stem with an opposite-decussate phyllotaxy and plagiotropic stems with an opposite-distichous phyllotaxy. B. Detail of a stem segment. C. Colleters. D. Flower bud. E. Flower in frontal view. F. Flower in lateral view. G. Staminal corona and gynostemium in lateral view. H. Staminal corona and gynostegium in frontal view. I. Pollinarium. Illustration based on live photographs of the type specimen *Jiménez & Hidalgo-Mora 5058* (USJ).

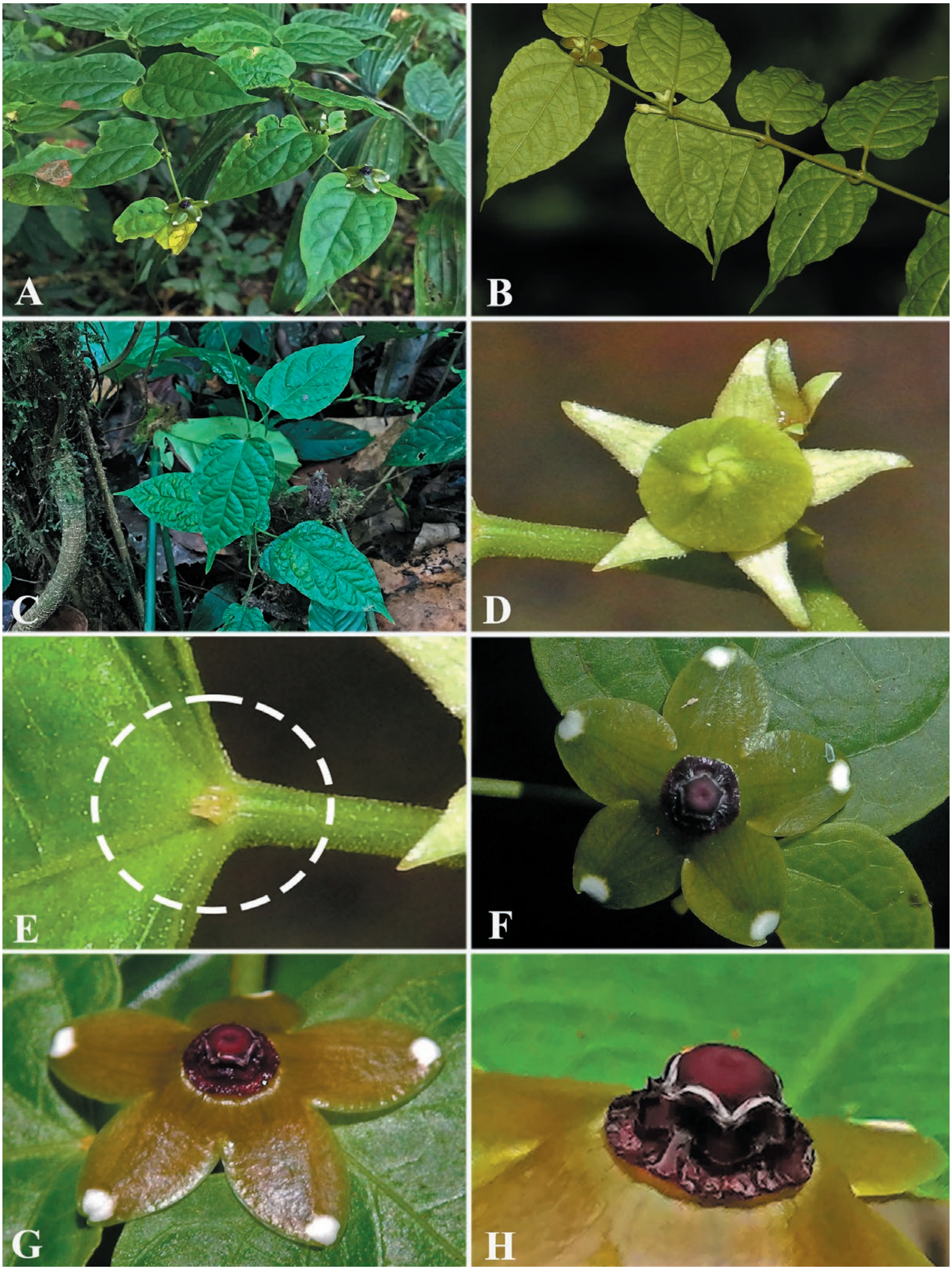

Figure 2. *Matelea tarrazuana*. A. Plagiotropic stems with an opposite-distichous phyllotaxy, adaxial side of leaves and flowers. B. Abaxial view of the leaves. C. Orthotropic stem with an opposite-decussate phyllotaxy. D. Flower bud with the calyx patent. E. Colleters on the base of the leaf blade. F. Green flower in frontal view. G. Brownish-green flower in lateral view. H. Detail of the staminal corona and gynostegium. Photographs based on type specimen *Jiménez & Hidalgo-Mora 5058* (USJ).

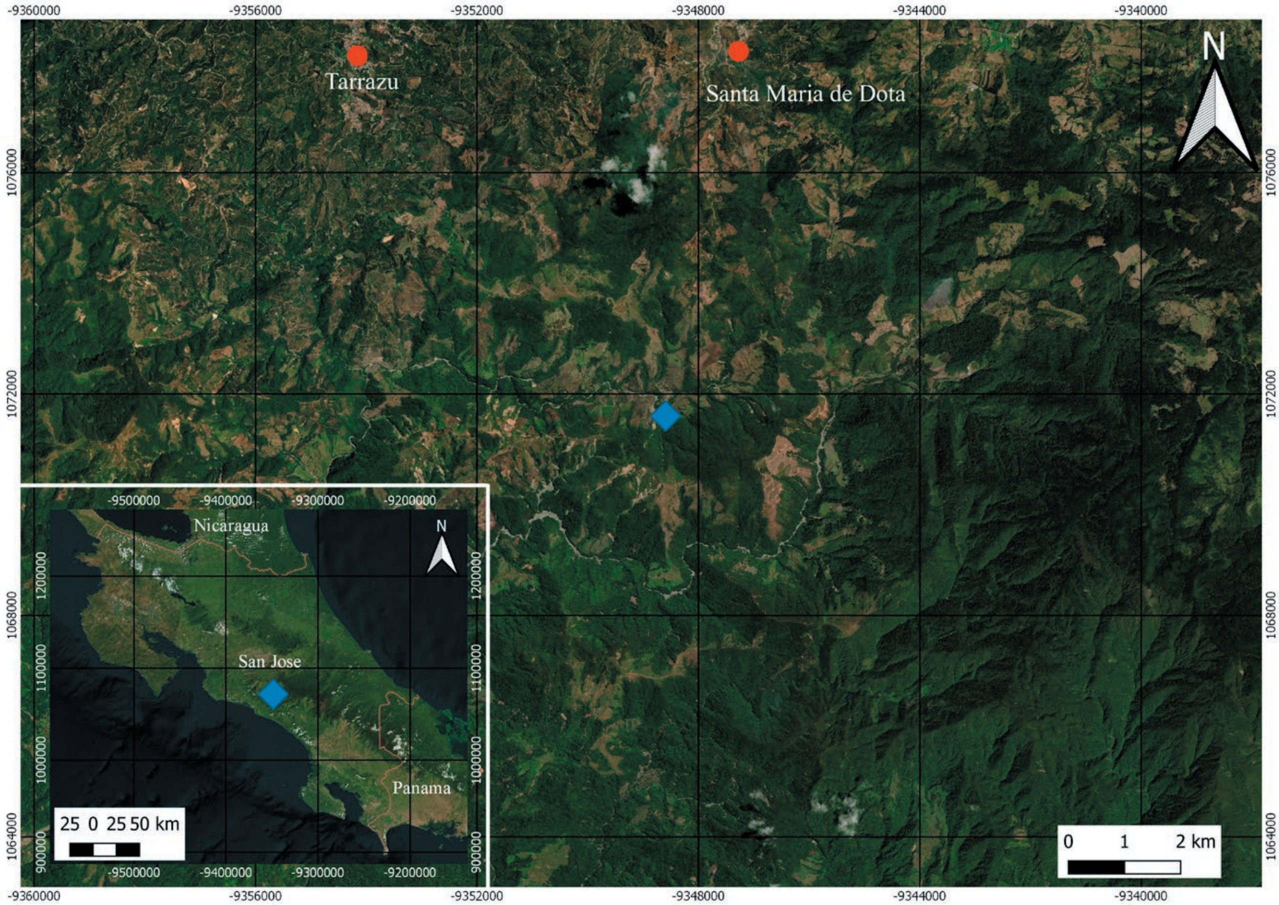

Figure 3. Distribution of *Matelea tarrazuana* J.E. Jiménez & J.E. Hidalgo-Mora.

Etymology

This species is named after Tarrazú, locality of the type specimen.

Distribution and habitat

Matelea tarrazuana is endemic to Costa Rica. It is known only from the type locality, in primary and secondary forest in San Joaquín de Tarrazú, Zona de los Santos region, San José province, at 1249 m in a premontane rain forest (Figure 3).

Phenology

Flowering has been recorded in March during dry season, and November during rainy season. It was also observed in bloom during April, May, and July but no vouchers were prepared. No fruits were seen.

Conservation Status

Matelea tarrazuana is not protected in any protected state area or private reserve in Costa Rica The two specimens in herbaria and the single known population severely affected by unsustainable agricultural and livestock activities suggest that this species is rare. Despite to has a restricted natural distribution, the Data is Deficient (DD).

Remarks

Matelea tarrazuana is easily to recognize because of the reflective white spot in the apex of each corolla lobe, a diagnostic characteristic that share with *M. corniculata*, *M. emmartinezii*, *M. pusilliflora*, and *M. ocellata* in Mesoamerica. In Costa Rica, only *M. corniculata* and *M. ocellata* are reported, but in different ecosystems. *Matelea corniculata* grows in a tropical moist forest Sarapiquí, Heredia (La Selva Biological station), whereas *M. ocellata* has been found in tropical dry forest Santa Elena peninsula (Santa Rosa national park). *Matelea tarrazuana* can be separated from *M. pusilliflora*, by its longer pedicels (0.4–0.6 vs. 0.1–0.2 cm), corolla lobes as long as wide, 0.4–0.5 cm long (vs. wider than long, 0.2–0.3 cm long), a purple staminal corona (vs. orange), and gynostegium

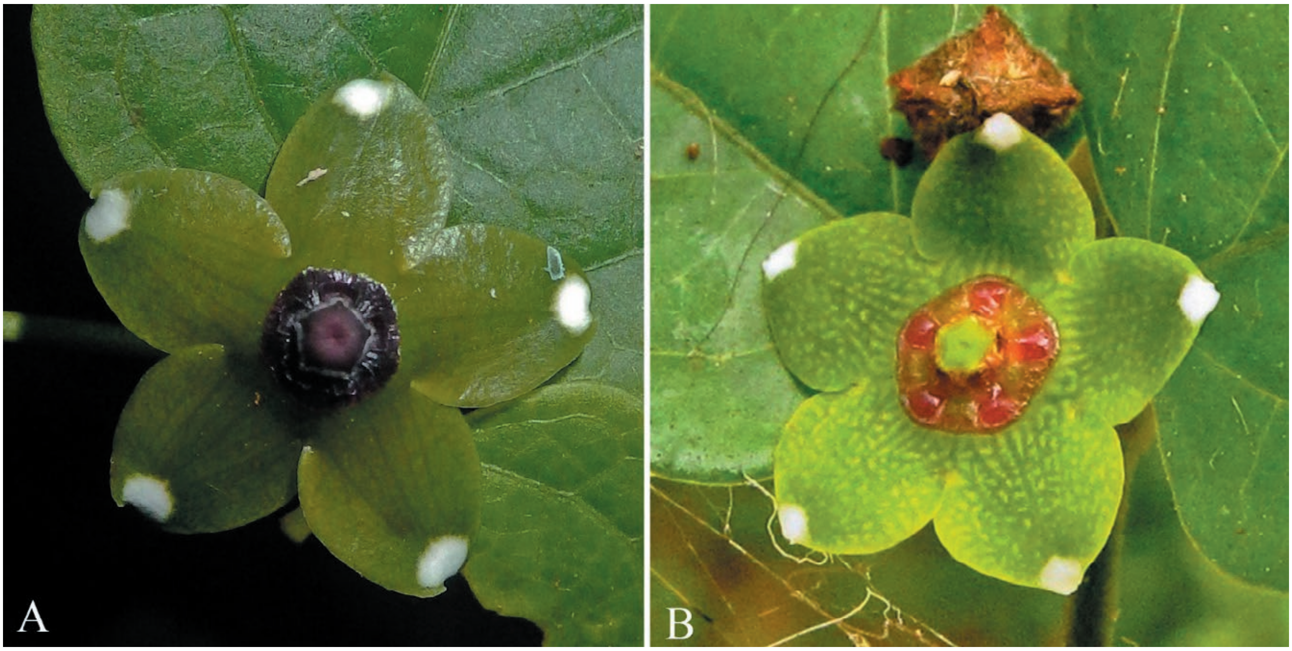

Figure 4. Flowers of *Matelea tarrazuana* (A) and *M. pusilliflora* (B) from Yucatan Peninsula. Photo of *M. tarrazuana* by J.E. Jiménez (*Jiménez & Hidalgo-Mora 5058* [USJ]), and photo of *M. pusilliflora* by Jan Meerman (Belize), not vouchered.

with the style apex and stigma purple (vs. green) (Figure 4). Diagnostic morphological characteristics to separate these species are given in Table 1.

Three morphological characters are peculiar in this species: the apparent lack of latex, the position of the leaves according to the type of stem and the progressive increase in size in the leaves in the plagiotropic stems. Morales & Stevens (2020) suggest species of *Matelea* in Costa Rica has latex, thus *Matelea tarrazuana* could be the only species of the genus in Costa Rica without latex. Furthermore, there is no documentation of the change in phyllotaxy depending on the type of stem in *Matelea* nor in the progressive size of the leaves. This species has an opposite-decussate leaves in orthotropic stems and opposite-distichous in plagiotropic stems (branches), and the leaves increasing progressively in size in the branches from the proximal to distal nodes. These three observations could be focused of taxonomic study in future studies of the group because they can represent important characters to differentiate species or clades.

This new species proposed here was found in a remnant forest surrounded by paddocks and especially coffee plantations. Unfortunately, the Zona de los Santos's region has been slowly deforested by coffee plantation in the last decades in less than one year, other three new and narrowly endemic species were published from this area (Cedeño *et al.* 2020, Juárez & Morales 2021). *Matelea tarrazuana* is the sixteen species of the genus documented for the country.

Additional specimen examined

COSTA RICA: San José, Tarrazú, San Lorenzo, San Joaquín, bosque contiguo al río San Joaquín aguas arriba del puente, bosque primario intervenido, 1200–1300 m, 9°34'52.86'' N, 83°58'48.90'' W, 10 Nov. 2020 (fl.), *Jiménez 5483* (USJ, in spirit).

Key to identify the species of Matelea with a reflective white spot in the apex of each corolla lobe for Mesoamerica

1. Corolla and calyx lobes reflexed; tube with a horn between each lobe of the corona .... ***M. corniculata***

1. Corolla and calyx lobes patent; tube without a horn 2

2. Corolla lobes longer than wider 3

3. Corolla lobes elliptic and cucullate; staminal corona green to brownish, the center smooth and shiny and the margin opaque, purple and radially striated; stye apex star-like, purple; Chiapas.. ***M. emmartinezii***

3. Corolla lobes ovate to deltate and flattened; staminal corona with 5 opposite erect wings, yellow to orange; style apex rounded-pentagonal, green; Caribbean lowland rainforest of Nicaragua and Costa Rica .... ***M. ocellata***

Table 1. Morphological comparison of the five Mesoamerican species of *Matelea* that have a reflective white spot in the apex of each corolla lobe.

Structure	*M. corniculata*	*M. emmartinezii*	*M. ocellata*	*M. pusilliflora*	*M. tarrazuana*
Leaf shape	Ovate to lanceolate	Ovate	Elliptic to ovate	Ovate	Ovate
Length × width (cm) of the leaf blade	4.5–11 x 1.5–6.5	4–5.5 x 1.5–2	3.8–9.2 x 1.5–3.9	2.9–7 x 1.1–2.5	2.5-6.5 x 1.2–3.5
Number of secondary veins (per side)	4–5	4–5	3–6	4–6	4–6
Numbers of colleters in leaves	2	2–4	3–6	2–4	4–6
Petiole length (cm)	0.4–1.2	0.5–1	1–2.2	0–3–0.6(–1.8)	0.8-1
Length × width (mm) of the sepals	2.1–3.2 × 0.8–1.5	2.2 × 0.9	1.1–1.9 × 0.7–1.2	2–2.2 × 1.1–1.2	0.4–0.5 × 0.1–0.3
Sepals shape	Ovate, reflexed	Elliptic, patent	Lanceolate, patent	Lanceolate to elliptic, patent	Ovate-lanceolate, patent
Latex color	Unknown	White	Unknown	Unknown	Colorless
Length of pedicel (cm)	0.3-0.5	0.2-0.25	0.4-1.4	0.1-0.2	0.4-0.6
Corolla lobes shape	Elliptic-reflexed	Elliptic-cucullate, patent	Deltate, patent	Ovate, patent	Ovate to slightly orbicular, patent
Corolla color	Brown	Green	Green	Lightgreen	Green to brownish-green
Color of staminal corona	Apparently brown	Purple greenish to brownish	Yellow to orange	Yellow to orange	Purple
Length x width of the corolla lobes (mm)	6.5–9.2 × 2.5–3.2	4.0 x 2.7	2.7–3.5 × 2.1–2.2	2.3–2.7 x 2.8–3.4	4–5 × 4–5
Length (mm) and (in case) shape of the corolla tube	0.5, with an erect horn between each corolla lobe	1-1.3	0.8-2	1.5-1.7	2
Shape and color of apex style	Rounded-pentagonal and strongly convex, color unknown	Star-like, purple	Rounded-pentagonal, unknown color	Rounded-pentagonal, green	Rounded-pentagonal, Purple
Folicles and seeds	Unknown	Unknown	Unknown	Unknown	Unknown

2. Corolla lobes wider than long or as wide as long 4

4. Pedicels 0.4-0.6 cm long, corolla lobes as long as wide, 0.4–0.5 cm long; staminal corona purple; gynostegium with the style apex and stigma purple; Tarrazú (Costa Rica........ .... ***M. tarrazuana***

4. Pedicels 0.1-0.2 cm long; corolla lobes wider than larger, 0.2–0.3 cm long; staminal corona orange; gynostegium with the style apex and stigma green; Yucatan Peninsula.... .... ***M. pusilliflora***

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We thank Jan Meerman from Belize for the permission to reproduce the photo of *M. pusilliflora*. Barry E. Hammel kindly shared the draft treatment of *Matelea* from Manual de Plantas de Costa Rica Vol. IV prior to its publication. We thank Maria Fernanda Cordero Pagoaga who made the scientific illustrations using in this work and Marco Cedeño for his support in the map elaboration. We appreciate the constructive and helpful comments of Warren Douglas Stevens and Juan Francisco Morales that improved this manuscript.

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Studies on Schismatoglottideae (Araceae) of Borneo LXX — New colonial species for the *Schismatoglottis* [Calyptrata Clade] from Sarawak

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Abstract. Three new colonial species of *Schismatoglottis* Calyptrata clade are described and illustrated from Sarawak and compared with the four pre-existing morphologically similar species occurring in the state. A modified description of *Schismatoglottis niahensis* is provided to correct a previous misinterpretation of the stem architecture. All seven recognized species are illustrated from living plants.

Keywords: Araceae, *Schismatoglottis*, Calyptrata clade, Sarawak, Borneo.

INTRODUCTION

Previous comprehensive regional accounts for *Schismatoglottis* (Hay 1996; Hay and Yuzammi 2000) provided an excellent baseline to undertake further study. Preliminary work on the *Schismatoglottis* Calyptrata clade for Sarawak (Wong 2012; Wong et al. 2016) recognized six species, four of which are stolonifeous-colonial, and of which *Schismatoglottis baangongensis* S.Y.Wong, Y.C.Hoe & P.C.Boyce (Wong et al. 2016: 80) was newly described and *S. muluensis* M. Hotta (Hotta 1966: 235) resurrected from within *S. calyptrata* Zoll. & Moritzi (Moritzi 1846: 83), with the latter treated as absent from Sarawak, and with its occurrence on Borneo considered to be doubtful.

Subsequently (Wong et al. 2018; Wong & Boyce 2020a) defined *S. calyptrata* as restricted to Maluku (the Type is from Pulau Ambon) through the Philippines archipelago and possibly occurring as far north as Lanyu Do (Taiwan) [but see *Schismatoglottis kotoensis* (Hayata) T.C.Huang, J.L.Hsiao & H.Y.Ye (Huang et al. 2000: 305)], eastwards through New Guinea and the Bismarck Archipelago to the Solomons. Determining to what extent *Schismatoglottis calyptrata* sensu strictiore occurs in the eastern part of this area still requires much work (see Hay in Hay & Yuzammi 2000; Wong et al. 2018). Implementing narrower species definitions means that plants formerly treated as *S. calyptrata* in Sarawak are new species that require publication for Borneo. In many instances the material to hand is inadequate to allow publication at the present time. This paper deals with three novelties for which we have complete material.

As noted in previous papers (e.g., Hay 1998; Boyce & Wong 2015; Kartini et al. 2015; Wong & Boyce 2020b) the extraordinarily complex surface geology of the island of Borneo is enormously important in the separation of species in aroid genera such as *Homalomena*, *Schismatoglottis*, and *Alocasia*, among others. Geology in this paper is specified based on Hutchison (1989, 2005) and Tate (2001).

1. *Schismatoglottis adducta* S.Y.Wong & P.C.Boyce, **sp. nov.**

Type: Malaysian Borneo. Sarawak: Sri Aman Division, Tempat Rekreasi Sungai Raya, banks of the Sungai Raya,1°06'49.2"N 111°30'56.8"E, 86 m asl., 9 Dec 2005, *P.C.Boyce, Jeland ak Kisai, Jepom ak Tisai & Mael ak Late AR-1632* (holotype SAR!). (Figures 1, 2 and 14A).

Diagnosis

Schismatoglottis adducta is most similar to *S. muluensis* by the presence of an elongated partially naked interstice separating the pistillate and staminate florets, and scattered ascending-clavate waxy white pistillate-zone staminodes, but readily distinguished by the blunt bullet-shaped spadix appendix (in *S. muluensis* the appendix cylindrical) two thirds the length of the staminate zone (in *S. muluensis* the appendix twice as long as staminate zone), by the pistillate floret zone comprising about one half of the spadix length (in *S. muluensis* the pistillate floret zone comprising slightly less than one third of the spadix), and dorsally fused to the spathe for about one third its length (vs not at all fused in *S. muluensis*). A bullet-shaped appendix occurs in *S. giamensis* and *S. roh*, from both of which *S. adducta* is distinguished by the elongated naked (vs abbreviated staminode-covered) interstice, and by having only the basal third (vs as least half) of the pistillate floret zone adnate to the spathe.

Description

Moderately robust colonial mesophytic herb 30–70 cm tall. Stems hypogeal, hapaxanthic, individual crowns linked by stout stolons about 10 cm long with internodes 3–9.5 cm long, 7–9 mm in diam., terminal active portion of stem slightly epigeal, erect. Leaves about 7 per crown; petiole 24–40 cm long, 1.8 cm wide at base, tapering to 3.5 mm wide at tip, ventrally weakly broadly channelled for 1/5 of length, smooth, dull medium green with faint slightly darker green striations; petiolar sheath 7–9 cm long × 5–10 mm wide, up to 3/10 of petiole length, persistent, fully attached, equal at both sides, slightly inrolled, tapering; blade 14–23.5 × 5.3–10.4 cm, narrowly hastato-cordate to rather broadly ovato-cordate, margins slightly undulate in the largest leaves, adaxially semi-matte rather dark green, posterior lobes bluntly triangular, 3–4 cm, sinus narrow, blade apex acute, ultimately tubular-mucronate for 1 cm; midrib adaxially slightly impressed, rounded-raised abaxially, about 7 mm wide at the insertion on petiole; primary lateral veins about 15 per side, diverging at 40°–60° from midrib, adaxially impressed, rounded raised abaxially alternating with rather fewer interprimary veins, these sometimes arising from near the base of more robust primary veins, especially in the lower half of the blade; secondary veins 0–2 arising from each primary vein with 3–4 secondary veins raised from primary veins near to petiole insertion; tertiary veins inconspicuous. Blooms up to 3 produced in sequence, erect and powerfully esteric-smelling during anthesis; peduncle 14–20 cm long × 4–9 mm wide, terete, medium green. Spathe 9.5 cm long; lower spathe narrowly oblong-ovoid, 4.5 cm long × 1.5 cm wide, base dorso-ventrally oblique for 40% (ventral side) to 25% (dorsal side) the length of the entire spathe, semi-glossy medium green, usually smooth; spathe limb at pistillate anthesis limb much inflated, turbinate, apex briefly mucronate, surrounding the spadix and gaping ventrally, greenish white with darker longitudinal veins, caducous immediately after pistillate anthesis. Spadix 7 cm long, about three quarters length of the spathe; pistillate floret zone slender conic, 3 cm long × 7 mm wide, comprising 40% of spadix length, white, basal third adnate to the spathe; pistils densely arranged, sub-globose-cylindric, 1 mm diam.; style distinct, very short; stigma capitate, somewhat domed, slightly narrower than ovary, 0.8 mm diam.; interpistillar staminodes few and scattered, ascending-clavate, stipe slender, upwards curved, 3 mm long, about twice as tall as pistils, waxy white; sterile interstice cylindric, 7 mm long × 3.5 mm wide, narrower than fertile zones, partially naked, proximally and distally with flattened wedge-shaped staminodes these grading into disproportionately larger (but sterile) florets, female proximally, male distally; staminate flower zone weakly obconic, 2 cm long × 4 mm wide, slightly under 30% the length of spadix, white; staminate florets very densely packed with individual

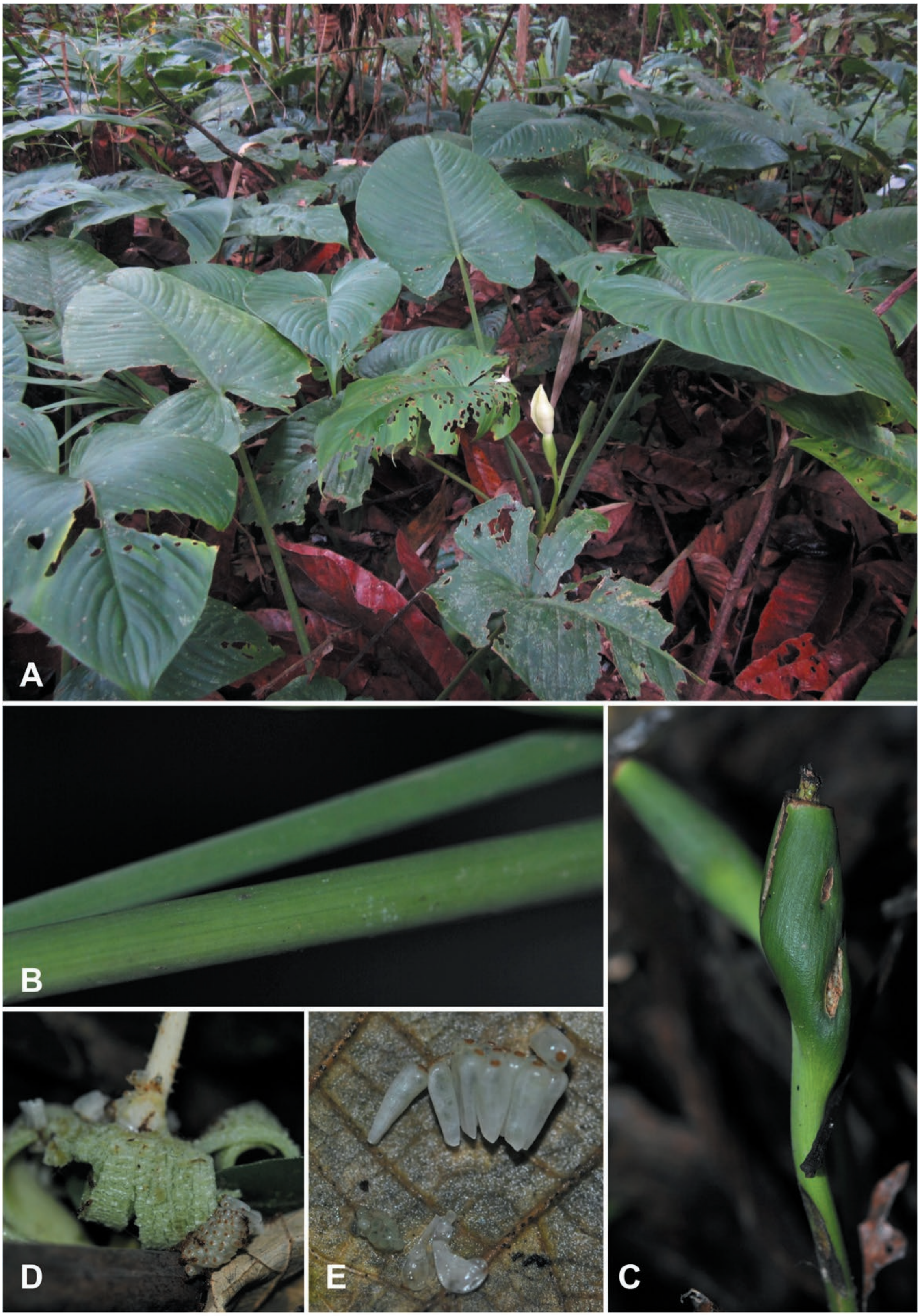

Figure 1. *Schismatoglottis adducta* S. Y. Wong & P. C. Boyce. **A.** Plant in habitat. **B.** Detail of petiole. **C.** Developing infructescence. **D.** Ripe infructescence with the persistent spathe splitting and reflexing. **E.** Fallen ripe fruits. A–D from *AR-1632*. Images © Hoe Yin Chen.

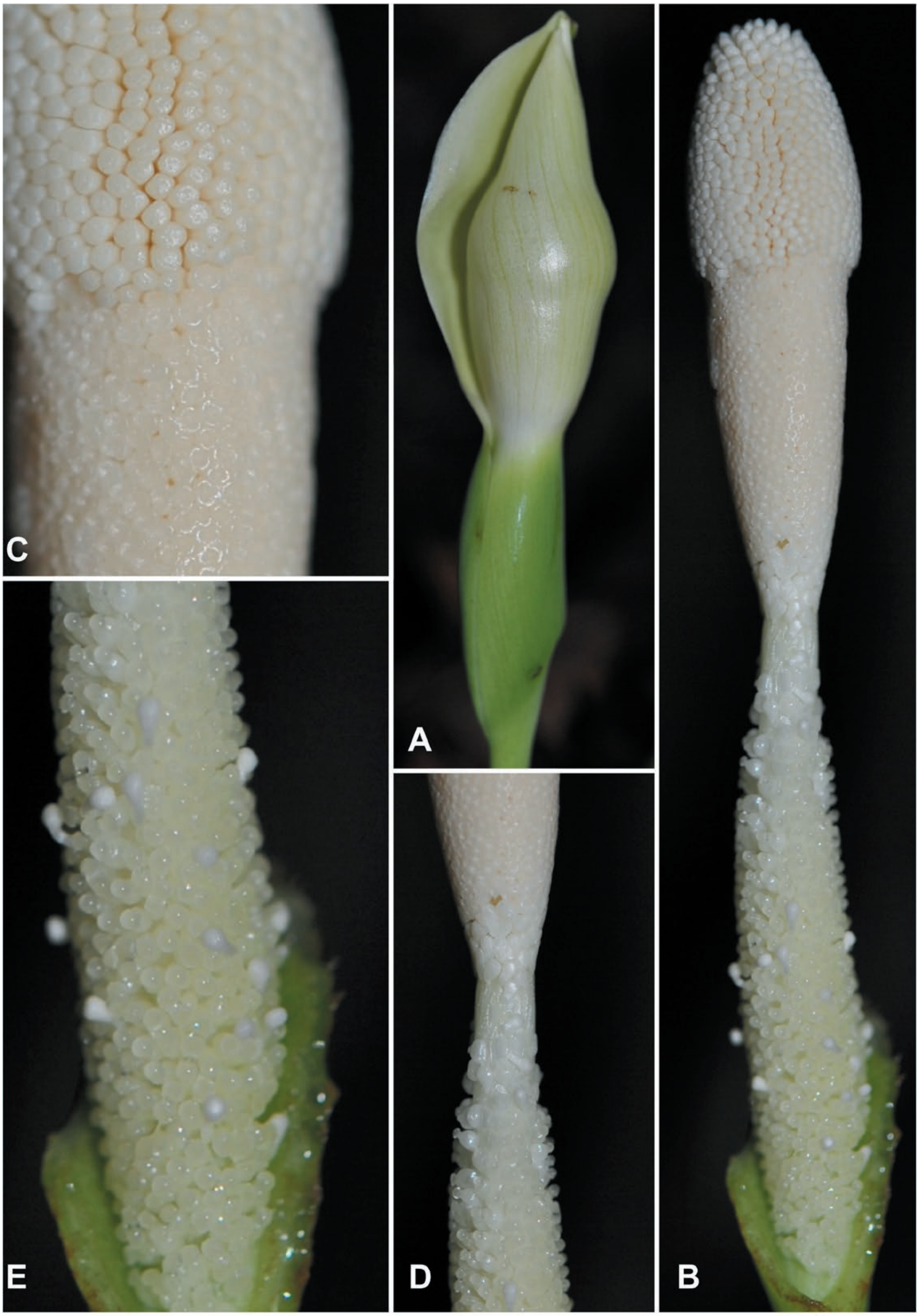

Figure 2. *Schismatoglottis adducta* S. Y. Wong & P. C. Boyce. **A.** Bloom at pistillate anthesis. **B.** Spadix at pistillate anthesis, spathe artificially removed. **C.** Detail of spadix, uppermost portion of staminate floret zone, and most of appendix. **D.** Detail of spadix, uppermost portion of pistillate floret zone, sterile interstice, and lowermost portion of staminate floret zone. **E.** Detail of pistillate floret zone. A–E from *AR-1632*. Images © Hoe Yin Chen.

florets hardly discernible, 0.6 mm wide, each comprising 2 truncate stamens, thecae very slightly sunken, surrounded by a narrow, raised rim and separated by a raised blunt connective; appendix bullet-shaped, 1.25 cm long × 7 mm wide, 15% length of spadix, base wider (about 1 mm) than apex of staminate zone, white; staminodes columnar with rounded tops, 2.5 mm long × 1 mm wide. Infructescence on a declinate peduncle, narrowly urceolate, dorsal side of the base strongly oblique, 4–6 cm long × 2–2.2 cm wide, deep green; lower spathe persistent, maturing to deep green on a paler peduncle, splitting and reflexing at fruit maturity; fruits obconic, 4 mm long × 1–2.5 mm wide, ripening semi-translucent white; seeds ovoid ellipsoid, 0.4 mm diam., longitudinally ridged.

Etymology

From Latin *adductus* — stretched, used in reference to the elongated distal portion of the sterile interstice separating the zones of pistillate and staminate florets.

Distribution

Widespread and locally abundant along the banks of the Batang Lupar and Sungai Raya near Sri Aman.

Ecology

Occurring in deep alluvial sandy clays over Eocene or Cretaceous sediments at low altitude under moist alluvial riverine forest.

Notes

Pollination biology data for *Schismatoglottis adducta* (and the other species covered here) are presented in Hoe et al. (2018). In summary pollination involves thermogenesis and floral odour production and consists of a biphasic pattern of thermogenesis in the appendix and the staminate zone with the first temperature peak occurring during pistillate anthesis and the second during staminate anthesis. During inter-anthesis, thermogenesis ceases, with the ambient temperature remaining higher than that of the spadix. Methyl ester- 3-methyl-3-butenoic acid is the single major compound in the floral scent profile, and the appendix the main olfactory structure. *Colocasiomyia* flies are the primary pollinators with *Cycreon* (Hydrophilidae) beetles secondary pollinators for all except *S. muluensis* for which *Atheta* (Staphylinidae) beetles are the primary pollinators.

Additional specimen examined (paratypes

MALAYSIAN BORNEO: Sarawak: Sri Aman Division. Lubok Antu, Engkililii, Tempat Rekreasi Batu Ngabau, 1°11’8.61”N 111°40’11.83”E, 40 m asl., 28 Aug 2012, *Hoe Yin Chen AR-4023* (SAR!).

Schismatoglottis baangongensis S.Y.Wong, Y.C.Hoe & P.C.Boyce, Aroideana 39(2): 80. 2016.

Type:— Malaysian Borneo. Sarawak, Kuching Division, Padawan, Siburan, Kampung Sikog, trail to Baan Gong waterfall, 01°020’16.1”N, 110°20’09.6”E, 26 Jul 2009, *P.C.Boyce & S.Y.Wong AR-2588* (holotype SAR!; isotype SAR - spirit!). (Figures 3, 4 and 14B).

Description

Moderately robust clumping to colonial mesophytic herb, 30–90 cm tall. Stems hypogeal, hapaxanthic, 0.5–1.5 cm diam., producing several stolons from each crown. Leaves 3–5 per crown; petiole, 42–48 cm long, weakly channelled 1/5 of length, smooth medium green, distally with prominent broken longitudinal darker green raised striations; petiolar sheath 11–14 cm long × 5–10 mm wide, up to 3/10 of petiole length, persistent, longitudinal striated, membranous, fully attached or (in very robust specimens) with a very short ligule, equal at both sides, slightly in-rolled or sometimes straight, tapering; blades ovato-sagittate to ovato-cordate, sometimes oblong-lanceolate, base cordate base, 20–39 cm long × 13–23 cm wide, softly coriaceous, adaxially glossy green, abaxially paler, posterior lobes subtriangular, 7–11 cm, sinus 8–11 cm wide, apex acuminate to acute for 2 cm, ultimately mucronate for 1 cm; midrib adaxially flush with blade, raised abaxially, 5 mm wide at the insertion; primary lateral veins 14 per side, diverging at 30°–80° from midrib, adaxially raised towards the midrib, marginally impressed, entirely raised abaxially; interprimary veins adaxially raised, alternating irregularly with primaries; secondary veins 0–2 arising from each primary vein with 3–4 secondary veins arising from primary veins near to petiole insertion; tertiary veins inconspicuous; broken vein-like pellucid canals slightly visible abaxially. Blooms up to 4 together per shoot, erect, strongly esteric-smelling during pistillate anthesis, odour absent during staminate anthesis; peduncle 10–15 cm long × 4–9 mm wide, terete, green, erect at anthesis. Spathe 11–12.5 cm long; lower spathe narrowly ovoid, 4 cm long × 2.3 cm wide, green, longitudinally ridged, demarcated from spathe limb by a constriction coinciding with sterile interstice; spathe limb turbinate, ovate when flattened, 6.5 cm long × 3.3 cm wide, mucronate for 2 mm, pale yellowish green at pistillate anthesis, ageing to dull pale yellow during anthesis, caducous in a single piece at onset of staminate

Figure 3. *Schismatoglottis baangongensis* S. Y. Wong, Y. C. Hoe & P. C. Boyce. **A & B.** Plants in habitat. **C.** Detail of synflorescence, with one bloom post-anthesis (left), and one at pistillate anthesis (right). **D.** Bloom at pistillate anthesis. A–D from *AR-2588*. Images © Hoe Yin Chen.

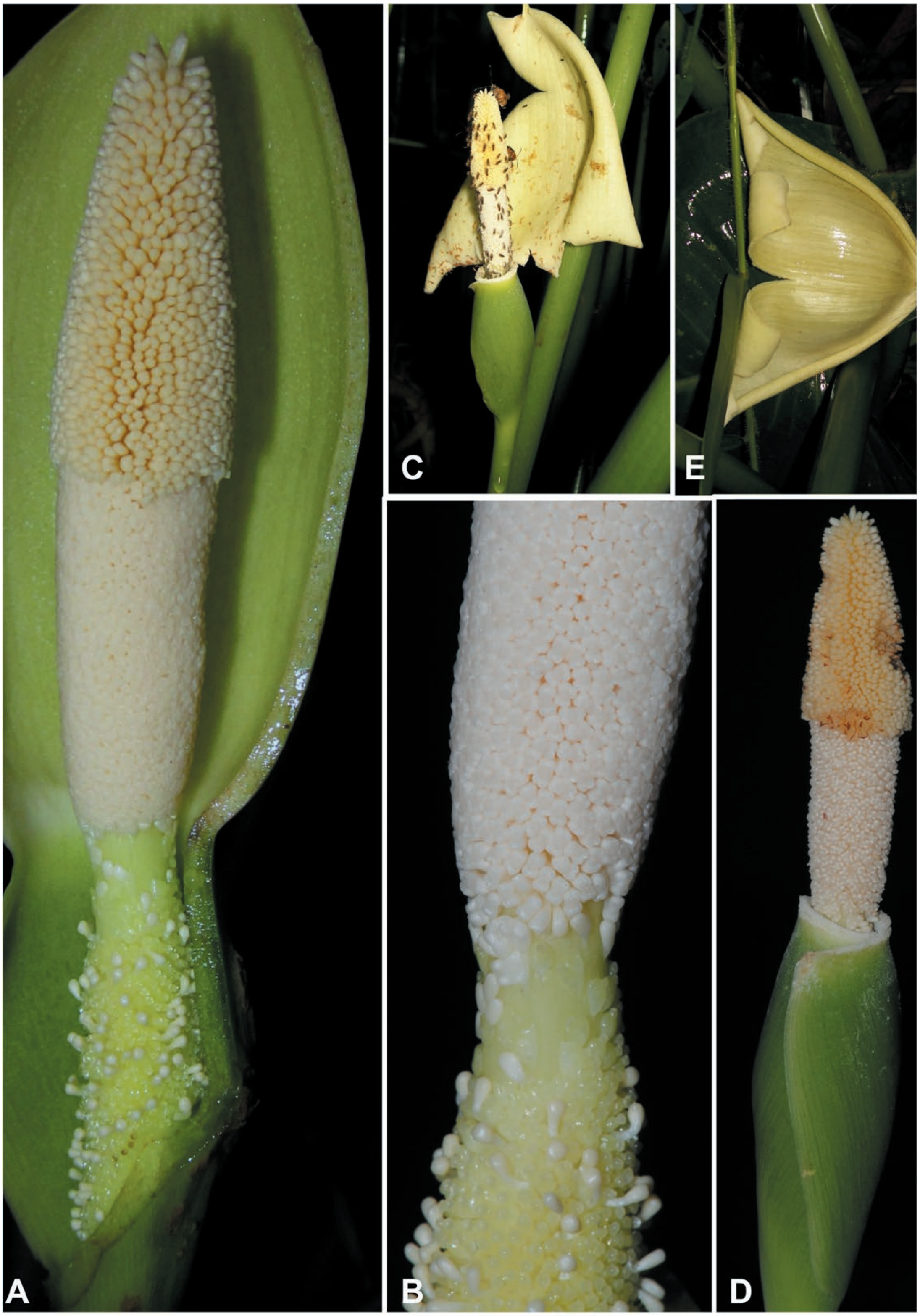

Figure 4. *Schismatoglottis baangongensis* S. Y. Wong, Y. C. Hoe & P. C. Boyce**. A.** Bloom at pistillate anthesis, nearside spathe artificially removed. **B.** Detail of spadix, uppermost portion of pistillate floret zone, sterile interstice, and lowermost portion of staminate floret zone. **C.** Bloom at onset of staminate anthesis with spathe limb beginning to shed. **D.** Bloom post anthesis with spathe limb shed. **E.** Caducous spathe limb. A–E from *AR-2588*. Images © Hoe Yin Chen.

anthesis. Spadix 9–10.5 cm long, shorter than spathe, sessile; pistillate flower zone slender obconic, 4–5 cm long × 1 cm wide, 2/5 of spadix length, bright green; pistils densely arranged, sub-cylindric to sub-globose, 0.8–1.2 mm diam.; style barely differentiated; stigma globose, truncate, smaller than ovary, 0.3 mm diam.; interpistillar staminodes numerous, strongly clavate, stipe slender, 0.5–0.8 mm in diam., twice height of pistils, waxy white; sterile interstice cylindric, 0.5–1 cm long × 5–6.5 mm wide, narrower than pistillate and staminate zone, partially naked, proximally and distally with flattened trapezoid staminodes; staminate flower zone weakly conic, proximally narrower, 2.2–2.7 cm long × 9–12 mm wide, 3/10 length of spadix, yellowish white; staminate florets densely arranged, butterfly-shaped from above, 1 mm long × 0.5 mm wide, each comprising 2 truncate stamens, thecae sunken, separated by a narrow, raised connective; appendix conical, 2.2–2.5 cm long × 1 cm wide, 3/10 length of spadix, base wider (1 mm) than apex of staminate zone, creamy yellow; staminodes columnar, 2.5 mm long × 1.2 mm wide, somewhat laxly arranged with diverging tips, giving appendix a coarsely papillate appearance, creamy yellow. Infructescence urceolate, 4–6 cm long × 2–2.2 cm wide, on a declinate peduncle; lower spathe persistent, splitting and reflexing at fruit maturity; fruits 2–4 mm long × 1–2.5 mm wide, green to yellow; seeds ovoid ellipsoid, 0.4 mm diam., 13–22 per fruit, encased by greenish yellow gel.

Etymology

Derived from the name of the type locality plus the Latin suffix, *-ensis*, to indicate origin.

Distribution

Schismatoglottis baangongensis is known from the type locality and its vicinity.

Ecology

Terrestrial in perhumid lowland forest associated with (but never occurring epilithically on) Jurassic Karst limestone, often forming dense stands along trails bordering to small streams, 70–75 m asl.

3. ***Schismatoglottis giamensis*** S.Y.Wong, Y.C.Hoe & P.C.Boyce, **sp. nov.**

Type: Malaysian Borneo. Sarawak: Kuching Division, Siburan, Kampung Giam, Sugun Jawan, 1°19'20.7"N 110°16'21.4"E, 70 m asl., 20 Jun 2009, *Wong Sin Yeng & P.C.Boyce AR-2549* (holotype SAR!). (Figures 5, 6 and 14C).

Diagnosis

Schismatoglottis giamensis most closely resembles *S. baangongensis* and *S.roh* by the bullet shaped appendix, but is distinguished among the three by having almost the entire pistillate floret zone dorsally adnate to the spathe (vs at most half pistillate zone dorsally adnate). *Schismatoglottis giamensis* is further distinguished from *S. baangongensis* and from *S. roh* by the larger stamens with thecae having a thickened rim, and additionally from *S. baangongensis* by the pistillate zone with the lower part narrowing and then the base expanding at the junction of pistillate zone the interstice (vs pistillate zone uniformly narrowing all the way to the base).

Description

Moderately robust colonial mesophytic herb, up to 1 m tall. Stem hypogeal, hapaxanthic, individual crowns arising from and producing further slender stolons, terminal active portion of stem somewhat epigeal, erect, stolons 10 cm long, internodes 3–9.5 cm long, 7–9 mm in diam. Leaves about 7 per crown; petiole 24–40 cm long, 1.8 cm wide at base, tapering to 3.5 mm wide at tip, weakly broadly channelled ventrally for 1/5 of length, smooth, medium green with faint darker green striations; petiolar sheath 7–9 cm long × 5–10 mm wide, up to 3/10 of petiole length, persistent, fully attached, equal at both sides, slightly in-rolled, tapering; blade 14–23.5 × 5.3–10.4 cm, narrowly hastato-cordate to rather broadly ovato-cordate, margins very slightly undulate in the largest leaves, adaxially semi-matte medium green; posterior lobes triangular, 3–4 cm, sinus narrow, blade apex acute, ultimately tubular-mucronate for 1 cm; midrib adaxially slightly impressed, rounded-raised abaxially, 7 mm wide at the insertion on petiole; primary lateral veins 12 per side, diverging at 40°–60° from midrib, adaxially impressed, rounded and? raised abaxially, alternating with about the same number of interprimary veins, these sometimes arising from near the base of more robust primary veins; secondary veins 0–2 arising from each primary vein with 3–4 secondary veins arising from primary veins near to petiole insertion; tertiary veins inconspicuous. Blooms up to 7 produced in sequence, erect, very powerfully esteric-smelling during anthesis; peduncle 10–25 cm long × 4–9 mm wide, terete, dark green with deeper green broken longitudinal lines, erect at anthesis. Spathe about 10 cm long; lower spathe oblong-ovoid, 4.5 cm long × 1.5 cm wide, at base strongly dorso-ventrally oblique, 40% (ventral side) to 25% (dorsal side) the length of the whole spathe, semi-glossy medium green, usually smooth; spathe limb differentiated from lower spathe by an abrupt constriction corresponding to the base of the male zone of the

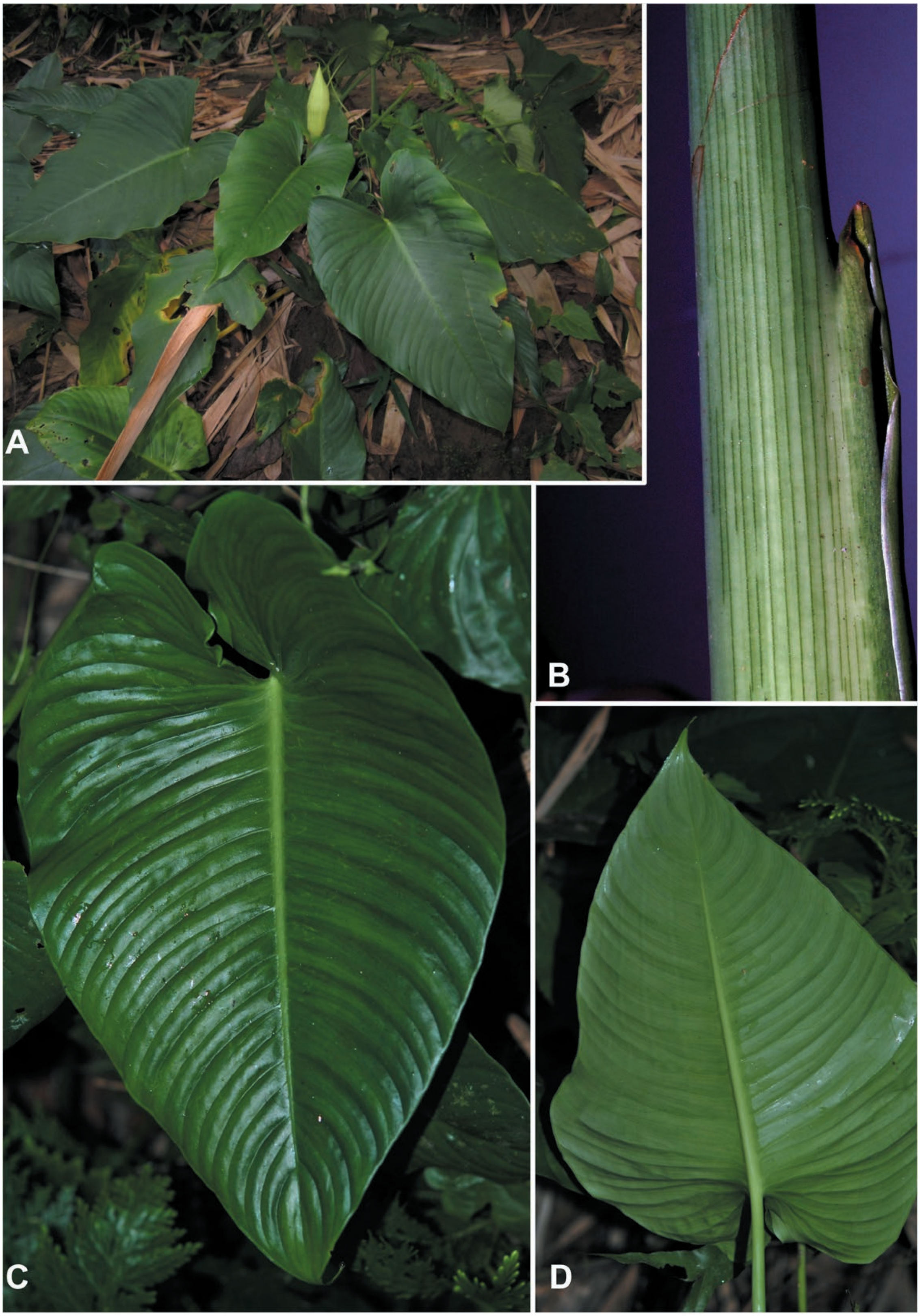

Figure 5. *Schismatoglottis giamensis* S. Y. Wong & P. C. Boyce. **A.** Plant in habitat. **B.** Detail of petiole showing the characteristic deep green striae. **C.** Leaf blade, adaxial surface. **D.** Leaf blade, abaxial surface. A–D from *AR-2549*. Images © P.C. Boyce.

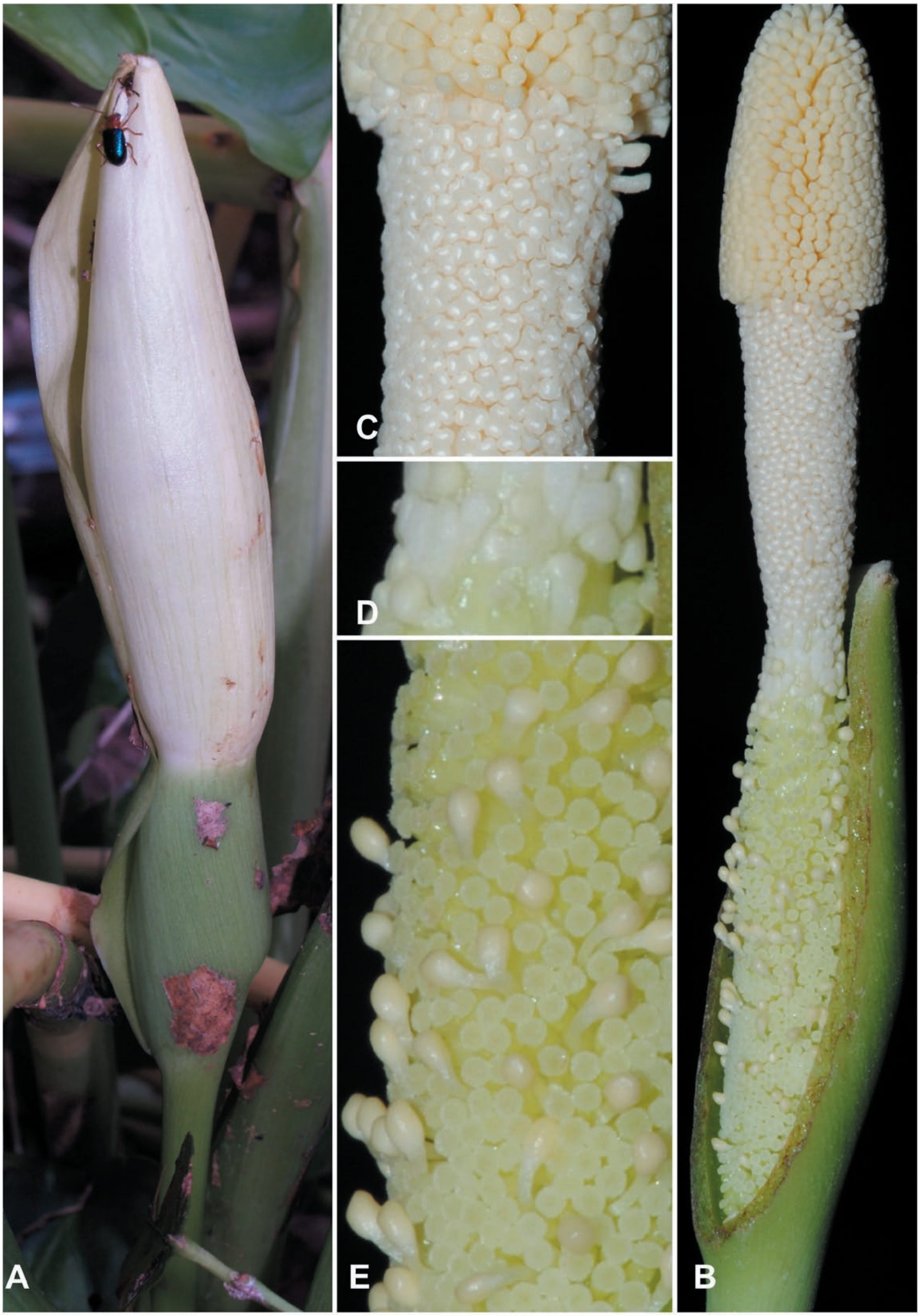

Figure 6. *Schismatoglottis giamensis* S. Y. Wong & P. C. Boyce. **A.** Bloom at pistillate anthesis. **B.** Spadix at pistillate anthesis, spathe artificially removed. **C.** Detail of spadix, uppermost portion of staminate floret zone and lowermost part of appendix. **D.** Detail of interstice. **E.** Detail of pistillate floret zone. A–E from *AR-2549*. Images © P.C. Boyce.

spadix, at pistillate anthesis much inflated, turbinate, the apex briefly mucronate, completely surrounding the spadix and gaping ventrally, lime green, caducous immediately after pistillate anthesis. Spadix 7 cm long, about three quarters length of the spathe; pistillate floret zone stoutly sub-conic, 3 cm long × 7 mm wide, comprising 50% of spadix length, pale green; pistils densely arranged, sub-globose-cylindric, 1 mm diam.; style distinct, very short; stigma capitate, somewhat domed, about two thirds the width of the ovary, 0.8 mm diam.; interpistillar staminodes numerous, scattered, ascending-clavate, stipe slender, upwards curved, 3 mm long, about twice as tall as pistils, creamy white; sterile interstice indistinct, slightly narrower than fertile zones, clothed with somewhat deformed pistils (proximally) and staminate florets (distally); staminate floret zone weakly obconic, 3 cm long × 4 mm wide, about 30% the length of spadix, white; staminate florets very densely packed with individual florets hardly discernible and irregularly orientated, 0.6 mm wide, each comprising 2 truncate stamens, thecae very slightly sunken, surrounded by a broad rim; appendix bullet-shaped, 1.25 cm long × 7 mm wide, 25% length of spadix, base wider than the apex of the staminate zone, creamy; staminodes columnar with rounded tops, 2.5 mm long × 1 mm wide. Infructescence on a declinate peduncle, narrowly urceolate, dorsal side of the base strongly oblique, 4–6 cm long × 2–2.2 cm wide, deep green; lower spathe persistent, splitting and reflexing at fruit maturity; fruits 4 mm long × 1–2.5 mm wide, ripening semi-translucent white; seeds ovoid ellipsoid, 12–40 per fruit, 0.4 mm diam., longitudinally ridged.

Etymology

Derived from the name of the type locality plus the Latin suffix, *-ensis*, to indicate origin.

Distribution

Known only from the type locality.

Ecology

In open perhumid lowland forest in alluvial sandy clay overlying Triassic volcanics.

Schismatoglottis muluensis M.Hotta, Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B, Biol. 32(3): 235. 1966.

Type: Malaysian Borneo. Sarawak, [Miri], Marudi ("Mardi"), western ridge of Gunung Mulu, 17 Mar 1964, *M. Hotta* 14623 (holotype KYO!). (Figures 7, 8 and 14D).

Description

Medium to moderately robust epilithic clumping herb 30–80 cm tall. Stems hypogeal, hapaxanthic, 2 cm diam. Leaves 3–5 per crown; petiole D-shaped, smooth, 34–47 cm long, green, weakly channelled for about 1/3 its length, longitudinal striations conspicuous but not noticeably darker; petiolar sheath 8–14 cm long × 5–10 mm wide, sheathing for 1/4–1/3 of petiole length, persistent, membranous, fully attached with a very short ligule in very robust plants, wings slightly in-rolled or sometimes straight, tapering, scattered with greenish dots; leaf blade ovato-sagittate to ovato-cordate, 25–27 cm long × 13–25.5 cm wide, leathery, adaxially semi-glossy dark green, abaxially paler, posterior lobes subtriangular to rounded, 4.5–8 cm, sinus 3.5–6 cm wide, apex acute to acuminate for 1–2 cm, ultimately with a 4 mm tubular mucro; midrib adaxially flush with blade, raised abaxially, 3.5–6 mm at insertion; primary lateral veins 16 per side, diverging at 30°–80° from the midrib, raised adaxially towards the midrib, marginally impressed, entirely raised abaxially; interprimary veins raised adaxially, alternating irregularly with primaries; secondary veins 3–4 arising from each primary vein; tertiary veins inconspicuous; vein-like pellucid canals clearly visible abaxially. Blooms 1–3 together, erect, smelling strongly esteric during pistillate anthesis, floral odour absent during staminate anthesis; peduncle 10–19 cm long × 6 mm wide, long, terete, green, erect at anthesis. Spathe 10 cm long; lower spathe ovoid-ellipsoid, 4 cm long × 1.7 cm wide, dull green, demarcated from spathe limb by a conspicuous constriction coinciding with lower part of staminate zone; spathe limb weakly turbinate at anthesis (triangular-ovate pressed flat), 6.5 cm long × 2.5 cm wide, mucronate for 5 mm, pale greenish yellow to pure white at pistillate anthesis, caducous in a single piece at onset of staminate anthesis. Spadix 9 cm long, shorter than spathe, sessile, free; pistillate flower zone cylindric, 3 cm long × 7 mm wide, 2/5 length of spadix, creamy yellow; pistils densely arranged, sub-globose, 1 mm long × 0.4 mm wide; style barely differentiated; stigma sub-globose, wider than ovary, 0.5 mm diam., wet with stigmatic secretion at the onset of pistillate anthesis; interpistillar staminodes very few and scattered, weakly clavate, stipe slender, 0.5 mm in diam., up to twice height of pistils, waxy white; interstice cylindric, 6 mm long × 5–7 mm wide, partially naked, narrower than fertile zones, white, distally with 2–5 whorls of flattened spheroid staminodes, these intergrading into lower part of staminate zone, proximally pistillodes compressed, intergrading into the upper pistillate zone; staminate flower zone weakly obconic, narrower proximally, 1.8 cm long × 5.5 mm wide, 2/7 length of spadix, white;

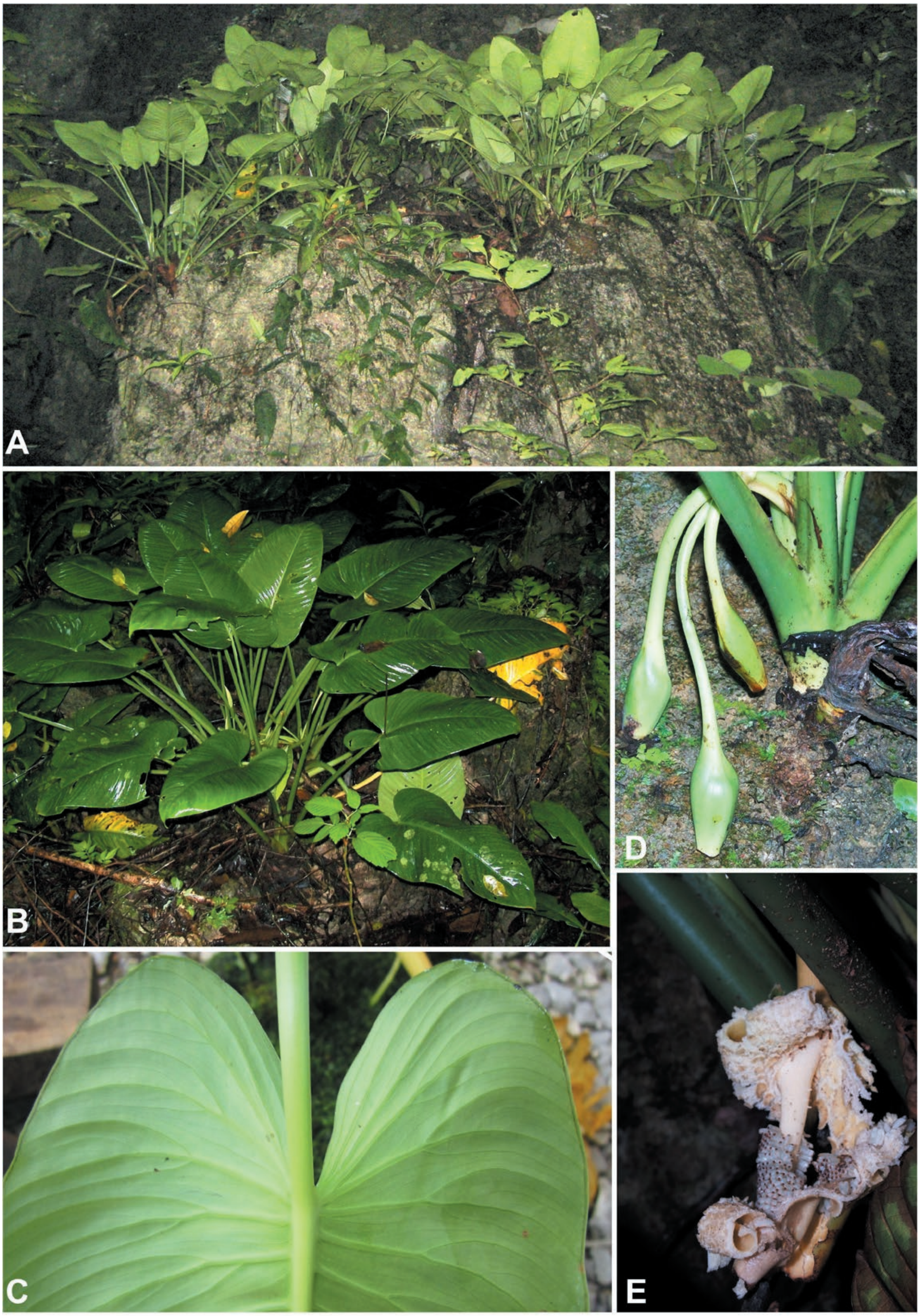

Figure 7. *Schismatoglottis muluensis* M. Hotta. **A & B** Plants in habitat occurring lithophytically on limestone. **C.** Abaxial side of leaf blade showing secondary veins arising from primary laterals. **D.** Developing infructescences. **E**. Ripe infructescence splitting to reveal fruits; naked portion of axis is where fruits have already been dispersed. A–E from *AR-1949*. Images © P.C. Boyce.

Figure 8. *Schismatoglottis muluensis* M. Hotta. **A.** Bloom at mid-pistillate anthesis. **B.** Spadix at late pistillate anthesis, part of spathe artificially removed. Note that many of the interpistillar staminodes have been eaten. **C.** Bloom at onset of staminate anthesis with spathe limb beginning to shed. A–C from *AR-1949*. Images © P.C. Boyce.

staminate florets densely arranged, 1 mm long × 0.5 mm wide, each comprising 2 truncate stamens; thecae separated by a narrow raised connective; appendix stoutly cylindric, 2 cm long × 5.5 cm wide, 2/7 length of spadix, base slightly (0.2 mm) wider than top of staminate zone, white; appendix staminodes densely arranged, sub-globose to sub-columnar, 1 mm long × 0.5 mm wide, white. Infructescences 1–4, 5 cm long × 2 cm wide, pendulous; lower spathe entirely persistent, splitting-reflexing when ripe; fruits 2 mm long × 1.5 mm wide, green to very pale yellow-green; seeds ovoid ellipsoid, 0.4 mm diam., longitudinally ridged, 7–40 per fruit, encased in transparent viscous gel.

Etymology

Derived from the name of the type locality plus the Latin suffix, *-ensis*, to indicate origin.

Distribution

Endemic to Mulu.

Ecology

Schismatoglottis muluensis is restricted to shaded damp Karst limestone formations at Mulu N.P., where it is notably abundant along the trail to Deer Cave occurring epilithically under perhumid lowland tropical forest between 40 and 75 m asl.

Schismatoglottis niahensis A.Hay, Telopea 9: 137. 2000

Type: Cult. RBG Sydney Acc. No. 940512 ex Malaysia, Sarawak, Niah National Park, Niah Caves area (orig. coll. *Hay et al. 9361*), Nov 1997, *C.Herscovitch s.n.* (holotype SAR!,; isotypes K!, KEP!, L!, NSW). (Figures 9, 10 and 14E).

Description

Robust herb 70 cm tall. Stem erect and largely epigeal, suckering, comprised of greatly elongated hapaxanthic modules, to 30 cm tall × 5 cm diam.; internodes 2 cm long. Leaves few together; petiole 40 cm long, sheathing in the lower ⅓–⅔; wings of sheath tapering, fully attached; blade sagittate, mid-green adaxially, paler below, 28–35 cm long × 13–22 cm wide, widest at or near base, the base cordate with rounded posterior lobes 7–9 cm long; midrib flush with the lamina (dry), stout and broad, with 13 rather stout, adaxially pale green primary lateral veins on each side, irregularly alternating with lesser interprimaries, sometimes branched especially in the lower part of the anterior lobe, diverging at 70° and almost straight for most of the way to the margin before deflecting distally; secondary venation rather obscure adaxially and abaxially, arising from the midrib and the primary veins; tertiary venation obscure. Blooms to 4 together, subtended by short cataphylls except the first subtended by a cataphyll reaching to half way along the spathe and bearing a reduced petiole and blade; peduncle 13–15 cm long. Spathe 11–15 cm long; lower spathe 4–5.5 cm long, narrowly ovoid, differentiated from the limb by a sharp constriction; limb ovate, 7–10 cm long, slightly inflated over the appendix, finally acuminate for 2 cm, caducous. Spadix 9 cm long, narrowly hourglass-shaped; female zone 3.8 cm long, adnate to the spathe in the lower 1.2 cm, 8 mm diam. in the middle, distally conoid and apically 3 mm diam.; pistils crowded, narrowly cylindric (especially near the base of the female zone, distally somewhat lower and thicker), 0.5 mm diam.; stigma sessile, button-like, about the same diameter as the ovary; interpistillar staminodes scattered among the pistils, more crowded in the distal part of the female zone, long-stalked, apically abruptly clavate and flat-topped, 1.5 times the height of the ovary; sterile interstice 2–3 mm long, slightly obconic, 3–4 whorls of sterile stamens drying very dark brown, lying level with the mouth of the lower spathe; male zone obconic, 2.8 cm long, distally 1 cm diam.; stamens densely crowded, 0.5 mm across, dumbbell-shaped with large round pores and the connective slender and raised into a short broadly triangular point somewhat off-centre; appendix more or less bullet-shaped, at the base slightly but abruptly wider than the top of the male zone, 1.2 cm diam., then somewhat tapering and finally obtuse; staminodes of appendix columnar, flat-topped and irregularly polygonal with rounded angles, 0.5 mm diam. Infructescence not observed

Etymology

Derived from the name of the type locality plus the Latin suffix, *-ensis*, to indicate origin.

Distribution

Known only from Niah National Park.

Ecology

At the base of limestone bluffs surrounded by swamp forest at low altitudes.

Notes

Hay (Hay & Yuzammi 2000) described the stems of *S. niahensis* as pleionanthic, whereas in fact they are hapaxanthic but unique in the clade for having much

Figure 9. *Schismatoglottis niahensis* A. Hay. **A** Plants in habitat. **B.** Leaf blade, adaxial surface. **C.** Two flowering shoots showing a succession of blooms. **D.** Detail of hapaxanthic shoot reiteration. A–D from *AR-4666*. Images © Hoe Yin Chen.

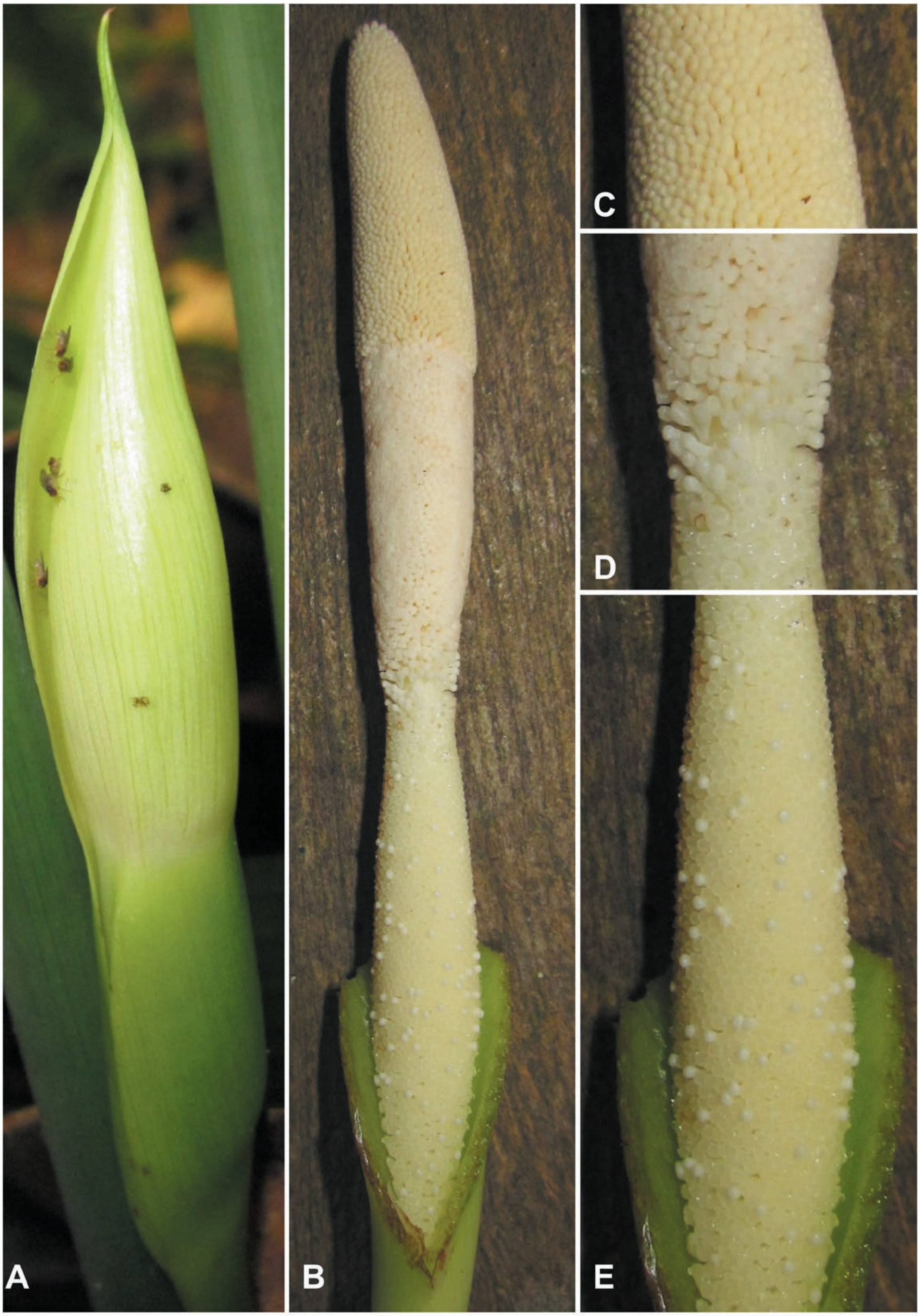

Figure 10. *Schismatoglottis niahensis* A. Hay. **A.** Bloom at pistillate anthesis. **B.** Spadix at pistillate anthesis, spathe artificially removed. **C.** Detail of spadix, lowermost part of appendix. **D.** Detail of interstice and uppermost part of pistillate floret zone. **E.** Detail of pistillate floret zone. A–E from *AR-4666*. Images © Hoe Yin Chen.

of the stem epigeal, thus giving a first impression of a pleionanthic shoot. Pollination data presented in Hoe et al. (2018), are under the name "*S. pseudoniahensis*", a manuscript name we utilized at the time of the study when we had yet to fully understand the identity of the plants occurring at Niah.

Schismatoglottis roh S.Y.Wong, Y.C.Hoe & P.C.Boyce, **sp. nov.**

Type: Malaysian Borneo. Sarawak: Kuching Division, Bau, Krokong, Gua Peri-peri, 1°22'51.9"N 110°07'09.3"E, 30 m asl. 9 May 2009, *Wong Sin Yeng & P.C.Boyce AR-2445* (holotype SAR). (Figures 11, 12 and 14F).

Diagnosis

Schismatoglottis roh resembles both *S. baangongensis* and *S. giamensis* by the bullet shaped appendix but is distinguished from both by very densely packed staminate florets, and by the much more abundant pistillate floret staminodes that are each about twice as long as the height of the pistil and truncate-topped (vs at most half as tall again as the pistils and rounded-clavate).

Description

Moderately robust colonial mesophytic herb, up to 75 cm tall. Stem hypogeal, hapaxanthic, individual crowns arising from and producing further slender stolons, terminal active portion of stem somewhat epigeal, erect, stolons up to 20 cm long, internodes 3–10 cm long, 7–10 mm in diam. Leaves about 10 per crown; petiole 15–28 cm long, 2 cm wide at base, tapering to 5 mm wide at tip, ventrally broadly channelled for 1/4 of length, smooth, medium green with darker green striations; petiolar sheath 7–11 cm long × 5–10 mm wide, up to 3/10 of petiole length, persistent, fully attached, equal at both sides, slightly in-rolled, tapering; blade 13–25.5 × 5–12 cm, narrowly hastato-cordate to rather broadly ovato-cordate, adaxially semi-glossy medium green, posterior lobes broadly triangular, 3–6 cm long, sinus narrow to rather wide, blade apex acute, ultimately tubular-mucronate for 1 cm; midrib adaxially slightly impressed, rounded-raised abaxially, 7 mm wide at the insertion on petiole; primary lateral veins 15 per side, diverging at 40°–60° from midrib, adaxially impressed, rounded raised abaxially alternating with about the same number of interprimary veins, these sometimes arising from near the base of more robust primary veins; secondary veins 0–2 arising from each primary vein with 3–4 secondary veins arising from primary veins near to petiole insertion; tertiary veins inconspicuous. Blooms up to 6 produced in sequence, erect, very powerfully esteric-smelling during anthesis; peduncle 10–25 cm long × 4–9 mm wide, terete, dark green with deeper green broken longitudinal lines, erect at anthesis. Spathe 10–12 cm long; lower spathe oblong-ovoid, 4.5 cm long × 1.5 cm wide, inserted obliquely on peduncle, semi-glossy dark green with darker longitudinal fine striations, demarcated from spathe limb by a pronounced constriction coinciding with start of staminate zone. Spathe 11 cm long; lower spathe narrowly ovoid, at base strongly dorso-ventrally oblique, 40% (ventral side) to 25% (dorsal side) the length of the whole spathe, semi-glossy medium green, smooth; spathe limb at pistillate anthesis much inflated, turbinate, the apex briefly mucronate, completely surrounding the spadix and gaping ventrally, lime green, caducous immediately after pistillate anthesis. Spadix 8 cm long, about three quarters length of the spathe; pistillate floret zone stoutly fusiform sub-conic, 3 cm long × 8 mm wide, comprising 50% of spadix length, creamy white; pistils very densely arranged, sub-globose-cylindric, 1 mm diam.; style distinct, very short; stigma capitate, somewhat domed, about two thirds the width of the ovary, 0.8 mm diam.; interpistillar staminodes very numerous, scattered, clavate, about twice as tall as pistils, stipe stout, straight, 3.5 mm long, pale creamy yellow; sterile interstice very indistinct, slightly narrower than pistillate zone, clothed with a few deformed staminate florets; staminate floret zone stoutly obconic, 3 cm long × 5 mm wide, about 30% the length of spadix, creamy white; staminate florets very densely packed with individual florets hardly discernible, 0.5 mm wide, each comprising 2 truncate stamens, thecae very slightly sunken, surrounded by a narrow rim; appendix bullet-shaped, 1.2 cm long × 8 mm wide, 20% length of spadix, base wider than the apex of the staminate zone, creamy; staminodes columnar with rounded tops, 2.5 mm long × 1 mm wide. Infructescence on a declinate peduncle, narrowly urceolate, dorsal side of the base strongly oblique, 4–7 cm long × 2–2.5 cm wide, medium green; lower spathe persistent, splitting and reflexing at fruit maturity; fruits 3.5 mm long × 2 mm wide, ripening semi-translucent white; seeds ovoid ellipsoid, 0.4 mm diam., longitudinally ridged.

Etymology

Coined from the Malay language word for a spirit, *roh*, used by way of allusion to the type locality, Gua Peri-peri, Fairy Cave.

Distribution

Restricted to Cretaceous Karst in the Bau area of Kuching.

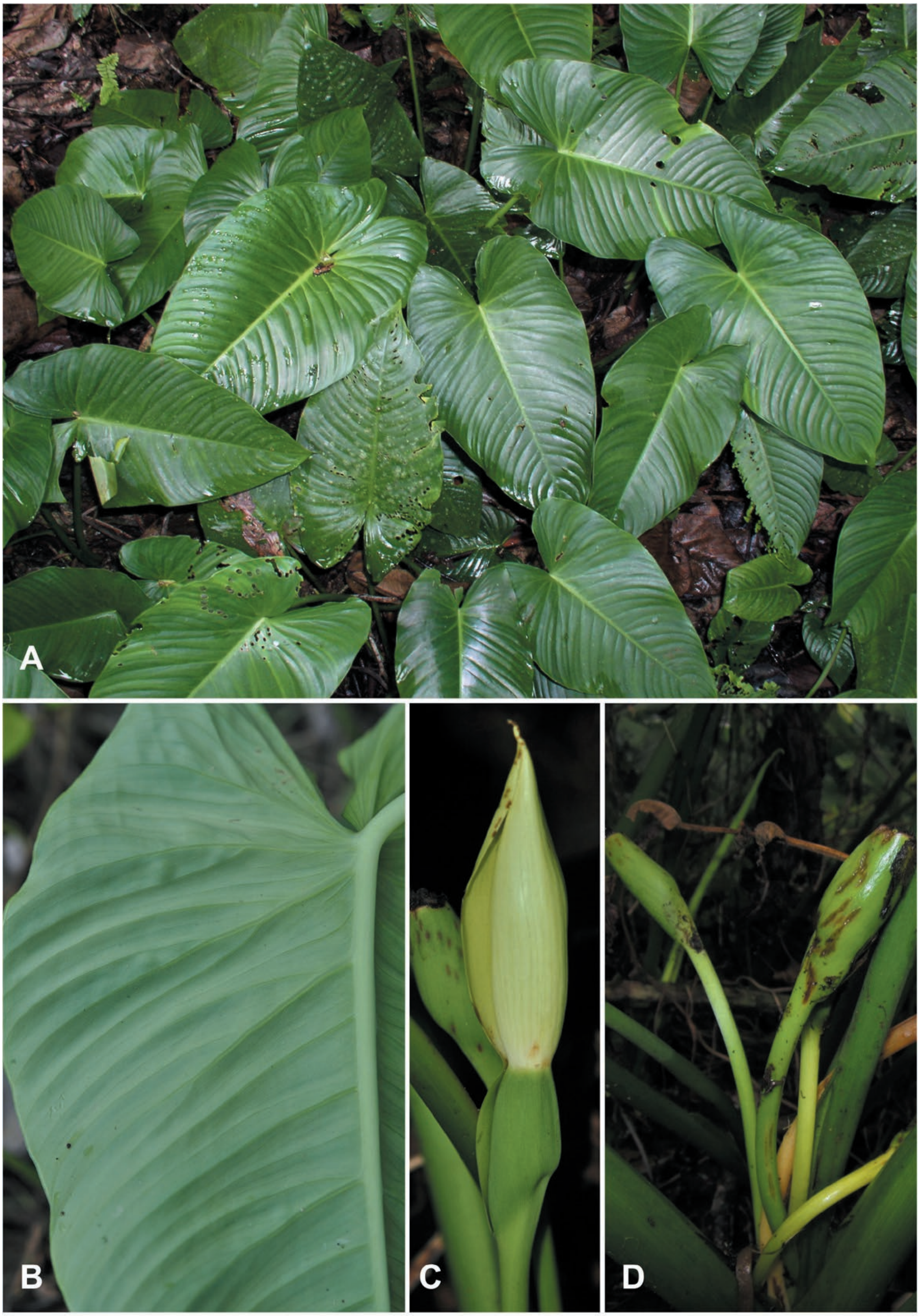

Figure 11. *Schismatoglottis roh* S. Y. Wong & P. C. Boyce. **A** Plants in habitat. **B.** Leaf blade, abaxial surface. **C.** Bloom at pistillate anthesis. **D.** Developing infructescences. A–D from *AR-2445*. Images © Hoe Yin Chen.

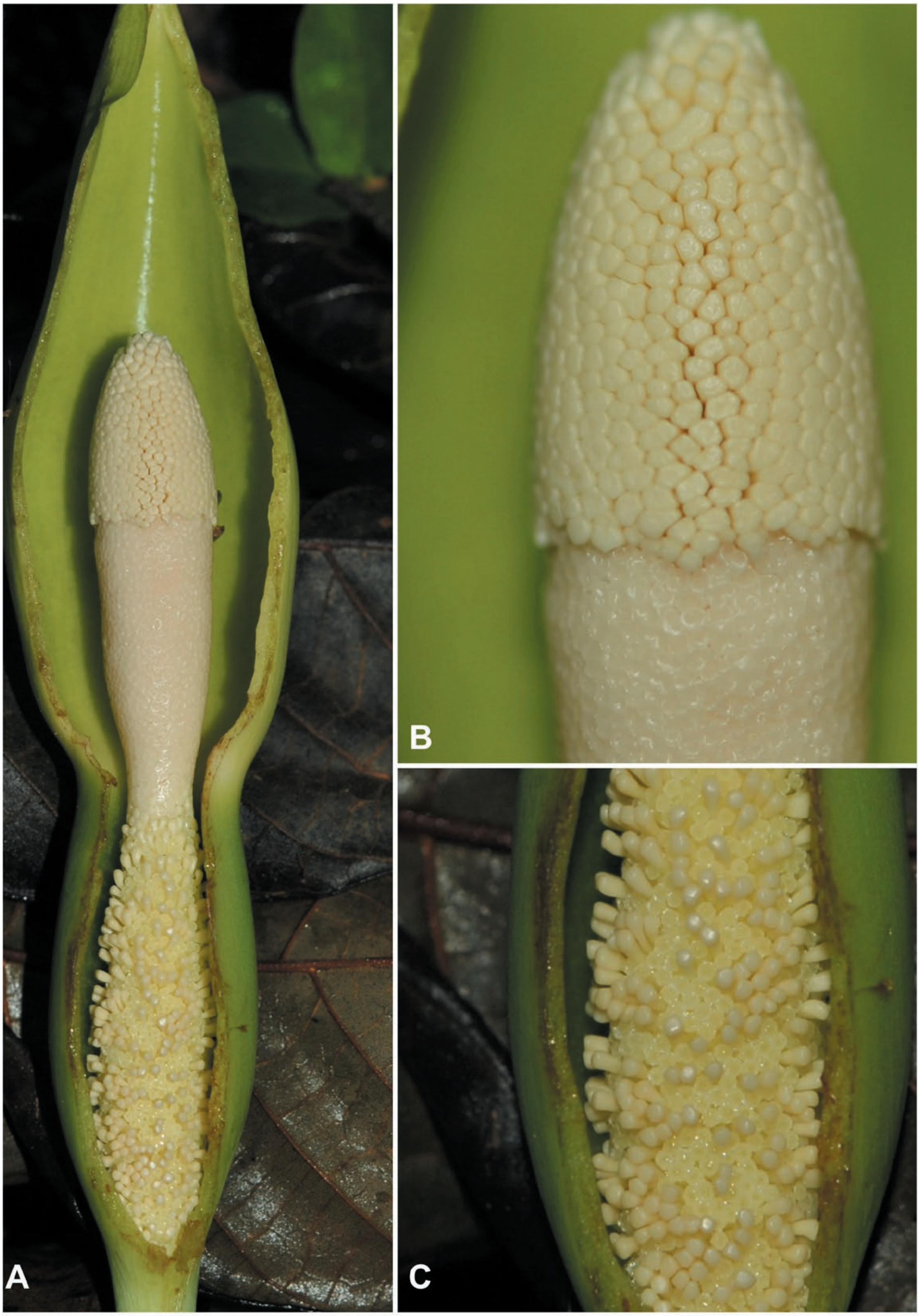

Figure 12. *Schismatoglottis roh* S. Y. Wong & P. C. Boyce. **A.** Bloom at pistillate anthesis, nearside spathe artificially removed. **B.** Detail of spadix, uppermost portion of staminate floret zone, and appendix. **C.** Detail of pistillate floret zone. A–E from *AR-2445*. Images © Hoe Yin Chen.

Ecology

Occurring in light to medium shade in alluvial soils at the base of Karst stacks, often near to.

Additional specimen examined (paratypes)

MALAYSIA: Sarawak, Kuching Division. Bau, Gua Angin, 1°24’54.8”N 110°08’08.2”E, 45 m asl., 21 Jun 2005, *P.C.Boyce & Jeland ak Kisai AR-1240* (SAR). Bau, Jalan Jugan - Siniawan, 1°26’46.97”N 110°12’46.88”E, 15 m asl., 10 Jun 2016, *Wong Sin Yeng & P.C.Boyce AR-4269* (SAR).

Schismatoglottis viridissima A. Hay, Telopea 9: 154. 2000.

Type: Cult. RBG Sydney Ac No. 940550, *C. Herscovitch s.n.* ex Malaysian Borneo. Sarawak: Kuching Division, Lundu, Gunung Gading, orig. coll. *A.Hay et al. 9397* (holotype SAR!; isotypes K!, KEP!, L!, NSW, US). (Figure 13 and 14G).

Description

Small mesophytic clump-forming herb to 25 cm tall. Stem hypogeal, hapaxanthic, 0.5 cm diam. Leaves 5 together in each crown; petiole to 20 cm long, sheathing in the lower third; petiolar sheath wings fully attached, tapering but apically truncate; blade narrowly ovate, brilliant green with a rubbery thinly subsucculent texture, 16 cm long × 7 cm wide, base cordate with rounded posterior lobes to 1.5 cm long, tip acute; midrib rather prominent; primary lateral veins 7 on each side, irregularly alternating with lesser interprimaries and diverging at 60–80°; secondary venation mostly arising from the midrib, some from bases of primary veins; tertiary venation forming an indistinct tessellate reticulum on both surfaces (visible in dry material). Blooms 2–3 together; peduncle fleshy, 4 cm long, mostly hidden by sheaths of subtending leaves. Spathe 9 cm long; lower spathe narrowly ovoid, 4 cm long, differentiated from limb by an abrupt constriction; limb 5 cm long, very broadly ovate, inflated over staminate zone and appendix and then acute, finally acuminate for 1 cm, greenish, caducous. Spadix 5–6 cm long, sessile, more or less hourglass-shaped; pistillate flower zone about half the length of spadix, 3 cm long, adnate to spathe in lower 2/3, 7 mm diam. in middle, then somewhat conic and attenuate to 5 mm diam.; pistils somewhat lax, more so in distal part of pistillate zone, bottle-shaped, bright green, 1 mm diam. in lower part of zone, 2 mm diam. higher up; interpistillar staminodes scattered among pistils, more or less mushroom-shaped, equalling ovaries in height, 0.5 mm diam.; sterile interstice ill-defined, upper 4 mm of pistillate zone thickly attenuate and occupied by mixed staminodes, stamens and abortive(?) pistils; staminate flower zone 1.4 cm long, subcylindric, 5 mm diam. in lower 5 mm (held within lower spathe chamber), remainder abruptly obconic, to 9 mm diam. and exserted from lower spathe chamber; stamens crowded, truncate, hourglass-shaped, with connective thin and not at all elevated above thecae, 1 mm across; appendix shortly bullet-shaped, base slightly but abruptly wider than top of staminate flower zone, 1 cm wide at base, 1.3 cm long; appendix staminodes flat-topped, centrally impressed, irregularly polygonal, 0.5–0.7 mm diam., dull medium yellow. Fruit unknown.

Etymology

Named for the peculiarly brilliant green leaf blades.

Distribution

Schismatoglottis viridissima occurs in NW Sarawak and Kalimantan Barat on acidic geologies.

Ecology

Terrestrial in moderate to light shade under perhumid lowland to upper hill forest on granites, or sandstones; 10–940 m asl. The Type locality is granite while elsewhere populations of what appears to be the same or at least a remarkably similar species occurs on sandstones (e.g., Kubah N.P, and Gunung Serembu).

Notes

Hay (Hay & Yuzammi 2000) erroneously states that *S. viridissima* occurs on limestone. This most likely is based upon confusion of this species with *S. roh* (see there). A specimen cited by Hay (ibid.) (*[J.A.R.]Anderson S.31966*) from Bukit Krian in the Bau limestone hills, is a further undescribed species of which currently we lack complete material to enable description.

Key to the colonial and gregarious species of the Schismatoglottis Calyptrata clade in Sarawak

1a. Pistillate zone free; appendix cylindrical, about twice as long a staminate zone; lithophytes of Karst limestone. Mulu N.P. .... ***Schismatoglottis muluensis***

1b. Pistillate zone dorsally variously adnate to spathe; appendix mostly bullet-shaped, often much shorter than, at most equalling the length of the staminate zone; terrestrial mesophytes, if associated with Karst limestone then never occurring epilithically 2

Figure 13. *Schismatoglottis viridissima* A. Hay. **A.** Plants in habitat, Gunung Gading N.P. **B.** Bloom at pistillate anthesis. **C.** Bloom at onset of staminate anthesis, spathe limb beginning to fall. **D.** Bloom at late staminate anthesis, spathe limb almost shed. **E.** Spadix at late pistillate anthesis, spathe artificially removed. **F.** Bloom post anthesis, spathe limb shed. A–E from *AR-5258*. Images © P.C. Boyce.

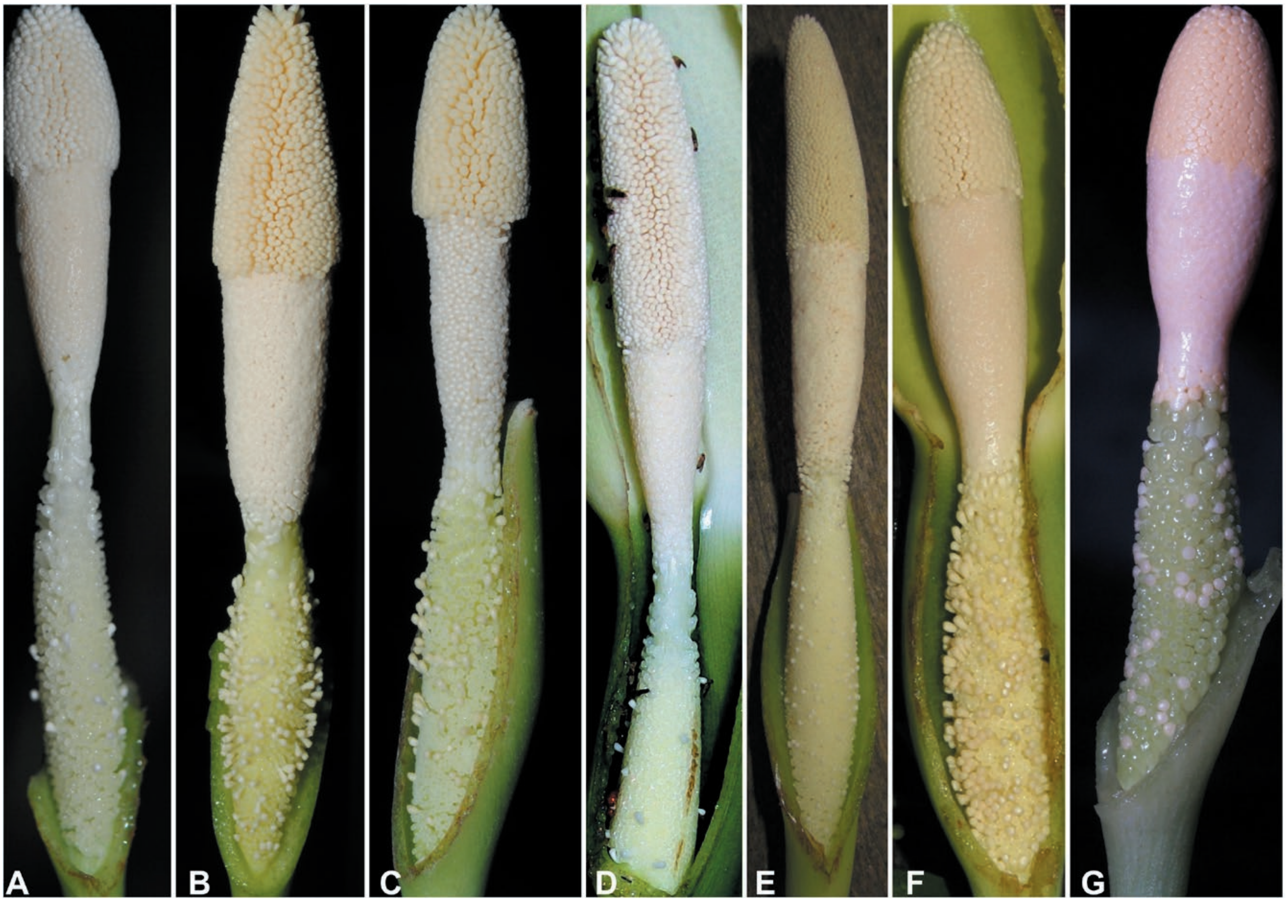

Figure 14. Spadix comparisons. **A.** *Schismatoglottis adducta*. **B.** *Schismatoglottis baangongensis*. **C.** *Schismatoglottis giamensis*. **D.** *Schismatoglottis muluensis*. **E.** *Schismatoglottis niahensis*. **F.** *Schismatoglottis roh*. **G.** *Schismatoglottis viridissima*. **A** from *AR-1632*. **B** from *AR-2588*. **C** from *AR-2549*. **D** from *AR-1941*. **E** from *AR-4666*. **F** from *AR-2445*. **G** from *AR-5258*. All images © P.C. Boyce.

2a. Leaf blades glossy brilliant green, rubbery and sub-succulent; spadix appendix hemispherical; granites and sandstone, Kuching Division .... ***Schismatoglottis viridissima***

2a. Leaf blades not as above; spadix appendix conical or bullet-shaped 3

3a. Stems erect and largely epigeal, suckering but not stoloniferous, comprised of greatly elongated hapaxanthic modules. Niah N.P. at the base of Karst cliffs in swampy forest. ....***Schismatoglottis niahensis***

3b. Stems creeping, hypogeal, stoloniferous 4

4a. Staminate and pistillate zones separated by an elongated partially naked interstice; pistillate florets white; interpistillar staminodes few, scattered, all curving-ascending; alluvial forest, Sri Aman...............***Schismatoglottis adducta***

4b. Staminate and pistillate zones contiguous or nearly so; pistillate florets creamy yellow or pale green; interpistillar staminodes numerous, straight or only very slightly curving-ascending.. 5

5a. Staminate florets very densely packed, forming a mass of apparently disorganized stamens, pale creamy yellow; interpistillar staminodes about twice as tall as the height of the pistil, truncate-topped; Cretaceous Karst, Bau. .... ***Schismatoglottis roh***

5b. Staminate florets not very densely packed, individuated flowers readily discernible, white; interpistillar staminodes at most half as tall again as the pistils, tops rounded-clavate 6

6a. Staminate zone dorsally fully adnate to spathe; thecae with a conspicuous thickened rim; alluvial sandy clay overlying Triassic volcanics........................***Schismatoglottis giamensis***

6b. Staminate zone dorsally adnate to spathe for about half its length; thecae without a thickend rim; Jurassic Karst limestone....................................***Schismatoglottis baangongensis***

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Studies on Schismatoglottideae (Araceae) of Peninsular Malaysia III: New species for the *Schismatoglottis* Calyptrata Clade

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Abstract. Three new colonial species of *Schismatoglottis* Calyptrata clade are described from Peninsular Malaysia and compared with the four already known morphologically similar species described from there. All seven species are illustrated from living plants and an identification key is provided.

Keywords: Araceae, *Schismatoglottis*, Calyptrata clade, Peninsular Malaysia.

INTRODUCTION

With the exclusion of *Schismatoglottis calyptrata* (Roxb.) Zol. & Moritzi (sensu Hay 1996; Hay in Hay and Yuzammi 2000) from the flora of Peninsular Malaysia (Wong et al. 2018; Wong and Boyce 2020) the *Schismatoglottis* Calyptrata Clade (Wong et al. 2016, 2018) is currently represented in the Malay Peninsula by four described species: *Schismatoglottis cordifolia* Ridl. (Ridley 1911: 112; Figures 1 and 10B), *S. guabatuensis* S.Y.Wong & P.C.Boyce (Wong and Boyce 2020: 1; Figure 10C), *S. lowiae* S.Y.Wong & P.C.Boyce (Wong and Boyce 2017: 31; Figures 2 and 10E), and *S. wallichii* Hook.f. (Hooker 1893: 537; Figs. 3 and 10G). During pollination biology studies by the third author (Hoe and Wong 2016; Hoe et al. 2018, 2020; Wong et al. 2016) it became evident that several populations encountered did not correspond to any of these four species, nor did they match any described species from Sumatera or further east. In conclusion we consider these populations to represent undescribed species and here describe three novel Peninsula Malaysian species belonging in the Calyptata clade. Geology in this paper is specified based on Tate et al. (2008).

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Figure 1. *Schismatoglottis cordifolia* Ridl. **A.** Plant in habitat. **B.** Bloom at pistillate anthesis. **C.** Bloom at pistillate anthesis, spathe limb naturally shed, nearside of lower spathe artificially removed. **D.** Detail of appendix and staminate florets. **E.** Detail of pistillate zone and interstice, nearside lower spathe artificially removed. All from *Zalhazman bin Hamzah s.n.*

Figure 2. *Schismatoglottis lowiae* S.Y.Wong & P.C.Boyce. **A.** Plant in habitat. **B.** Bloom at pistillate anthesis. **C.** Bloom at pistillate anthesis, nearside of spathe artificially removed. **D.** Detail of pistillate zone and interstice, nearside lower spathe artificially removed. All from *AR-3286*.

Figure 3. *Schismatoglottis wallichii* Hook.f. **A.** Plant in habitat. **B.** Bloom at pistillate anthesis. **C.** Bloom at onset of staminate anthesis, spathe limb beginning to shed. **D.** Bloom at late staminate anthesis, spathe limb splitting into numerous circumferential pieces. **E.** Spadix at pistillate anthesis, spathe artificially removed. **F.** Pistillate floret zone. **G. & H.** Staminate zone fertile to tip (**G**) and with a few terminal staminodes (**H**). A–G from *AR-16*; H from *AR-762*.

Schismatoglottis caesia S.Y.Wong, P.C.Boyce & Y.C.Hoe, **sp. nov.**

Type: Malaysia, Kelantan, Gua Musang, Kuala Koh, Taman Negara Kuala Koh, 4°52.333'N 102°26.872'E, 11 Jan 2014, *Hoe Yin Chen AR-4332* (holotype KEP; isotype SAR). (Figures 4, 5 and 10A).

Diagnosis

Schismatoglottis caesia is immediately differentiated from all other species of the *Schismatoglottis* Calyptrata clade by the glaucous pale grey leaf blades.

Description

Medium sized moderately robust, evergreen, stoloniferous colonial herb, 20–60 cm tall. Stems hypogeal, hapaxanthic, 0.8-1.8 cm diam. Leaves 3–6 together; petiole D-shaped, smooth, 15–19 cm long, slightly channelled along its length, green, distally with darker longitudinally broken-striate striations; petiolar sheath, 8 cm long × 0.5 wide, sheathing for 2/5 of petiole length, persistent, membranous, fully attached with a very short ligule, equal on both sides, slightly in rolled or sometimes straight, tapering, green with scattered greenish striate dotting; blades ovato-sagittate to ovato-cordate (sometimes oblong-lanceolate with the base cordate), 17.5–19 cm long × 7–10.5 cm wide, weakly coriaceous, glaucous pale grey, posterior lobes subtriangular, 3–4.5 cm long, sinus 4–5.5 cm across, apex of anterior lobe acute for 2–3 cm, ultimately mucronate for 2.5 mm; midrib adaxially flush with blade, raised abaxially, 3.5 mm wide at the insertion of the leaf blade; primary lateral veins 16 per side, diverging at 30°–80° from the midrib, raised adaxially towards the midrib, marginally impressed, entirely raised abaxially; interprimary veins raised adaxially, alternating irregularly with primaries; few (0–2) secondary veins emerging from each primary veins (3–4 from primary veins near to insertion); pellucid canals inconspicuous. Blooms 1–3 in a synflorescence, erect at anthesis, emitting an esteric smell during pistillate anthesis, odour absent during staminate anthesis; peduncle 10–12 cm long × 4–8 mm diam., terete, green; spathe 12 cm long; lower spathe narrowly ovoid, 4.8 cm long × 1.8 cm wide, green, externally longitudinally ridged, separated from spathe limb by a constriction coinciding with lower staminate zone; spathe limb pale greenish yellow and turbinate at anthesis, 7 cm long × 3.8 cm wide, mucronate for 4.5 mm, slightly paler prior to staminate anthesis, caducous in a single piece at the onset of staminate anthesis; spadix 8 cm long, shorter than spathe, sessile; pistillate zone fusiform, 4 cm long × 8 mm wide, ½ length of spadix, light green; pistils sub-cylindric to sub-globose, 1.5–2 mm long × 0.6–1 mm wide, densely arranged; style barely differentiated; stigma sub-globose, truncate, narrower than ovary, 0.3 mm diam., wet with stigmatic secretion at the onset of pistillate anthesis; interpistillar staminodes scattered, slightly exceeding the pistils in height, clavate, stipe hardly differentiated, tip about 0.5 mm in diam., white; interstice sub-cylindric, 0.5–0.8 cm long × 5 mm wide, narrower than pistillate and staminate zones, partially naked occupied by scattered flattened pistils, with 1 whorl of flattened spherical staminodes in the distal part, these intergrading into the lower staminate zone, pistillodes flattened in proximal part of interstice; staminate zone sub-cylindric, narrower at proximal end, wider at distal end, 1.5–2 cm long × 8–10 mm wide, ¼ length of spadix, yellowish white; staminate florets 1 mm long × 0.5 mm wide, butterfly-shaped from above, densely arranged, each comprising 2 truncate stamens, tops depressed, overtopped by a broad, raised connective; pollen powdery, white; appendix bullet-shaped, 1.3–1.5 cm long × 1 cm wide, about 1/5 length of spadix, slightly wider (0.2–0.5 mm) than the top of staminate zone, yellowish white; staminodes polygonal, sub-globose towards the tip of the appendix, 2 mm long × 0.5 mm wide, densely arranged. Infructescences 1–3, fruiting part 4.5 cm long × 2 cm wide, on declinate peduncles; lower spathe entirely persistent, splitting and reflexing downwards when at fruit maturity; fruits 3 mm long × 1–2 mm wide, light yellow; seeds ovoid ellipsoid, longitudinally ridged, 0.4 mm diam., encased in yellow gel.

Etymology

The specific epithet is derived from the Latin noun, '*caesius*', bluish grey, referring to the unique colouration of the leaf blades.

Distribution

Schismatoglottis caesia is only known from two populations in east Kelantan, separated by about 120 km.

Ecology

Perhumid lowland tropical forests, on alluvial sandstone-derived mud overlying Triassic granite, along track margins and on steep slopes along the margins of streams, 50–100 m asl.

Notes

The glaucous leaf blades of *Schismatoglottis caesia* are highly distinctive, even sterile juvenile plants are readily identifiable and immediately distinguished from the co-occurring *S. lowiae*. The type population occurs

Figure 4. *Schismatoglottis caesia* S.Y.Wong, P.C.Boyce & Y.C.Hoe. **A.** Plant in habitat. **B.** Leaf blade abaxial surface. **C.** Detail of petiole. **D.** Synflorescence showing sequential development (left to right). All from *AR-4332*.

Figure 5. *Schismatoglottis caesia* S.Y.Wong, P.C.Boyce & Y.C.Hoe. **A.** Bloom at pistillate anthesis, nearside spathe artificially removed. **B.** Bloom at pistillate anthesis. **C.** Detail of pistillate zone. **D.** Detail of upper part of pistillate zone, interstice with flattened staminodes, and lowermost part of staminate zone. **E.** Appendix and upper part of staminate zone. All from *AR-4332*.

adjacent to (although not associated with) Ordovician-Devonian Karst, suggesting that the species is not able to colonize karst. By the same token there are species in the Calyptrata clade (e.g., *S. guabatuensis*) that never occur away from limestone. Such geological obligations appear to be a contributing factor behind the high species diversity that aroids, and several other herbaceous and woody plant families, display in SE Asia (e.g., Wong and Boyce 2021).

Additional specimens examined (paratypes)

MALAYSIA. Kelantan. Tanah Merah, Hulu Kusial, Gua Ipoh, Lata Hujan, 5°43'53.1"N 102°01'03.5"E, 16 Mar 2016, *Wong Sin Yeng & P.C. Boyce AR-3317* (KEP, SAR) & *Wong Sin Yeng & P.C. Boyce AR-3318* (KEP, SAR); Tanah Merah, Jedok, Kampung Lawang, Lata Bijih, 5°43'54.37"N 102° 0'58.80"E, 16 Mar 2016, *Wong Sin Yeng & P.C.Boyce AR-3322* (KEP, SAR).

Schismatoglottis laxipistillata S.Y.Wong, P.C.Boyce & Y.C.Hoe, **sp. nov.**

Type: Malaysia, Kedah, Merbok Division, Bedong, Hutan Lipur Rekreasi Tupah Merbok, just outside the entrance, beside the boundary of a quarry, 5°44'2.88"N100°26'30.60"E, 11 Dec 2013, *Hoe Yin Chen AR-4331* (holotype SAR; isotype KEP). (Figures 6, 7 and 10D).

Diagnosis

Schismatoglottis laxipistillata is distinguished from the other species in the Calyptrata Clade by its laxly arranged pistils.

Description

Medium to moderately robust, evergreen, stoloniferous herb forming clumps, 35–40 cm tall. Stems hypogeal, hapaxanthic, 1–2 cm diam. Leaves 3–8 together; petiole D-shaped, smooth, 18–20 cm long, white to very pale green, weakly channelled for ½ its length, longitudinal striations raised distally, darker green; petiolar sheath 5–8 cm long × 0.5–1 cm wide, sheathing for 1/3 of petiole length, persistent, membranous, fully attached with a very short ligule, equal at both sides, slightly inrolled or sometimes straight, tapering, green with scattered greenish broken-striate; blades ovato-sagittate to ovato-cordate (sometimes oblong-lanceolate with the base cordate), 29 cm long × 16 cm wide, weakly coriaceous, adaxially dull green, some plants variegated with spattered grey-green central stripes, abaxially paler, posterior lobes subtriangular, 3.5–5 cm long, sinus 3–7 cm across, apex of anterior love acute for 2 cm, ultimately mucronate for 3 mm; midrib adaxially flush with blade, raised abaxially, 4 mm at insertion; primary lateral veins 13 per side, diverging at 30°–80° from the midrib, raised adaxially towards the midrib, marginally impressed, entirely raised abaxially; interprimary veins raised adaxially, alternating irregularly with primaries; few (0–2) secondary veins from each primary veins (1–2 arising from primary veins near to insertion); tertiary veins inconspicuous; vein-like pellucid canals not visible. Inflorescences up to five in a synflorescence, erect, emitting an esteric smell during pistillate anthesis–but not during staminate anthesis; peduncle 8–16 cm long × 3–8 mm wide, terete, green, erect at anthesis; spathe 10.5 cm long; lower spathe narrowly ovoid, 4.2 cm long × 2 cm wide, green, externally longitudinally ridged, separated from spathe limb by a constriction coinciding with the interstice; spathe limb turbinate, 6.5 cm long × 3.5 cm wide, mucronate for 3 mm, pale greenish yellow at pistillate anthesis, slightly pallid prior to staminate anthesis, caducous in a single piece at onset of staminate anthesis; spadix 8.5 cm long, shorter than spathe, sessile; pistillate zone fusiform, 4 cm long × 7 mm wide, 1/2 length of spadix, light green; pistils sub-cylindric to sub-globose, 1.5 mm long × 0.5-1 mm wide, laxly arranged; style barely differentiated; stigma globose from above, truncated, smaller than ovary, 0.3 mm diam., wet with stigmatic secretion at the onset of pistillate anthesis; interpistillar staminodes clavate, stipe slender, 0.5 mm in diam., only slightly taller than pistils, scattered, white; interstice sub-cylindric, 0.6–1 cm long × 5 mm wide, more slender than pistillate and staminate zone, partially naked with a few flattened irregular closely packed spheroid staminodes at the distal end, partially intergrading into the lower staminate zone, and with a few flattened pistillodes at the proximal end; staminate zone obconic, 1.8 cm long × 10 mm wide, ¼ length of spadix, yellowish white; staminate florets 1 mm long × 0.5 mm wide, butterfly-shaped from above, densely arranged, each comprising 2 truncate stamens, with a broad connective, densely arranged, yellowish white; pollen powdery, white; appendix bullet-shaped, 1.6 cm long × 1 cm wide, 1/5 length of spadix, equal or weakly (0.2 mm) wider than apex of staminate zone, yellowish white; staminodes sub-globose to polygonal, 2 mm long × 0.4–1 mm wide, densely arranged. Infructescences 1–5 together, persistent spathe 5 cm long × 2 cm wide, declinate; lower spathe entirely persistent, splitting from the top with segments reflexed when ripe; fruits 3 mm long × 1–2 mm wide, light yellow; seeds ovoid ellipsoid, 0.4 mm diam., 4–8 per fruit, with greenish yellow gel.

Figure 6. *Schismatoglottis laxipistillata* S.Y.Wong, P.C.Boyce & Y.C.Hoe. **A.** Plant in habitat. **B.** Base of plant with emerging bloom. **C.** Leaf blade abaxial surface. **D.** & **E.** Detail of upper portion (**D**) and lower portion (**E**) of petiole. All from *AR-4331*

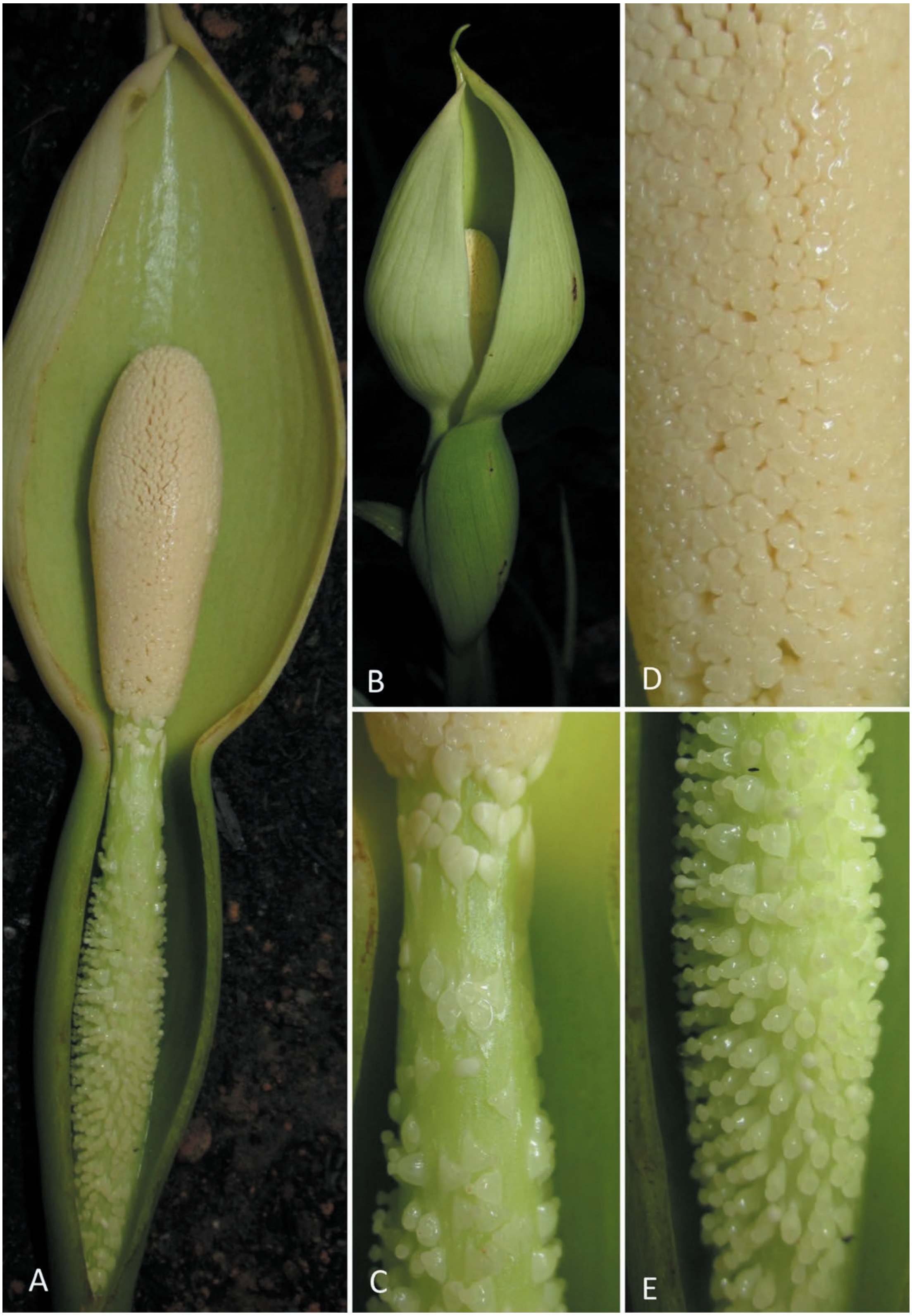

Figure 7. *Schismatoglottis laxipistillata* S.Y.Wong, P.C.Boyce & Y.C.Hoe. **A.** Bloom at pistillate anthesis, nearside spathe artificially removed. **B.** Bloom at pistillate anthesis. **C.** Detail of upper part of pistillate zone, interstice with flattened staminodes, and lowermost part of staminate zone. **D.** Detail of staminate zone. **E.** Detail of pistillate zone. All from *AR-4331*

Etymology

The specific epithet refers to the uniquely, in the species group, laxly arranged pistils.

Distribution

Schismatoglottis laxipistillata is only known from its locality at Hutan Lipur Rekreasi Tupah where it is threatened by land clearance for quarrying.

Ecology

Perhumid lowland forest, occurring beside the margin of the waterfall and stream and restricted to steep Ordovician-Devonian Karst slopes in pockets of occasionally inundated mud. About 100 m asl.

Notes

Initially it was thought that the lax pistillate florets were an artefact of the first specimen encountered, but their occurrence is highly uniform through the known population.

Additional specimen examined (paratypes)

MALAYSIA. Kedah. Merbok, Bedong, Hutan Lipur Rekreasi Tupah, 5°44'39.30"N 100°26'30.24"E, 104 m asl, 11 Dec 2013, *Hoe Yin Chen AR-4330* (KEP, SAR).

Schismatoglottis pantiensis S.Y.Wong, P.C.Boyce & Y.C.Hoe, **sp. nov.**

Type: Malaysia, Johor, Kota Tinggi, Hutan Simpan Panti, starting point of trail to Mount Panti, 1°48'35.70"N 103°51'5.94"E, 4 Dec 2013, *Hoe Yin Chen AR-4322* (holotype KEP; isotype SAR). (Figures 8, 9 and 10F).

Diagnosis

The spadix of *Schismatoglottis pantiensis* is superficially similar to that of *S. lowiae* differing by the pistillate zone extending to almost half the length of the spadix (vs about 1/3), by the interstice up to three times longer, and with the interstice staminodes and staminate florets readily distinguished (vs interstice staminodes and staminate florets almost indistinguishable until pollen is shed from the anthers), and consequently their respective zones easily discerned, and by a short bullet-shaped appendix comprised of clearly individuated staminodes (vs appendix blunt-cylindrical with the individual staminodes not discernible.

Description

Medium to moderately robust, evergreen, stoloniferous herb forming clumps, 35–40 cm tall. Stems hypogeal, hapaxanthic, 1–1.5 cm diam. Leaves 3–7 together; petiole D-shaped, smooth, 15–18 cm long, green, weakly channelled throughout its length, longitudinal striations raised and darker distally; petiolar sheath, 8 cm long × 0.5 wide, sheathing for 1/3–1/2 of petiole length, persistent, membranous, fully attached with a very short ligule, equal at both sides, slightly in-rolled or sometimes straight, tapering, green with scattered greenish broken striations blades ovato-sagittate to ovato-cordate (sometimes oblong-lanceolate with the base cordate), 16–23 cm long × 9–13 cm wide, softly coriaceous, adaxially glossy green, abaxially paler, posterior lobes subtriangular, 4–6 cm long, sinus 4.5-5 cm across, apex of anterior lobe acute for 2 cm, ultimately mucronate for 5 mm; midrib adaxially flush with blade, raised abaxially, 4 mm at the insertion of blade; primary lateral veins 14 per side, diverging at 30°–80° from the midrib, raised adaxially towards the midrib, marginally impressed, entirely raised abaxially; interprimary veins raised adaxially, alternating irregularly with primaries; secondary veins rather; vein-like pellucid canals not visible. Inflorescences up to 3 per synflorescence, erect, emitting an esteric smell during pistillate anthesis, this absent during staminate anthesis; peduncle 13 cm long × 6 mm wide, terete, green, erect at anthesis; spathe 12 cm long; lower spathe narrowly ovoid, 5 cm long × 1.8 cm wide, green, longitudinally ridged externally?, separated from spathe limb by a constriction coinciding with the lower staminate zone; spathe limb turbinate, 7 cm long × 2.7 cm wide, mucronate for 4 mm, pale greenish yellow at pistillate anthesis, slightly pallid prior to staminate anthesis, caducous and falling in a single piece at onset of staminate anthesis; spadix 7 cm long, shorter than spathe, sessile; pistillate zone cylindric, 3.5 cm long × 7 mm wide, length of spadix, light green; pistils sub-globose, 1 mm long × 0.5–1.2 mm wide, densely arranged; style short, light green; stigma sub-globose from above, truncate, smaller than ovary, 0.3 mm diam., wet with stigmatic secretion at the onset of pistillate anthesis; interpistillar staminodes absent; interstice cylindric, 0.8–1 cm long × 6 mm wide, very slightly narrower than pistillate and staminate zone, not naked, comprised 10–12 whorls of sub-globose staminodes that resemble staminodes of appendix, densely packed, staminodes not impressed; staminodes 0.5–1 mm wide, sub-globose, light yellow; staminate zone sub-cylindric, narrower at proximal but wider at distal end, 1.7 cm long × 7–9 mm wide, 1/4 length of spadix, yellowish white; staminate florets butterfly-shaped from above, 1 mm long ×

Figure 8. *Schismatoglottis pantiensis* S.Y.Wong, P.C.Boyce & Y.C.Hoe. **A.** Plant in habitat. **B.** Base of plant with emerging sequentially produced blooms. **C.** Leaf blade adaxial surface. **D.** Detail of petiole. All from *AR-4322*.

Figure 9. *Schismatoglottis pantiensis* S.Y.Wong, P.C.Boyce & Y.C.Hoe. **A.** Bloom at pistillate anthesis, nearside lower spathe and spathe limb artificially removed. **B.** Detail of interstice, staminate zone, and appendix. **C.** Detail of pistillate zone. **D.** Bloom at pistillate anthesis. All from *AR-4322*.

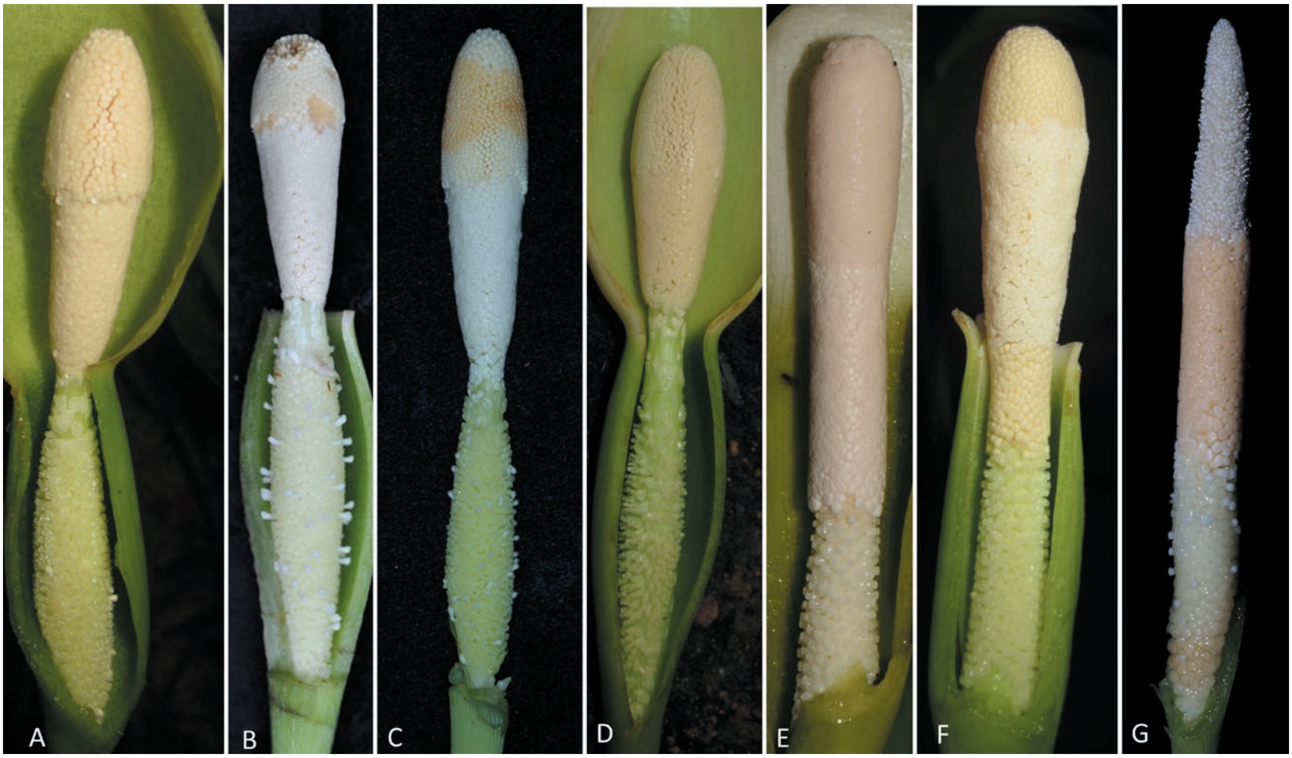

Figure 10. Spadix comparisons. **A.** *Schismatoglottis caesia*. **B.** *Schismatoglottis cordifolia*. **C.** *Schismatoglottis guabatuensis*. **D.** *Schismatoglottis laxipistillata*. **E.** *Schismatoglottis lowiae*. **F.** *Schismatoglottis pantiensis*. **G.** *Schismatoglottis wallichii*.

0.5 mm wide, densely arranged, each comprising 2 truncate stamens, tops depressed, connective narrow; pollen powdery, white; appendix bullet-shaped, 0.9 cm long × 0.9 cm wide, 1/7 length of spadix, base about equalling top of staminate zone, yellowish white; staminodes sub-globose, 1 mm diam., densely arranged. Infructescences 1–3 together, 3.2–5.2 cm long × 0.8–1.5 cm wide, declinate; lower spathe entirely persistent, splitting and reflexed when ripe; fruits 2 mm long × 1–1.8 mm wide, light green; seeds ovoid ellipsoid, 0.4 mm diam., 4–17 per fruit, encased with greenish yellow gel.

Etymology

The specific epithet is derived from the name of the type locality plus the Latin suffix, *-ensis*, to indicate originating from.

Distribution

Schismatoglottis pantiensis is only known from Hutan Simpan Panti, Kota Tinggi, Johor.

Ecology

Lowland tropical forest on deep permanently moist podzols, below 25 m asl.

Additional specimens examined (paratypes)

MALAYSIA. Johor. Kota Tinggi, Hutan Simpan Panti, starting point of trail to Mount Panti,1°48’35.70”N 103°51’5.94”E, 4 Dec2013, *Hoe Yin Chen AR-4323* (KEP, SAR) & *AR-4326* (KEP, SAR) & *AR-4337* (KEP, SAR). Kota Tinggi, Hutan Simpan Panti, starting point of the trail to Mount Panti, 1°48’33.90”N 103°51’6.24”E, 4 Dec 2013, *Hoe Yin Chen AR-4324* (KEP, SAR) & *AR-4325* (KEP, SAR) & *AR-4327* (KEP, SAR) & *AR-4328* (KEP, SAR).

Key to the Peninsula Malaysian species of Schismatoglottis Calyptrata Clade

1a. Spadix fertile to the tip, or with at most a few terminal staminodes; spathe limb splitting into numerous circumferential pieces before falling. Perak, vicinity of Taiping.. ***Schismatoglottis wallichii***

1b. Spadix with a distinct sterile appendix; spathe limb caducous in a single piece..2

2a. Leaf blades glaucous. East Kelantan. Triassic granite... ***Schismatoglottis caesia***

2b. Leaf blade not glaucous...3

3a. Pistillate florets laxly arranged. Kedah, Hutan Lipur Rekreasi Tupah Merbok, Ordovician-Devonian Karst .... ***Schismatoglottis laxipistillata***

3b. Pistillate florets densely arranged 4

4a. Interpistillar staminodes present 5

4b. Interpistillar staminodes absent 6

5a. Pistillate floret zone green, accounting for less than half of the spadix length; interpistillar staminodes only slightly taller than the associated pistils; appendix conical 1.5 times longer than wide. Batu Caves, Silurian limestone .... ***Schismatoglottis guabatuensis***

5b. Pistillate floret zone white, accounting for more than half of the spadix length; interpistillar staminodes twice as tall as the associated pistils; appendix hemispherical and about as wide as long. Hulu Perak, Cambrian Baling sandstones .. .. ***Schismatoglottis cordifolia***

6a. Pistillate zone accounting for almost half the length of the spadix; interstice staminodes and staminate florets readily distinguished, and their respective zones easily discerned; appendix short bullet-shaped comprised of clearly differentiated staminodes. Johor, Hutan Simpan Panti, permanently moist podzols .... ***Schismatoglottis pantiensis***

6b. Pistillate zone accounting for about 1/3 the length of the spadix; interstice staminodes and staminate florets closely similar, the zones not readily separable at first sight; appendix blunt-cylindrical with the individual staminodes not discernible. Heavy clay soils over granite; widespread but localized in Kelantan, Perak, and northern Selang .... ***Schismatoglottis lowiae***

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Studies of the Homalomeneae (Araceae) of Peninsular Malaysia VII: *Homalomena puncticulosa* [Chamaecladon Clade], a new species from recreational forest

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Abstract. *Homalomena puncticulosa* is described and illustrated as a new species of the Chamaecladon Clade known from a single population in Selangor, and compared with the superficially similar *H. kiahii* Furtado, and other similar Sumateran species.

Keywords: *Homalomena* Chamaecladon Clade, taxonomy, Selangor, Triassic granite.

INTRODUCTION

During fieldwork in recreational forest, which is to say forest that has continual public access for recreational activities such as mountain biking, swimming, etc., on the fringe of the protected Taman Negeri Selangor, a population of a facultatively rheophytic Chamaecladon clade *Homalomena* was encountered that aroused interest by having the petioles and the spathe exterior longitudinally ribbed, a characteristic previously unrecorded for the genus in the Malay Peninsula. At the time of collecting, all blooms were post-anthesis and, although the spathes were highly characteristic, the critical spadix characteristics were unobservable. Plants bought into cultivation subsequently flowered and, as discussed below, confirmed that the plants indeed did not match any of the species described for Peninsular Malaysia.

As noted in previous papers (Baharuddin and Boyce 2005, 2010, 2011, Boyce and Wong 2017; Wong and Boyce 2021; Zulhazman et al. 2011, 2012) *Homalomena* remains least well-studied large genus of Asian Araceae, within which species of the Chamaecladon clade (Wong et al. 2013) are perhaps the most poorly understood.

Geological occurrences in this paper are verified with Tate et al. (2008).

Homalomena puncticulosa S.Y.Wong & P.C.Boyce **sp. nov.**

Type: Cultivated Buso, Bau, Kuching [original collection: Malaysia. Selangor, Batu Caves, Jalan Sungai Tua, Kampung Pasir Ulu Yam, Taman Negeri Selangor, Sungai Tua, 3°18’44.28”N 101°41’57.46”E, 160 m asl., 6 Jun 2011, *P.C.Boyce, Wong Sin Yeng & April Ting Pei Jen AR-3590* (holotype KEP!; isotype KEP – spirit). (Figure 1).

Diagnosis

Homalomena puncticulosa differs from all other described species occurring in Peninsular Malaysia by the pistils with conspicuous red punctations, and by the longitudinally ribbed petioles and spathe limb exterior. Sterile plants are similar in overall appearance to *H. kiahii*, notably by the proportionately (to the blade length) short petioles, but immediately distinguished by the ribbed petiole. From species in Sumatera in which the spathe exterior and/or petioles are longitudinally ribbed (*H. mobula* and *H. plicata*) *H. puncticulosa* is distinguished by the leaf blades smooth, not adaxially ornamented, and by pistils with red punctations.

Description

Small slightly aromatic (terpenoids) facultatively rheophytic herbs to c. 20 cm tall. Stem epigeal, erect or rooting-ascending, rooting from the nodes and through the petiole bases, new shoots flushed reddish-brown, later becoming green, older portions of stems medium brown; roots c. 1–2 mm diameter, tough, flexuous, pale brown, younger portions velvety. Leaves numerous, petioles erect, older ones slightly spreading with the blades held more or less flat; petiole 4–11 cm long, c. 2 mm diameter midway, dorsally narrowly channelled, pale green suffused with reddish brown, notably in the lower half, conspicuously longitudinally acute-ribbed; petiolar sheath 1.5–4 cm long, extending c. one-half length of the longest petiole, clasping at the base, width between both margins c. 2 mm, wings persistent, tips truncate; leaf blade narrowly elliptic, 6–15 cm long, 3–4 cm wide, thinly coriaceous, dark matte medium green adaxially, noticeably paler matte green abaxially, base cuneate, apex acuminate with a short (c. 2 mm long) tubule, margins smooth; midrib adaxially almost flush with the blade, abaxially prominent with the basal half reddish brown; primary lateral veins c. 8 on each side of midrib, adaxially impressed, abaxially slightly prominent, diverging at c. 35–60° from the midrib, alternating with much fainter regularly interspersed interprimaries; secondary venation faint, striate; tertiary venation almost invisible; all veins running into a slightly thickened intramarginal vein. Blooms up to seven produced sequentially in a simple synflorescence; peduncle terete, slender, 2–3 cm long, c. 2 mm diameter, reddish brown to reddish maroon, microscopically glandular-pubescent; spathe oblong ellipsoid, not constricted, c. 2 cm long, 8 mm wide at base, with a terminal short stout mucro to c. 2 mm long, exterior longitudinally ribbed, with the dorsal median rib forming a sharp keel that extends from the spathe down the peduncle, spathe inflating at anthesis with the margins spreading slightly, then closing post staminate anthesis and persisting until basal dehiscence at fruit dispersal, exterior matte reddish brown, visible exterior microscopically glandular-pubescent, with the portion of the exterior formerly hidden by the overlapping margin on opening exposed and glossy, interior similarly coloured to exterior but wholly glossy, margins hyaline. Spadix sub-equalling spathe limb at opening, c. 2 cm long, c. 3.5 mm diameter at mid-point, very briefly stipitate, stipe c. 0.5 mm long, smooth, very pale pink with a few minute red speckles; pistillate floret zone c. 5 mm long; pistils congested, stoutly bottle-shaped, c. 2 mm tall × 1 mm diameter, olive green with numerous scarlet speckles, style about 1 mm long, stout, stigma capitate, slightly wider than the style, c. 0.4 mm diameter, olive green; each pistil with a single staminode situated on proximal side of the floret relative to the base of the spadix; interpistillar staminodes oblong fusiform, c. 0.5 mm long, waxy white; staminate flower zone c. 1.5 cm long, stoutly oblong-conical, apex blunt; staminate florets well-defined, each consisting of two, occasionally three stamens, stamens rounded, c. 0.5 mm tall, 1–1.5 mm long × 0.5–0.9 mm wide, creamy white with the thecae tips slightly transparent. Infructescence, fruit and seed not observed.

Etymology

The specific epithet *puncticulosa* is from the Latin meaning, minutely dotted, referring to the scarlet speckles on the pistils.

Distribution and ecology

So far known only from recreational forest abutting the Taman Negeri Selangor where it occurs as a facultative rheophyte on heavily shaded forested stream-edge Triassic granite rocks at low altitudes.

Notes

In Peninsular Malaysia *Homalomena puncticulosa* is most similar in overall appearance to Johore *H. kiahii* Furtado (1937: 207), although readily differentiated by the ribbed petioles. Although there are species of

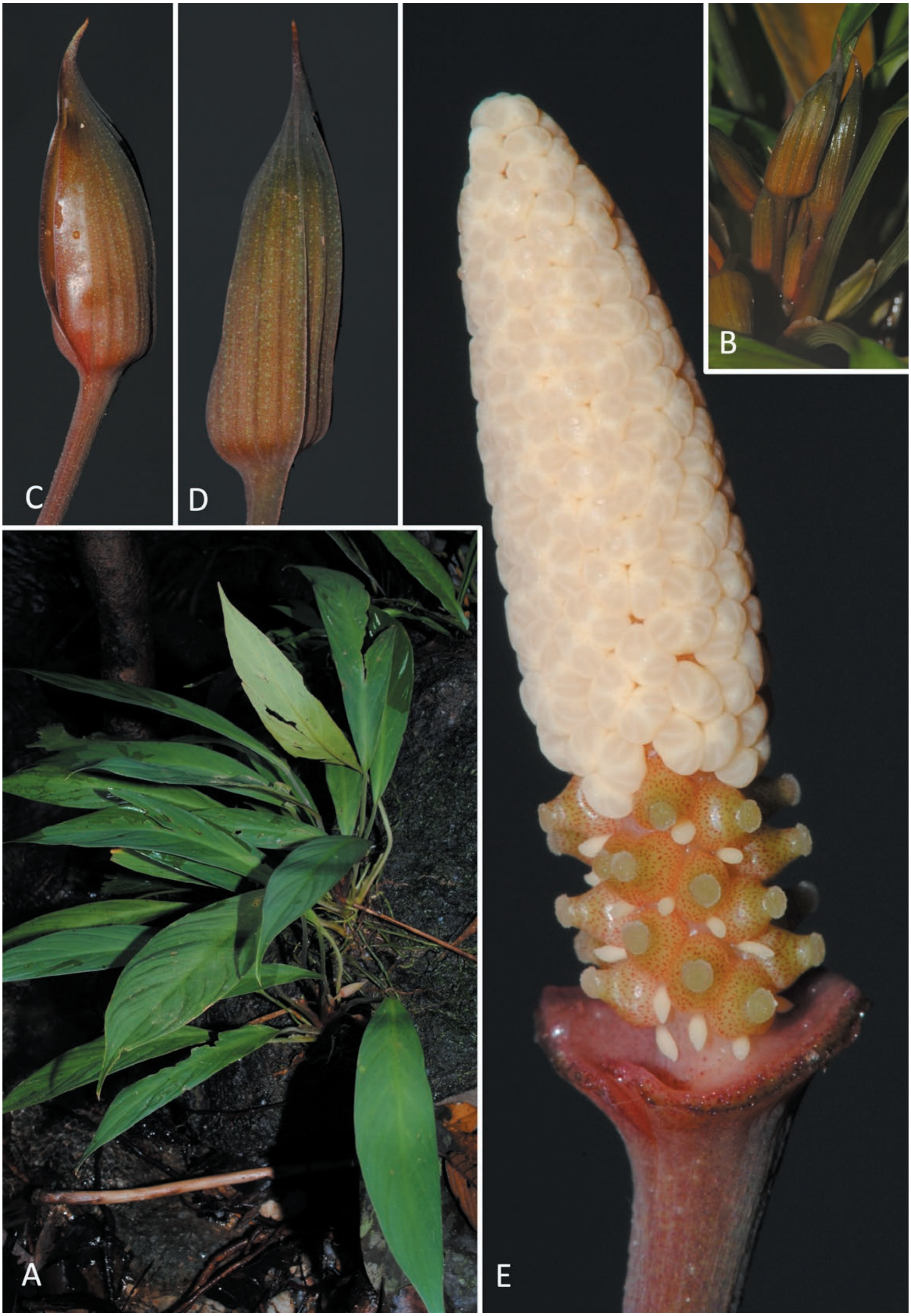

Figure 1. *Homalomena puncticulosa* (A) Plant in habitat. (B) Flowering shoot showing externally ribbed spathes and petioles. (C) and (D) Bloom at pistillate anthesis. (E) Spadix at pistillate anthesis, spathe artificially removed. All from *AR-3590*.

Homalomena Chamaecladon clade with spathes externally ribbed occurring on Sumatera (among them *H. mobula* P.C.Boyce & S.Y.Wong and *H. plicata* P.C.Boyce & S.Y.Wong (Boyce & Wong 2016: 254, 257) these have distinctly elaborated leaf blades or leaf epidermis quite different to these Selangor plants. Elsewhere in Sumatera *Homalomena puncticulosa* resembles *H. batoeensis* Engl. (Engler 1912: 47) and *H. multivenosa* Ridl. (Ridley 1926: 92) from the islands to the west of Sumatera, both of which have the spathe conventionally smooth on the outside, and unribbed petioles, differing further from the latter by leaf blades with far fewer primary lateral veins.

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Four new species of *Monstera* (Araceae) from Panama, including one with the largest leaves and another with the largest inflorescences in the genus

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Abstract: *Monstera bocatorensis* Croat & M.Cedeño, *Monstera donosoensis* Croat, M.Cedeño & O.Ortiz, *Monstera gigas* Croat, Zuluaga, M.Cedeño & O.Ortiz, and *Monstera titanum* Croat, M.Cedeño & O.Ortiz are newly described from Panama, and illustrated from living material.

Keywords: Araceae, Central America, *Monstera*, Panama, Parque Internacional de La Amistad, Talamanca, taxonomy.

INTRODUCTION

Monstera Adanson (1763), widespread in the Neotropics, is especially diverse in the Cordillera de Talamanca of Costa Rica and Panama (Madison 1977), principally on the Caribbean slope (Cedeño-Fonseca 2019). This genus, composed of nomadic vines (Sperotto et al. 2020), belongs to Araceae subfamily Monsteroideae, and is the only Neotropical genus of the pantropical tribe Monstereae, or *Rhaphidophora* clade (Tam et al., 2004; Zuluaga et al. 2019). Despite a relatively recent revision (Madison, 1977), *Monstera* is taxonomically the most poorly understood genus of Araceae in the Neotropics (Grayum 2003). The morphological features manifest on herbarium specimens are often inadequate for characterization and identification, due to the large size of the plants and their extreme intraspecific variation (Grayum 2003).

Madison (1977) believed that Panama had the highest diversity of *Monstera* species, but recent studies (e.g., Cedeño-Fonseca et al. 2018, 2020a, 2020b, 2020c, 2020d, 2020e) have elevated Costa Rica, with 32 accepted species of *Monstera*, to first place in this category. However, field work in

Panama during 2016–2019, as part of an ongoing revision of *Monstera* for the Mesoamerican region (Croat et al., in prep.), has revealed the four new species here described, raising the Panamanian total for the genus to 29 species. All of these new species belong to *Monstera* section *Monstera* (*sensu* Madison, 1977: 90), characterized by seedlings with foliose leaves — unlike the stoloniferous sections *Echinospadix* Madison (1977) and *Marcgraviopsis* Madison (1977), and the juvenile stage with the leaves not appressed ('shingling') to the phorophyte (host tree).

MATERIALS AND METHODS

The first and second author carried out field exploration in Panama between 2016 and 2021 and studied *Monstera* collections deposited at the following herbaria: CR, HLDG, JVR, LSCR, MEXU, MO, NY, PMA, SEL, UCH, and USJ. Herbarium acronyms cited above and elsewhere in this paper follow Thiers (2021). Three of the four species described here are illustrated with photographic plates showing different parts of the plants in life, adapted from the "Lankester Composite Dissection Plate" technique proposed for Orchidaceae at Lankester Botanical Garden, Universidad de Costa Rica (Pupulin and Bogarín 2004). Due to the high demand for species of the genus *Monstera* as ornamental plants, and a rapidly growing black market that endangers native populations (even in protected areas), coordinates are here omitted from all specimen citations.

TAXONOMIC TREATMENT

Monstera bocatorensis Croat & M.Cedeño, **sp. nov.** (Figures 1, 2)

Type: Panama. Bocas del Toro: Along road between Chiriquí Grande and Fortuna, 7.7 mi W of Chiriquí Grande, 1.5 mi W of Punta Peña, disturbed primary forest, 80 m, 9 Mar 1985, *T.Croat & M.Grayum 60088* (holotype: MO-3123561!; isotypes, B, COL, K, NY, PMA!, US).

Diagnosis

Monstera bocatorensis is characterized by its smooth and glaucous stems, long, smooth petioles glaucous throughout and 46–90 cm long, short petiole sheaths that extend only to the middle or ¾ of its length, usually deeply pinnatifid (rarely entire) leaf-blades, never perforate, and smooth, light green or dark green peduncles, 27–45 cm long, entirely covered by the cataphylls.

Description

Habit: Robust nomadic vine, appressed-climbing. Seedlings: bearing foliose leaves. Juvenile plants: root climbers; stems completely terrestrial or ascending, dark green, smooth and glaucous, cylindrical; internodes 0.5–4 cm long, 0.5–1 cm diam.; petiole dark or light green, smooth and glaucous at the base, 8–20 cm long, sheathed for 3–7 cm, or up to the middle; petiole sheath persistent and involute; unsheathed portion terete; leaf-blades ovate to elliptic-ovate, attenuate at the base, acuminate at apex, thinly coriaceous, 10–25 × 6–10 cm, not appressed to the phorophyte; fenestrations absent or present (usually one fenestrated side which breaks at the margin). Adult plants: root climbers; stems dark green or shiny beige, cylindrical and slightly flattened; internodes 1–2.5 cm long, 1.5–3 cm diam.; cataphylls with a very small blade at the apex, persistent, light green to pruinose; anchor roots light brown, with root trichomes; feeder roots light brown, with root trichomes; petiole light green or dark green, smooth and glaucous throughout, 46–90 cm long, sheathed up to the middle or 5–15 cm beyond the middle; petiole sheath persistent and involute; unsheathed portion terete and slightly ribbed near the geniculum; geniculum sunken adaxially and convex abaxially, 2–3.5 cm long; leaf-blades ovate to oblong-ovate, rounded at the base, short-acuminate at apex, subcoriaceous, (31–)48–58 × (13.5–)20–32 cm, 1.7–2.0(–2.6) times longer than wide, not decurrent on the geniculum; midrib ribbed adaxially, convex abaxially; primary lateral veins 14–20 per side, departing midrib at 60–90°, strongly sunken adaxially, prominent abaxially; secondary veins completely parallel; collective veins scarcely visible on the margins of each lobe; fenestrations absent; margins deeply pinnatifid or (rarely) entire, generally with 2–6 lobes per side, 3–20 cm wide, with 3–10 veins per lobe. Inflorescences on ascending stems, 1 or 2 simultaneously in flowering season; peduncle smooth, light green or dark green, 27–45 cm long, 1 cm diam., entirely covered by cataphylls; spathe acuminate, membranous, completely open, with margins overlapping at the base, light green during development, creamy or white externally and white with longitudinal greenish or white veins internally at anthesis, 12 –17 × 5–9 cm, up to 6 cm longer than the spadix; spadix white during development and at anthesis, 11–12 cm long, 1.7–2.2 cm diam.; basal sterile flowers 3–5 mm long, globose and with a very prominent stigmatophore and an orange stigmatic secre-

Figure 1. *Monstera bocatorensis*. **A.** Front view of open inflorescence. **B.** Developing inflorescence. **C.** Front view of open inflorescence with peduncle and persistent cataphyll. **D.** Back view of open inflorescence. **E.** Juvenile plant. **F.** Adult plant. **G.** View of spadix at female anthesis, showing flowers with stigmatophore lateral-flattened. Photos by Marco Cedeño-Fonseca.

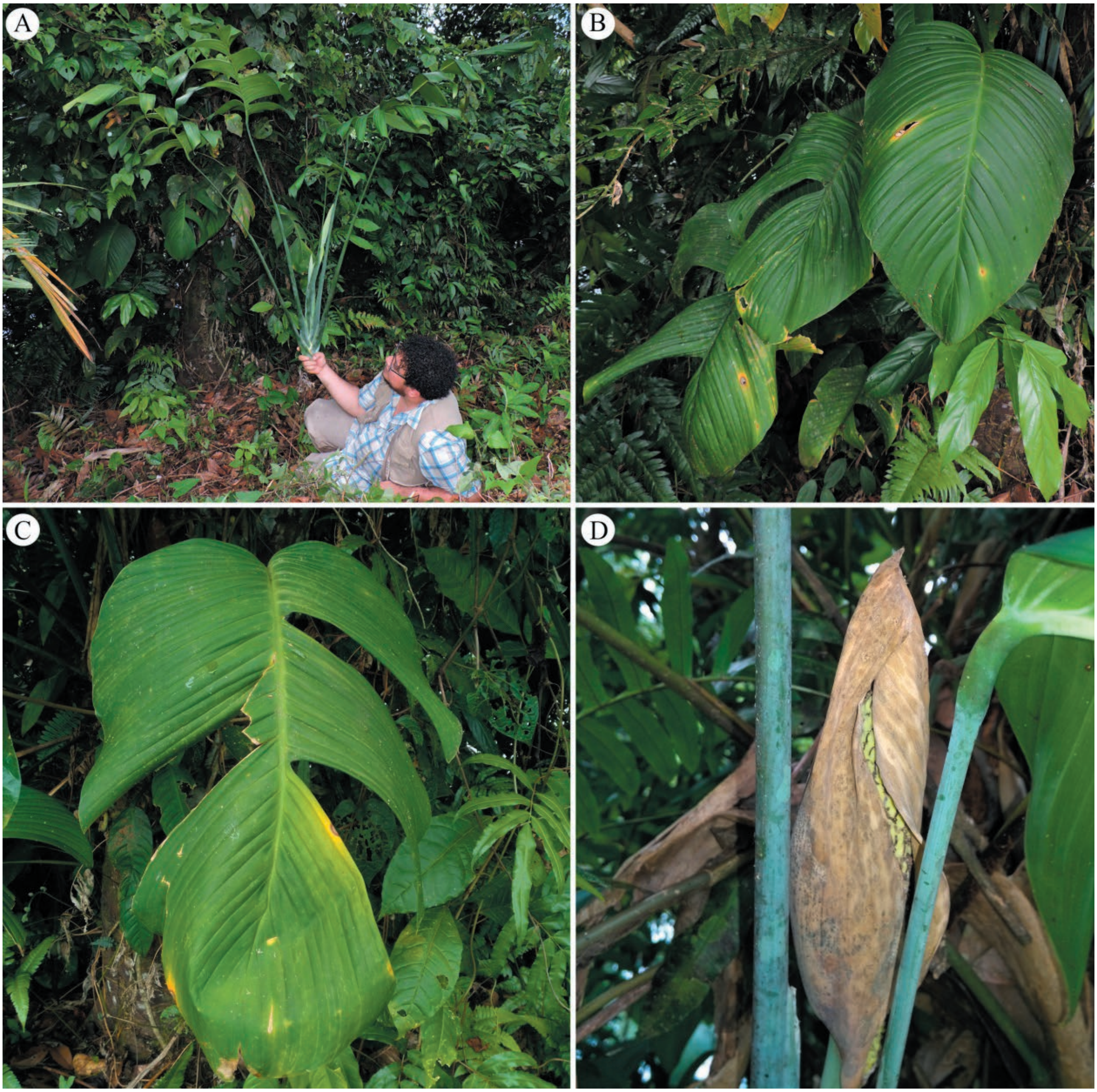

Figure 2. *Monstera bocatorensis*. **A.** Adult plant, leaf-blades with 4–6 lobes per side. **B.** Adult plant, one leaf-blade entire and one with 2 or 3 lobes per side. **C.** Adult plant, leaf-blade with 2 or 3 lobes per side. **D.** Spathe, marcescent after male anthesis and enclosing the spadix. Photos by Marco Cedeño-Fonseca.

tion; fertile flowers 5–6 mm long; stamens with laminar filaments 1.5–5 mm long; anthers 1–2 mm long; ovary quadrangular in longitudinal section, 1.5–2.5 × 1.5–2 mm; style quadrangular, cylindrical, or hexagonal, 0.5–1 × 2–3 mm; stigmatophore columnar, slightly ribbed on style, 0.5–1 mm long; stigma linear with a transparent stigmatic secretion; berries with green stylar cap during development, unknown when ripe; pulp unknown; seeds unknown.

Etymology

The species is named after Bocas del Toro Province, Panama, where all the known specimens have been collected.

Distribution and habitat

Monstera bocatorensis is endemic to Panama, where it is known only from the western slopes of the mountains east of Fortuna Dam below the Continental Divide in Bocas del Toro Province, from sea level to 1100 m, in the *Tropical wet forest* and *Premontane wet forest* life zones.

Phenology

Fruiting has been recorded in March and June.

Conservation status

Monstera bocatorensis should be considered as data deficient (DD), because we lack adequate geographic distribution and population information to make an assessment based on the IUCN criteria (IUCN Standards and Petitions Subcommittee 2017; IUCN 2019).

Notes

This species is characterized by its ovate, yellowish-drying leaf-blades that are never perforate, frequently pinnatifid with two or three very unequal pinnae, or rarely entire. Other characteristic features are the short petiole sheaths that extend only to the middle or ¾ of its length, as well as the glaucous petioles and blades. This species is similar to *M. glaucescens* Croat & Grayum (Grayum 1997), but differs from that species by its leaf-blades drying light yellow-brown on the lower surface and with having the pinnae markedly unequal. In contrast, the leaves of *M. glaucescens* have blades that dry dark brown and have much narrower pinnae, with more long-tapered and more prominently falcate pointed lobes. Another species with which it could be confused is *Monstera croatii* M.Cedeño & A.Hay (in Cedeño et al., 2020c), but that species differs by its deeply pinnatifid and bluish green leaf blades, with bifid lobes, a persistent sheathing mucronate cataphyll, and spathe with two longitudinal keels.

Additional specimens examined (paratypes):

PANAMA. **Bocas del Toro,** Laguna de Chiriquí, rincón SE. Nuri: campamento cerca población Guaymi. 15 km W de Puntas Cricamola, entrando Ensenada de Catavela, y subiendo Quebrada Nuri, 10-25 m, *Foster et al. 14604* (MO); Fortuna, La Fortuna area to Chiriquí Grande and the oil pipeline; along dirt road 10 mi from continental divide, just past 2nd large bridge; 1 mi north from highway, 130 m, *Hammel et al. 14599* (MO); Chiriquí Grande, Rembala, Vicinity of Chiriquí Grande, near town of Rembala [Rambala], on trail west of road, 250 m, *McPherson et al. 11150* (MO).

Monstera donosoensis Croat, M.Cedeño & O.Ortíz, **sp. nov.** (Figures 3, 4)

Type: Panama. Colón: Donoso District. Minera Panamá copper-mining concession, slopes and ridges in drainage of Quebrada Brazo, 243 m, 30 Aug 2014, *M.Grayum, G.McPherson, C.Ramos, I.Vergara-Pérez & L.Rojas 13242* (holotype, PMA!; isotype, MO-6636330!).

Diagnosis

Monstera donosoensis is characterized by its dark green petioles with a deciduous or slightly persistent sheath, entire, pinnatilobed, or scarcely pinnatifid leaf blades, with or without fenestrations, spathe yellowish or cream externally and white or creamy internally, and flowers with the style hexagonal, strongly conical, and distally cylindrical.

Description

Habit: robust nomadic vine, appressed-climbing. Seedlings: bearing foliose leaves. Juvenile plants: root climbers; stems light green or beige, sometimes white-dotted, smooth, cylindrical; internodes 2–5 cm long, 0.5–1 cm diam.; petiole distinct, light green, smooth, 8–15 cm long, sheathed to the base of the geniculum; petiole sheath deciduous or slightly persistent; leaf-blades ovate to lanceolate, attenuate or cuneate at the base, the tip acuminate, subcoriaceous to coriaceous, 10–25 × 9–15 cm, not appressed to the phorophyte; fenestrations absent or present, only in one side of the lamina. Adult plants: root climbers; stems beige to light brown, smooth, cylindrical; internodes 1–4 cm long, 1–5 cm diam.; anchor roots light brown or beige; feeder roots corky, dark brown; petiole dark green, scarcely white-dotted, smooth, 22–41.5 cm long, fully sheathed, or for up to 15 cm; petiole sheath deciduous or slightly persistent, horizontally open; geniculum smooth, sunken adaxially, convex abaxially, 0.5–3 cm long; blades ovate to elliptic, rounded or truncate at the base, subcoriaceous to coriaceous, obtuse to short-acuminate at apex, drying glossy, beige or brownish, 26.5–47 × 16.3–25 cm, 1.62–1.88 times longer than wide, decurrent on the geniculum, decurrent portion 1–2 mm wide; midrib ribbed adaxially, convex abaxially, drying light or reddish brown on both surfaces, primary lateral veins 6–20 per side, strongly sunken adaxially, prominent abaxially, departing the midrib at 50–60°, drying brownish or reddish; secondary veins prominent and parallel, reticulate toward the margin; collective veins slightly visible toward lobes; fenestrations absent or present; margins entire, pinnatilobed or scarcely pinnatifid, with 2–8 lobes per side. Inflorescences: on ascending stems;

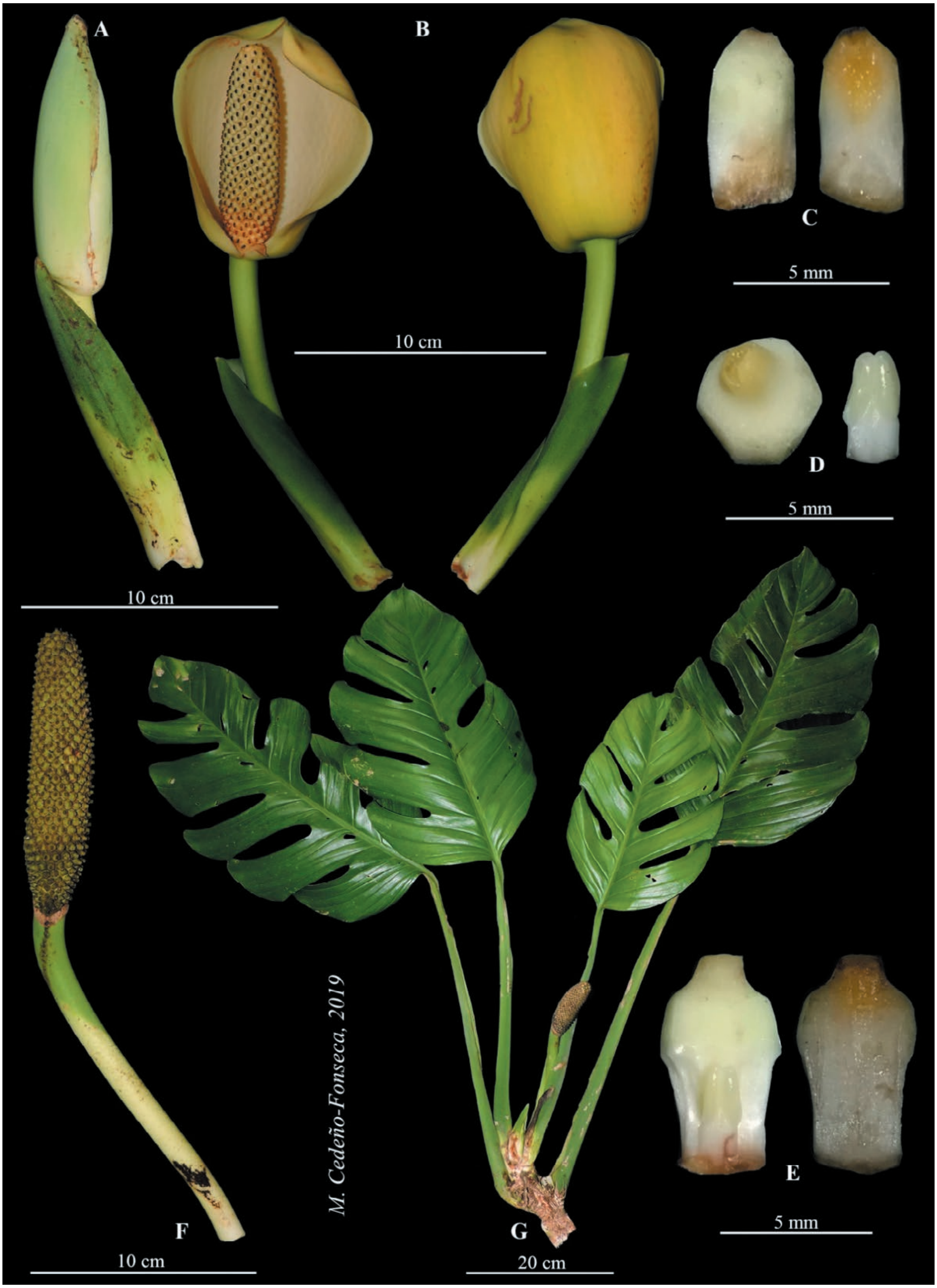

Figure 3. *Monstera donosoensis.* **A.** Developing inflorescence. **B.** Front and back views of open inflorescence. **C.** Sterile flower in lateral view (left) and longitudinal section (right). **D.** Stylar plate, top view (left), and individual stamen (right). **E.** Fertile flower in lateral view (left) and longitudinal section (right). **F.** Immature infructescence. **G.** Adult plant. Photos by Marco Cedeño-Fonseca.

Figure 4. Different adult plants of *M. donosoensis* recollected in Santa Rita, Colón, Province, Panama, showing entire, pinnatilobed, and scarcely pinnatifid (with 2–4 lobes per side) leaf-blades. Photo by Riccardo M. Baldini (Tropical herbarium FT, University of Firenze, Italy)..

peduncle smooth, 11.5–19 cm long; spathe obtuse to short-acuminate, light green during development, yellowish or cream externally and white or creamy internally at anthesis, completely open, marcescent after anthesis, 10–20 × 6–10 cm, up to 2 cm longer than the spadix; spadix white or cream (both during development and at anthesis), 9–10.5 cm long, 1.8–2.5 cm diam., 4.1–4.2× longer than wide; basal sterile flowers 4–6 mm long, with an orange stigmatic secretion; fertile flowers 5–9 mm long; stamens with laminar filaments 2–6.5 mm long; anthers 1.3–2 mm long; ovary rectangular in longitudinal section, ribbed, 3–4 × 1.5–2.5 mm; style hexagonal and strongly conical, distally cylindrical, 2–5 × 2–3 mm; stigma circular, with an orange stigmatic secretion; berries with a light or dark green stylar cap during development, mature stylar cap cream-yellowish; pulp unknown; seeds unknown.

Etymology

The species is named after Donoso District, Colón Province, Panama, in which the type was collected.

Distribution and habitat

Monstera donosoensis is endemic to Panama, where it is known from Darién, Coclé, Colón, Veraguas, Panamá, Panamá Oeste provinces, and Guna Yala comarca, at elevations of 100–1600 m, in the *Premontane rainforest* life zone.

Phenology

Flowering has been recorded in January, March, April, June, August, October, November, and December. Fruiting has been recorded in January, February, March, April, July, and October.

Conservation status

The distribution of this species includes at least 10 locations of which seven are in protected areas. It has an EOO of 29, 214.84 km^2 and an AOO of 104 km^2, therefore, *M. donosoensis* could be assessed as Least Concern [LC].

Notes

This species is characterized by its thick stems, with moderately short internodes, long, nearly fully sheathed petioles, with the sheath deciduous or slightly persistent, and moderately coriaceous, dark brown-drying, usually sparsely perforate, ovate-elliptic, and weakly acuminate leaf-blades, inequilaterally subrounded to acute at the base, with the primary lateral veins heavily aggregated near the base and the fenestrations (when present) large and few, mostly beginning near the midrib, as well as by its long-pedunculate inflorescences with the spathe greenish, cream-colored within, and the spadix about 2/3 as long as the spathe, and especially by its flowers with a protruding, hexagonal, strongly conical and distally cylindrical style. *Monstera donosoensis* is similar to *M. dissecta* (Schott) Croat & Grayum (1987), but differs in having petioles speckled with white dots, with the sheath deciduous or slightly persistent, coriaceous leaf-blades, and flowers with a hexagonal, strongly conical, and distally cylindrical style. *Monstera donosoensis* has similar characteristics to the South American *M. adansonii* Schott subsp. *klotzschiana* (Schott) Mayo & I.M.Andrade (2013), but the latter differs in having dark green, less frequently mottled petioles with the sheath persistent, and slightly coriaceous leaf-blades.

Additional specimens examined (paratypes)

PANAMA: **Coclé,** Road to Coclesito. Logging camp 12 miles from Llano Grande, 200 m, *Churchill et al. 3984* (MO); Along road past Furlong's Finca, due N of Cerro Pilón, 880 m, *Croat 37573* (MO); On Atlantic slope near the Continental Divide along lumbering road N of El Cope, 9.4 km above El Cope (2.2 km N of lumber sawmill), 750–900 m, *Croat 44750* (MO); Near continental divide along lumber road 5.2 mi N of El Cope, 1.5 mi N of lumber camp. Cloud forest on steep slopes, 900 m, *Croat*

44574 (MO); North of El Copé, 500 m, *D'Arcy 11294* (MO); Foot of Cerro Pilón, above El Valle de Antón, Rain forest, 2000 ft, *Porter et al. 4431* (MO); Trail between the Río Blanco and the Continental Divide north of El Cope and El Petroso sawmill, 400–1700 ft, *Sytsma et al. 2605* (MO); North rim of El Valle de Antón, near Cerro Turega, 650–700 m, *Woodson & Schery 185* (MO). **Colón,** Santa Rita Ridge Road, 4–6 km from Transisthmian Highway. Disturbed primary forest, 150–200 m, *Croat 34281* (MO); Santa Rita Arriba. Bosque secundario, orillas de la carretera, 380 m, *Ortiz et al. 3452* (PMA, MO). **Darién,** Cerro Tacarcuna massif west ridge, vicinity of summit camp, lower montane wet forest, 1500–1600 m, *Gentry & Mori 14161* (MO). **Panamá,** Chepo, El Llano–Cartí Road, 7–12 km from Interamerican Highway, 360–400 m, *Croat 25155* (MO); Capira, Cerro Campana, along trail to Summit, 780–875 m, *Croat 25194A* (MO); Capira, Cerro Campana, along trail to summit, 780–875 m, *Croat 25244* (MO); Cerro Jefe, 21 km above Pan-Am Highway, 600 m, *Croat 35890* (MO); Capira, Middle slopes of Cerro Campana, ca. 1 mile from Interamerican Highway, 150 m, *Croat 35990* (MO); Chepo, Road from El Llano to Cartí, 8.7 km N of the Panamerican Highway, 200–300 m, *Folsom & Small 6162* (MO); Near top of Cerro Jefe to 1 mile beyond, 900–1000 m, *Gentry 3499* (MO); Cerro Jefe, in forest alongside road north off of road to tower, 820 m, *Hammel & McPherson 14534* (MO); Chepo, Along newly cut road from El Llano to Carti-Tupile; 12 miles above Pan-Am Highway, Primary forest, 200–500 m, *Liesner 693* (MO); Capira, Summit of Cerro Campana, Rain forest, 3220 ft, *Porter 4951* (MO); El Llano-Cartí Road, tropical moist forest, 12 km from Pan American Hwy, 1000 ft, *Sytsma 1745* (MO); Chepo, 16–18 km from Interamerican Highway on the El Llano-Cartí Road, 400 m, *Tyson & Nee 7356* (MO). **San Blas,** El Llano-Cartí Road, 350 m, *de Nevers & Herrera 4356* (MO). **Veraguas,** Santa Fe, 5 miles W of Santa Fé on road past Escuela Agricola Alto Piedra on Pacific side of divide, 800–1200 m, *Croat 23053* (MO); 2/10 mile beyond fork in road at Escuela Agricola Alto Piedra on road to Rio Calovebora, 750 m, *Croat & Folsom 33969* (MO); "Cerro Tute" ridge up from former Escuela Agrícola, Santa Fé, moist forest, 800–1000 m, *Hamilton & Dressler 3042* (MO); Santa Fe, Along steep trail to summit of Cerro Tute, ca. 3 km above Escuela Agricultura Alto Piedra near Santa Fé, 3000–3100 ft, *Sytsma & Antonio 3058* (MO). Coclé: Near sawmill 16.7 km N of turnoff to Coclesito from Llano Grande, 700 ft, *Hammel 1836* (MO).

Monstera gigas Croat, Zuluaga, M.Cedeño & O.Ortiz, **sp. nov.** (Figure 5, 6, 7)

Type: Panama. Chiriquí: Fortuna Dam area, unnamed creek to E of road flowing into Río Hornito near Quebrada Moro, 1200 m, 16 Jun 1984, *W.Churchill 5508* (holotype, MO-3216379–821!; isotype, PMA!).

Diagnosis

Monstera gigas is characterized by petioles with white dots, a slightly persistent sheath, sometimes enormous leaf blades subcordate at the base, with entire margins, with or without fenestrations, and 24–65 primary lateral veins per side, sunken adaxially, departing the midrib at 80–90° in the lower part of the blade and 55–75° toward the apex.

Description

Habit: very robust to gigantic pachycaul appressed-climbing nomadic vine or rarely terrestrial. Seedlings: bearing foliose leaves. Juvenile plants: unknown. Adult plants: root climbers; stems pale green, smooth, cylindrical; internodes 1.5–2 cm long, 3–11 cm diam.; anchor roots unknown; feeder roots unknown; petiole light green, white-dotted, smooth, (45–)66–81(–140) cm long, sheathed up to (0.36–)0.74–0.86 its total length, 13–17 cm; petiole sheath slightly persistent, drying dark brown with pale brown margins; geniculum white-dotted, 17 cm long, 3 cm diam.; leaf-blades narrowly ovate-elliptic, rounded on both sides, subcordate on one side and rounded on the other side, or unequal (one side 4–5 cm wider) at the base, short-acuminate at apex, moderately coriaceous, (43–)72–86(–140) × (25.6–)34–40(–61) cm, 1.67–2.2 times longer than wide; fenestrations absent or present; margins entire; midrib weakly sunken adaxially to weakly discolored toward the distal margin, greenish white and thicker than broad abaxially, convex toward the apex, closely rounded and pale brown below; primary lateral veins (21–)24–65 per side, sunken adaxially, closely narrowly rounded and pale abaxially, departing the midrib at (40°–) 55–75° toward the apex and 80–90° in the lower part of the blade; secondary veins parallel, moderately prominent adaxially. Inflorescences on ascending stems; peduncle smooth, 34–38.5 cm long, 1.7–2.2 cm diam.; spathe acuminate, white at anthesis, coriaceous, 30–34 × 15–18.5 cm; spadix white at anthesis, 20–25.5 cm long, 3.2–4.2 cm diam.; basal sterile flowers 3–5 mm long; fertile flowers 5–6 mm long; stamens with laminar filaments; anthers 1.5–2 mm long; ovary rectangular in longitudinal section, ribbed, 4–5 × 1.5–2.5 mm; style hexagonal, 1.5–2 × 1.5–2 mm; stigma circular; berries with a white stylar cap when ripe; seeds unknown.

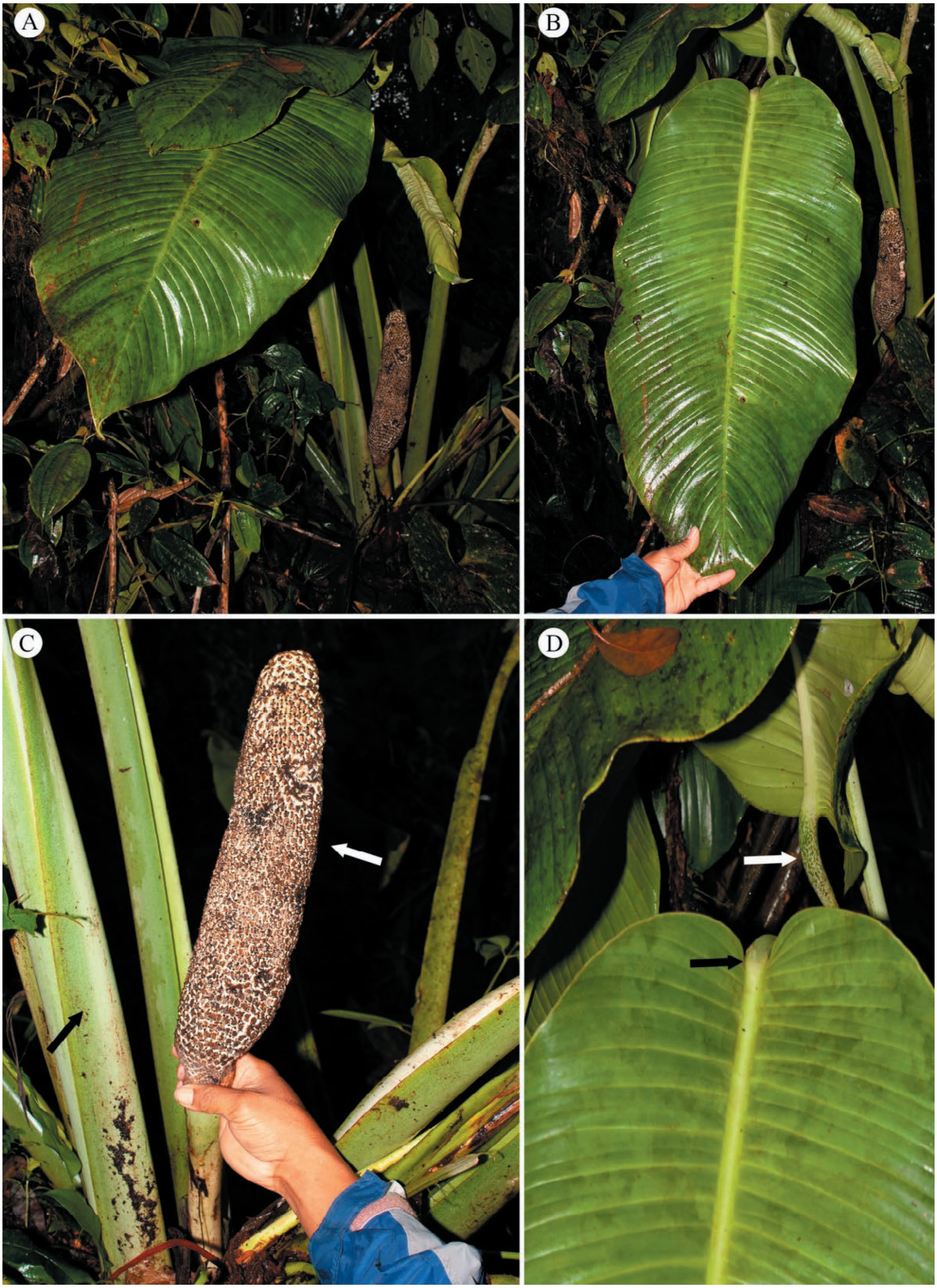

Figure 5. *Monstera gigas*. **A.** Adult plant. **B.** Adult leaf-blade. **C.** Petiole (with black arrow indicating slightly persistent sheath) and immature infructescence (with white arrow indicating white stylar cap). **D.** Adult leaves (with white arrow indicating white-dotted geniculum and black arrow indicating subcordate base of blade). Photos by Alejandro Zuluaga.

Figure 6. *Monstera gigas*. Adult plant with the stem beige, 11 cm diam, and leaves up to 3 m of length. Photos by Marco Cedeño.

Figure 7. *Monstera gigas*. Michael Mittermeier (left) with a leaf up to 3 m of length, and Marco Cedeño and Orlando Ortiz (right) with a leaf up to 2 m of length. Photos by Esteban Jiménez.

Etymology

The epithet is a noun in apposition, from the ancient Greek word "*gígas*" meaning a giant, in reference to the exceedingly large size of its leaves, the largest recorded in the genus.

Distribution and habitat

Monstera gigas is endemic to Panama, where it is known only from the type locality in the region of the Fortuna Lake at 1200–1300 m, in the *Premontane rain forest* life zone.

Phenology

Fruiting has been recorded in January, April, July, and September.

Conservation status

Monstera gigas should be considered as data deficient (DD).

Notes

This species is characterized by its usually nomadic-vine (but sometimes terrestrial) habit (but sometimes terrestrial), large stems with short, stout internodes, subterete, pale yellowish brown petioles sheathed to within 13–17 cm from the base (to 36 cm on preadult leaves), and ovate-elliptic, grayish-drying, entire and non-perforated, short-acuminate leaf-blades, rounded at the base and with 24–65 primary lateral veins per side, as well as by its moderately short-pedunculate, massive, green-white spathes, green spadices, and flowers with a narrow style covered for nearly its entire width by the stigma, the latter bearing a tubular extension that protrudes beyond the end of its center. Leaves at the upper end of the size range for this species, exceeding 3 m in length, are the largest so far know in the genus, and the plant is perhaps the most massively constructed member of its entire subfamily. *Monstera gigas* was first collected by last author as sterile material in April 1980, and was assumed at the time to be a new species. Later the same year it was found fertile by Thomas Antonio. Because of its large, entire leaves, it later became confused with *M. standleyana* G.S.Bunting (Bunting 1967), to which it is most probably closely related; however, the latter species differs in having fully sheathed petioles and dark brown-drying leaf-blades, rounded or acute at the base, with the basal veins arising at more acute angles and with short, pale lineations (as least on the upper surface), as well as by its flowers with a broader style and an oval stigma lacking a tubular extension.

One collection, *Churchill 5508* (the holotype), was described as being terrestrial, making it exceptional for *Monstera gigas*; however, it may have ended up accidentally in that situation. The inflorescence of the same collection was reported to have harbored Dynastinae scarab beetles.

Additional specimens examined (paratypes)

PANAMA: **Chiriquí,** Vicinity of Gualaca, ca. 8.6 mi from Planos de Hornito on the road to the La Fortuna dam site, 4000 ft, *Antonio 5002* (MO); Along road between Gualaca and Fortuna dam site; 7.9 mi beyond (NW) of Los Planes de Hornito; virgin forest, 1300 m, *Croat 49904* (MO); Gualaca-Chiriquí Grande, 4.8 mi beyond IRHE facilities at Dam, 4 mile N of bridge over Bayano Lake, along gravel road which turns off main highway, 100 m beyond pipeline marker 108, *Croat 68031* (MO); Chiriquí, Gualaca, Hornito. Fortuna, camino a Chiriquí Grande, 1230 m, *Cedeño et al. 2328* (MO, PAM, USJ). **Veraguas,** Vicinity of Santa Fe on slopes of Cerro Tute-Arizona above school at Alto Piedras; on trail to summit, 900-1100 m, *McPherson 13672* (MO).

Monstera titanum Croat, M.Cedeño & O.Ortiz, **sp. nov.** (Figure 8, 9, 10)

Type: Panama. Panamá, Antón, El Valle. Valle de Antón, camino a Altos del María, 1030 m, 26 Marz 2021, *M.Cedeño, O. Ortíz, J.E.Jiménez & M.Mittermeier 2385* (holotype, PMA!; isotype, USJ!, MO!).

Diagnosis

Monstera titanum is characterized by its dark green stems with white dots, petioles 50–95 cm long, with the sheath slightly persistent, leaf blades subcordate at the base, with 20–40 primary lateral veins per side, departing the midrib at 75–95°, prominent collective veins, and compound fenestrations, with small fenestrations along the midrib or near the margins, and its inflorescence up to 95 cm in length.

Description

Habit: robust terrestrial plant in walls or robust nomadic vine, appressed-climbing. Seedlings: bearing foliose leaves. Juvenile plants: root climbers; stems smooth, dark or light green, sometimes with white dots, cylindrical; internodes 5–15 cm long, 0.5–1 cm diam.; petiole distinct, dark or light green, sometimes with white dots, smooth, 10–25 cm long, sheathed to the base of the geniculum; petiole sheath slightly persistent or completely deciduous; leaf-blades with collective veins visible, obovate, subcordate to truncate at base, acuminate at apex, thinly coriaceous, 10–20 × 8–13 cm, not appressed to the phorophyte; fenestrations absent or present, arranged on both sides of the midrib and in a single row of small ellipsoid fenestrations, 2–2.7 mm long. Adult plants: root climbers; stems light or dark green, white-spotted, smooth or slightly verrucose, cylindrical; internodes 1.5–3 cm long, 2–10 cm diam.; anchor roots black; feeder roots black; petiole light green, white-spotted, smooth or verrucose at the base, 50–95 cm long, sheathed to base of the geniculum or 15 cm before; petiole sheath slightly persistent; geniculum smooth, sunken adaxially, convex abaxially, 2–4.5 cm long; leaf-blades narrowly ovate-elliptic, subcordate at the base, acuminate at apex, subcoriaceous to coriaceous, drying dark brown and semiglossy adaxially, greenish yellow to brown abaxially, 47–100 × 28–35 cm, 1.6–1.7 times longer than wide, decurrent on geniculum (decurrent portion 1–2 mm wide); midrib flattened adaxially, convex abaxially, drying reddish, light brown or black on both surfaces; primary lateral veins 20–40 per side, strongly sunken adaxially and prominent abaxially, departing midrib at 75–95°, drying reddish, black or light brown; secondary veins parallel and reticulate toward the margin, undulate when dry; collective veins prominent; fenestrations absent or present in two or three rows, the first row along the midrib, with small fenestrations of 0.5–5.5 × 0.5–3.5 cm, the second and third rows near the margins, with larger fenestrations of 9–14.5 × 1.7–3 cm; margins entire. Inflorescences on ascending stems, very large; peduncle smooth, 25–48 cm long; spathe acuminate, coriaceous, completely open, light green during development, creamy or white externally and white or creamy internally at anthesis, 16.5–47 × 10–20 cm, up to 10 cm longer than the spadix; spadix cream at anthesis, 18–24 cm long, 2.5–6 cm diam., 5.5–7.3 longer than wide; basal sterile flowers 4–5 mm long; fertile flowers 7–9 mm long; stamens with laminar filaments 2–9 mm long; anthers 2–3 mm long; ovary rectangular in longitudinal section, ribbed , 5–6 × 2–3 mm; style pyramidal, distally cylindrical, 4–5 × 2.5–3 mm; stigma linear; berries with a creamy stylar cap during development, ripe berries color unknown; seeds unknown.

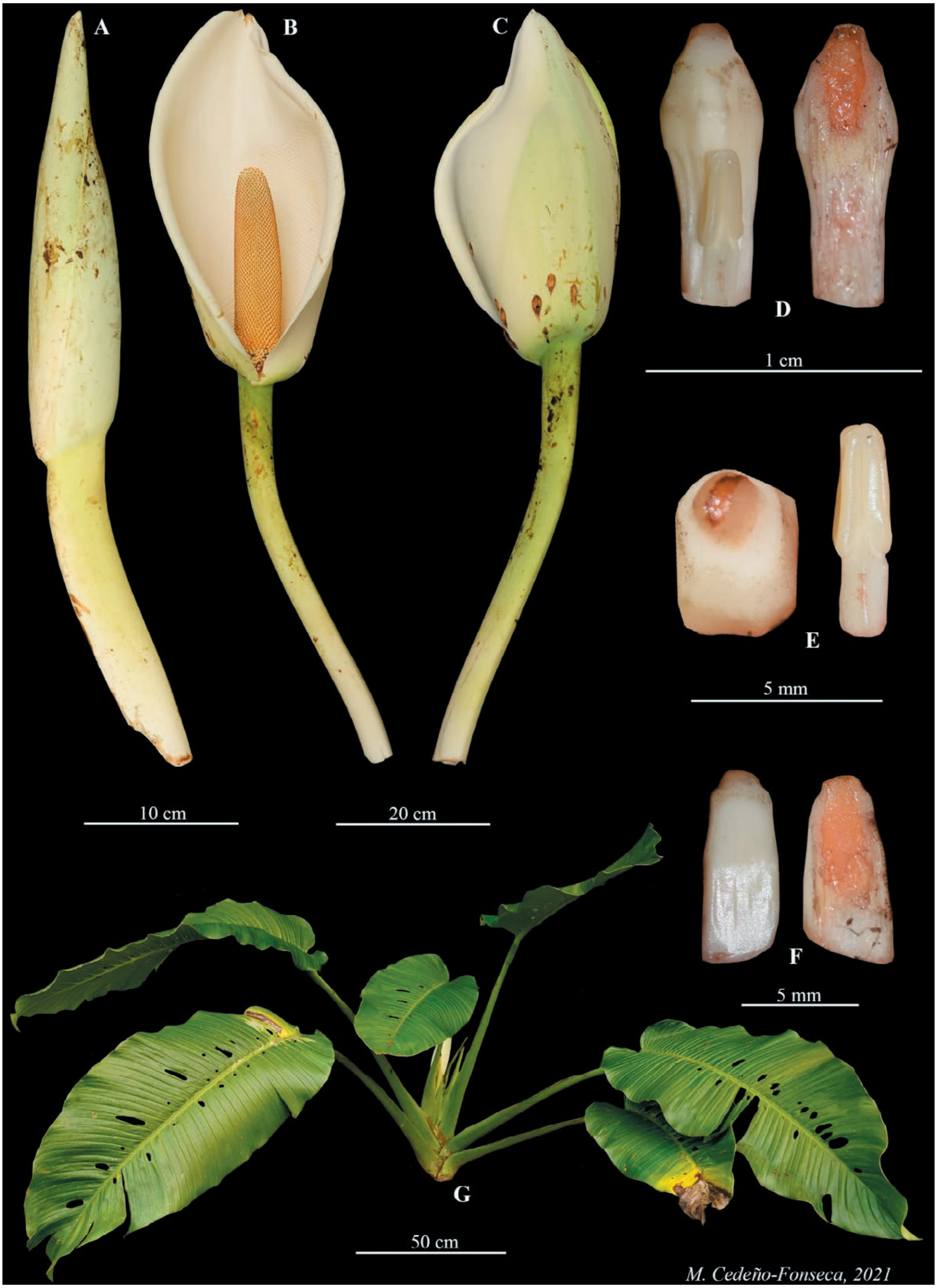

Figure 8. *Monstera titanum*. **A.** Developing inflorescence. **B & C.** Front and back views of open inflorescence. **D.** Fertile flower in lateral view (left) and longitudinal section (right). **E.** Stylar plate, top view (left), and individual stamen (right). **F.** Sterile flower in lateral view (left) and longitudinal section (right). **G.** Adult plant. Photos by Marco Cedeño-Fonseca *(M. Cedeño et al. 2385)*.

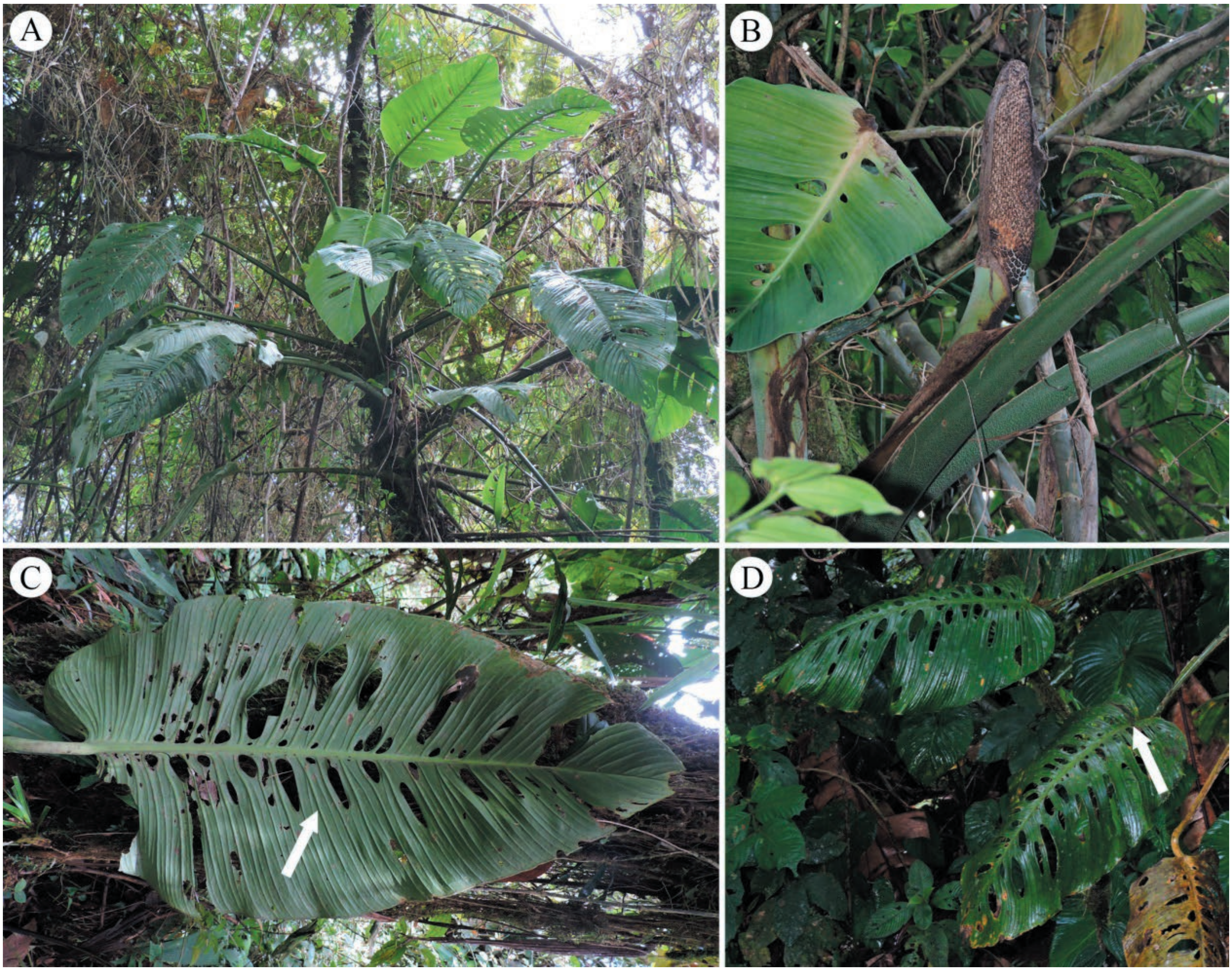

Figure 9. *Monstera titanum*. **A.** Adult plant. **B.** Immature infructescence, with marcescent spathe. **C.** Adult leaf-blade (with arrow indicating primary lateral veins departing the midrib at 75–95°). **D.** Adult leaf-blades (with arrow indicating subcordate base). Photos by Marco Cedeño-Fonseca.

Etymology

The species epithet, conveying enormous size, is from the greek 'titanikos' itself drawn from the Titans, the race of giant ancient Greek gods. It alludes to the huge size of the inflorescence, the largest known in the genus.

Distribution and habitat

Monstera titanum is endemic to Panama, where it is known from the type locality on Altos del Maria, Valle of Anton, and the border of Chiriquí and Bocas del Toro Provinces, at 1450–1480 m elevation in the *Premontane rain forest* life zone.

Phenology

Flowering has been recorded in January, March and July, and fruiting in March and November.

Conservation status

Monstera titanum should be considered as data deficient (DD).

Notes

This species is characterized by its juvenile plants with narrowly ovate, often perforated leaves and adult plants growing as nomadic vines with an appressed-climbing habit, stems with short internodes, densely speckled, fully sheathed petioles with a sharply sulcate geniculum, large, narrowly ovate-elliptic, subcordate leaf-blades with two rows of small elliptic fenestrations on both sides and drying pale greenish yellow-brown on the lower surface. The inflorescence is remarkable for its extraordinary size, with the peduncle and whitish, long-

Figure 10. *Monstera titanum*. Orlando Ortiz (left) with a leaf up to 1.90 m of length, Michael Mittermeier (center) with a inflorescence up to 95 cm of length, and Marco Cedeño (right) with a leaf up to 2.50 m of length. Photos by Esteban Jiménez.

acuminate spathe each up to almost half a meter long in very robust individuals. The spadix was often found eaten by beetles but with the spathe still intact. This is unusual as typically the spathes are much more ephemeral than the spadices. *Monstera titanum* is similar to *M. alfaroi* Croat & M.Cedeño (Cedeño et al., 2020e), but differs in having smooth, light green and white-spotted petioles (vs. black-warty, light green and light brown petioles), cordate leaf-blades (vs. rounded at base), and smooth (vs. warty) peduncles.

Additional specimens examined (paratypes)

PANAMA: **Bocas del Toro,** Cerro Colorado, 9.2 miles W of Chamé; along trail E of road which leads down to stream, 1450–1480 m, *Croat 69033* (MO); Cerro Colorado, along road between Río San Felix and mining exploration camp, 7 mi W of Chamé, along trail through Guaymí village, 1500 m, *Croat 69190* (MO); Bocas del Toro–Chiriquí border, Fortuna Dam region, along continental divide trail, 1200 m, *McPherson 13548* (G, MO, NY). **Chiriquí,** Cerro Colorado, along mining road, 31.6 km beyond bridge over Río San Félix (10.6 km beyond turnoff to Escopeta), 1690 m, *Croat 37178* (MO); Fortuna, Hornito, Along the road to the Fortuna Dam site, N of Gualaca, 22.7 mi beyond the bridge over the Río Estí, 11.8 mi N of Los Planes de Hornito, 10.7 mi N of jct. to tunnel, 1400 m, *Croat 48691* (MO); Along road between Fortuna Lake and Chiriquí Grande; 4.5–5 km N of dam over Fortuna Lake, 1100–1135 m, *Croat 60003* (MO); Cerro Colorado, along road to old copper mine development N of San Félix, 18.6 mi N of bridge over river near San Félix, 6.6 mi beyond Chamé and road to Escopeta, 1475–1485 m, *Croat 75008* (MO); Cerro Colorado, along road to copper mine development N of San Félix, 20.5 mi N of the bridge near San Félix, 8.3 mi beyond Chamé and turnoff to Escopeta, 1630 m, *Croat 75026* (MO); Gualaca, Reserva Forestal Fortuna. División Continental, 1154 m, *Ortiz et al. 1809* (PMA, MO); Gualaca, Corregimiento Hornito, Reserva Forestal Fortuna, senderos cerca al centro de investigaciones Jorge L. Arauz, 1200–1500 m, *Zuluaga 914* (PMA, MO, WIS); Ngäbe-Buglé (Bocas del Toro): Cerro Colorado, 9.2 mi W of Chamé, along trail E of road which leads down to a stream, 1450–1480 m, 6 Jul 1988, *T.B. Croat 69012* (MO, PMA); Chiriquí, Gualaca, Hornito. Fortuna, camino a Chiriquí Grande, 1230 m, *Cedeño et al. 2329* (PAM, USJ).

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Lectotypification of five names in the genus *Blumea* (Asteraceae)

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Abstract. The lectotypification of five names in the genus *Blumea* (Asteracea): *Blumea glomerata* DC., *B. pterodonta* DC., *B. hamiltonii* DC., *Blumea arenaria* DC. and *Blumea virens* DC., is discussed and lectotypes designated.

Keywords: Asteraceae, Blumea, Nomenclature, Taxonomy.

INTRODUCTION

The genus *Blumea* DC. (1833: 514) (Asteraceae) consists of about 100 species worldwide (Pornpongrungrueng *et al*., 2016). This genus is one of the largest in the tribe Inuleae and its highest diversity is seen in Tropical Asia (Anderberg, 1991). A total of 36 taxa are present in India (Hooker 1882; Hajra et al. 1995).

As part of the taxonomic studies of the genus *Blumea*, the authors studied relevant literature and critically examined specimens in different herbaria. During this we found that some names need typification. Hence we lectotypified five names viz, *Blumea glomerata* DC., *B. pterodonta* DC., *B. hamiltonii* DC., *Blumea arenaria* DC. and *Blumea virens* DC. according to article 9.3 of Schenzen code (Turland et al. 2018).

Blumea glomerata DC. in Wight (1834: 150)

Type: India, Negapatam (K barcode K000978451, digital image!) lectotype here designated; isolectotype (K barcode K000978450, digital image!), NY (barcode 02201069, digital image!), E (barcode E00417373, digital image!), P (barcode P00692160, P00692161), Figure 1.

This species was first described by De Candolle (1834:15) in Wight's Contribution of India. He cited the collection locality as "In arenosis maritimis circa Madras et Negapatam. Ad Montes Circars'. De Candolle's description was based on one collection of Wight (Herb. Wight propr. 1434) and specimens of

Figure 1. Lectotype of *Blumea glomerata* (K000978451). © Copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

Heyne and Roxburgh; Wallich 3055 is also cited under the name *Conyza glomerata*, a nomen nudum based on specimens from Prome, Amherst & Moalmyne and Nepalis. These all are syntypes according to article 9.6 of Shenzhen code. Pornpongrungrueng (2016) in her revision of the genus Blumea DC. in continental South East Asia cited a holotype at Kew (Wight 1434). She incorrectly cited the type locality as Myanmar, Prome and cited only one specimen. The use of the term holotype is not correct because three (or possibly six) syntypes were cited in the protologue. The term holotype is not correctable to lectotype because of the absence of a designating statement (Art.7.11). So Pornporngruengs citation cannot be counted as an effective lectotypification.

Blumea pterodonta DC. in Wight (1834: 16)

Type: India: Peninsula Indiae Orientalis, “Ad littora maris, locis arenosis magis in Coromandelia frequens”, Herb. Wight propr. 1437 (E barcode E00413688!, digital image!) lectotype here designated. Figure 2.

This species was first described by De Candolle (1834: 15) in Wight’s Contribution of India. De Candolle used Herb. Wight propr. 1437 for describing this species. As a result of thorough searching in different herbaria we traced two sheets in K (barcodes K000974743!, K000974744!), one each at E (barcode E00413688!) and P (barcode P01816053!). According to Art.9.6 of Shenzhen code these are all syntypes. The sheet in E bears an annotation of De Candolle’s Peninsula India Orientalis with a hand written annotation about the species and bears all characters and agrees well with the protologue. It qualifies to be designated as the lectotype of *Blumea pterodonta*.

Blumea hamiltonii DC. (1836: 439)

Type: lectotype, Step I. Randeria (1960: 249). Step II.: India (K barcode K000978436, digital image!) lectotype here designated; isolectotypes (K barcode K001118229, K001118230, K000974837, K001118231, K000978438, K000978439, K0009978440, digital images!). Figure 3.

This species was described by De Candolle (1836: 439). De Candolle used Wallich’s specimens for describing this species. Randeria (1960) in revisionary studies mentioned its type material as 3938/48 of Wallich in Kew. The protologue reads “in India or. ad Kamaon, ad Sukonaghur, ad Koemari legit cl. Hamilton. Conyza necessaria Ham.! Herb. Gnaphalium Hamiltoni Wall.! cat. n. 3938 comp. n. 48”. In Wallich’s Numerical list (1829-1849), cat. n. 3938 is Stemodia gratioloides Benth. and cat. n. of Gnaphalium hamiltonii is 2938. So, in protologue it must be a typographical error. There are four sheets of Wallich 2938 in Kew with different barcode numbers. But Randeria did not make a precise indication regarding which specimen could be treated as type and no particular notes is present in any of the sheets. In all the sheets atleast 4 specimens are mounted. Randeria’s determinavit label is found in 2 sheets. So, Randeria’s typification can be treated as effective first step lectotypification (Art. 7.11 of the ICN). Based on accurate state of preservation and accurate matching with the protologue, the specimen K000978436 is selected here as the lectotype. Other specimens belonging to the original material should be treated as isolectotypes.

Blumea arenaria DC in Wight (1834: 13)

Type: India “in arenosis proper Negapatam”, Wight 1422 (K barcode K000978497, digital image!) lectotype here designated; isolectotype (K barcode K000978496, digital image!). Figure 4.

This species was described by De Candolle (1834: 13). Giri and Mitra (1984:143) created a new combination (Blumea obliqua (Linn.) Druce var arenaria (DC) Giri et B. Mitra) using this name. They also cited type material of *Blumea arenaria* as Wight 1421 (K). As Giri and Mitra (1984:143) did not do any lectotypification by citing the single specimen mentioned, their reference is not considered as lectotypification. Currently there are two specimens at Kew belonging to Wight 1421 with different barcode numbers (K000978496 and K000978497) and also we traced Wight 1421 sheets from E and G. An effective lectotypification is needed in order to narrow down Giri & Mitra’s to a single specimen (Art. 9.6 of the ICN). Hence, we select the sheet K000978497 as the lectotype of *Blumea arenaria* because it exactly matches with the protologue.

Blumea virens DC. in Wight (1834: 14)

Type: lectotype, Step I. Randeria (1960:272). Step II.: India, Negapatam (E, barcode E00417360, digital image!) lectotype here designated; isolectotype (E barcode E00417361, digital image!). Figure 5.

This species was described by De Candolle (1834: 14). Randeria (1960) in revisionary studies of the genus

Figure 2. Lectotype of *Blumea pterodonta* (E00413688). © Copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

Figure 3. Lectotype of *Blumea hamiltonii* (K000978436). © Copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

Figure 4. Lectotype of *Blumea arenaria* (K000978497). © Copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

Figure 5. Lectotype of *Blumea virens* (E00417360). © Copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

Blumea cited type specimen as Wight 1430 (E). We traced two sheets from Royal Botanic Garden Edinburgh (E) of Wight's 1430 with different Barcode numbers. Both the sheets have isosyntype labels. One of the sheets has two *Blumea virens* specimens, but one is a collection of Stocks and Laws. Therefore, Randeria's typification can be treated as effective first step lectotypification (Art. 7.11 of the ICN). In order to narrow the type down to a single specimen second step lectotypification is needed. Therefore the sheet E00417360 is selected here as the second step lectotype. The selected sheet bears a complete and well preserved specimen.

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On the status of the genus *Hybochilus*, with a new combination in *Leochilus* (Orchidaceae: Oncidiinae)

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Abstract. The name *Rodriguezia inconspicua*, proposed as a replacement name for *Trichocentrum candidum*, is a homotypic synonym of the latter, as well as the new combinations based on the same name. The genus *Hybochilus*, typified by *Rodriguezia inconspicua*, is reduced into synonymy under *Trichocentrum*. A new combination, *Leochilus candelariae*, is proposed to accommodate the species from Costa Rica. *Rodriguezia candelariae* is typified.

Keywords: *Leochilus candelariae*, nomenclature, *Rodriguezia candelariae, Trichocentrum*, taxonomy, typification.

INTRODUCTION

When working at the index cards included in Epidendra, the taxonomic database created and maintained by Lankester Botanical at the University of Costa Rica (2021), we continuously revise original protologues and other materials associated with nomenclatorial types. This not only provides us with a better understanding of taxonomic concepts, but also gives us the opportunity to check for their agreement with the provisions of the International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2018, "the Code" hereafter), and therefore for their legitimacy. This frequently led us to find taxonomic errors, discrepancies, and inconsistencies in the original material and subsequent names and synonyms based on misinterpreted types. The following account deals with the taxonomic status of *Hybochilus* Schltr., and the nomenclature of a species in the genus *Leochilus* Knowles & Westc.

Kränzlin (1895) published *Rodriguezia inconspicua* Kraenzl. based on a specimen he received from the Swiss botanist and entomologist Eugène John Benjamin Autran (1855–1912), at that time the curator of the Boissier Herbarium in Geneva. The herbarium hosted a large number of orchid specimens prepared from the impressive Barbey-Boissier living collections, where 772 species and 62 varieties of living orchids, belonging to 122 genera, had been accessed until 1895 (Autran and Durand 1896). Autran was in charge of the orchid identification, and he maintained scientific contacts with other European specialists, like Schlechter and Kränzlin in Berlin, and Cogniaux in Brussels, to whom he regularly sent botanical samples of orchids for study (Pupulin et al. 2016). Among the collections received at Chambésy were the plants that the Swiss Jean François Adolphe Tonduz (1862–1921) sent from Costa Rica, several of which were described in the *Bulletin de l'Herbier Boissier*, of which Autran himself was the editor. The specimen on which Kränzlin (1895) prepared his description of *R. inconspicua* was originally collected in Costa Rica by Tonduz, qualified as the "Head of the Botanical Institute" (Kränzlin 1895), without specific locality, and grown in the greenhouse of Mme. Barbey at Chambésy (Pupulin et al. 2016). The collections of the Natural Department at the National Museum of Costa Rica host another specimen arguably prepared from the same collection by Tonduz and received from the Herbier Boissier, where it was prepared in 1897 from a plant grown in the nursery of Chambésy, but also this sheet bears no specific geographic data.

Kränzlin received this small-flowered specimen of Oncidiinae and erroneously believed that it corresponded to *Trichocentrum candidum*, a species described almost sixty years before by John Lindley (1843). He expressly based his *nomen novum* on that species, in the belief that the epithet "candidum" could not be maintained in *Rodriguezia* Ruiz & Pav., being predated by the previous *R. candida* Bateman ex Lindl. (Kränzlin 1895). That name, however, was not validly published until 1991 (Christenson 1991) because Lindley (1837) only noted that *R. candida* was the name suggested by Bateman in their correspondence for the species he eventually described as *Burlingtonia candida*. Probably, Kränzlin never studied the type of *T. candidum* in the herbarium of Lindley at Kew (where he could have observed the different habit of the plant, the very different inflorescences, as well as the flower almost ten times larger than those of the specimen collected by Tonduz), but simply relied on a copy of Lindley's analytical drawing of the flower, made by Reichenbach and kept in his orchid herbarium, now at the Naturhistorisches Museums in Vienna. The similarities between the drawing made by Lindley and that prepared by Kränzlin based on *Tonduz s.n.* (G 00168703, erroneously annotated as a holotype) (Figure 1) are superficial at most (Chase 1987, Pupulin 1995), but the comparison of the drawings convinced Kränzlin that *T. candidum* had all the features of a miniature *Rodriguezia* and that transferring it to that genus would have made *Trichocentrum* Poepp. & Endl. more natural (Kränzlin 1895).

While it is true that Kränzlin intended to give the species a new name, he did not designate a new type (Chase 1987). According to the Code (art. 6.11 and 7.4), a replacement name (avowed substitute, *nomen novum, nom. nov.*) is typified by the type of the replaced synonym, even though it may have been misapplied to a taxon considered not to include that type (Turland *et al.* 2018). It is worthy to note that, even in the case when *Rodriguezia inconspicua* was proposed with a different type, the citation of *Trichocentrum candidum* as a synonym would have had the effect to invalidate the name according to Art. 36.1 of the Code: "A name is not validly published (a) when it is not accepted by the author in the original publication […]" (Turland et al. 2018).

TAXONOMIC TREATMENT

As Schlechter (1920) selected *Rodriguezia inconspicua*, a synonym of *Trichocentrum candidum,* as the *typus generis* of his *Hybochilus*, the latter genus must be reduced under the synonymy of *Trichocentrum* Poepp. & Endl.:

Trichocentrum Poepp. & Endl., Nov. Gen. Sp. Pl. 2: 11, pl. 115. 1836

Type: *Trichocentrum pulchrum* Poepp. & Endl. (1836).

(=) *Hybochilus* Schltr., Repert. Spec. Nov. Regni Veg. 16(468/473): 429-430. 1920, **syn. nov.**
Type: *Hybochilus inconspicuus* (Kraenzl.) Schltr. (1920).
Bas. *Rodriguezia inconspicua* Kraenzl., Bull. Herb. Boissier 3(12): 630-631. 1895, **nom. nov.**; replaced syn.: *Trichocentrum candidum* Lindl.

Both *Hybochilus inconspicuus* and *Leochilus inconspicuus* (Kraenzl.) M.W.Chase & N.H.Williams, being based on an avowed substitute for *Trichocentrum candidum*, are typified by the type of the older name (Art. 7.4, Turland *et al.* 2018) and have therefore to be reduced under its synonymy:

Trichocentrum candidum Lindl., Edwards's Bot. Reg. 29: Misc. 9. 1843.

Type: Guatemala. Without specific locality, *G. Skinner s.n.* (holotype, K-L).

(=) *Rodriguezia inconspicua* Kraenzl., Bull. Herb. Boissier 3(12): 630-631. 1895, *nom. nov.*

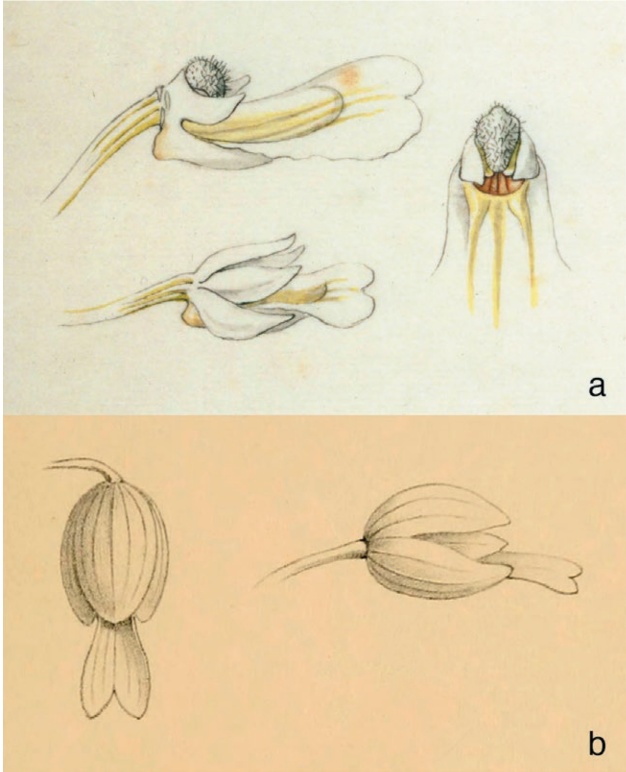

Figure 1. Comparison between the drawing made by Lindley of a flower from the holotype of *Trichocentrum candidum* (**a**) and the sketch of a flower made by Kränzlin from his *Rodriguezia inconspicua* (**b**).

(≡) *Hybochilus inconspicuuus* (Kraenzl.) Schltr., Repert. Spec. Nov. Regni Veg. 16(468/473): 430. 1920, **syn. nov.**
(≡) *Leochilus inconspicuus* (Kraenzl.) M.W.Chase & N.H.Williams, Lindleyana 21(3): 21. 2008, **syn. nov.**

According to the phylogenetic analyses of the Oncidiinae carried out by Neubig et al. (2012), *Hybochilus* belongs to a large clade of Neotropical epiphytic orchids, mostly characterized by their ecological preference for the outermost branches of the tree canopies, and which are also known as "twig epiphytes". It is a morphologically quite diverse group, but most genera in the clade developed floral structures specialized to attract pollinators luring for nectar. The sampled species of *Hybochilus* and *Leochilus* cluster into a relatively basal subclade of the "Rodriguezia clade", sister to *Plectrophora* Focke and *Tolumnia* Raf., and consecutively sister to *Rodriguezia* (Neubig et al. 2012). Species of *Leochilus* and *Hybochilus*, as well as *Goniochilus* M.W.Chase, share the presence of a shallow, open nectar cavity at the base of the lip, which attracts short-tongued polybiine wasps and halictid bees (Chase 1986a). Likely, species in the group are maintained genetically isolated by the different size of the pollinators that can slide under the column to reach the nectary (Chase 1986b, 2009). On this ground, Chase *et al.* (2008) adopted a broad circumscription of *Leochilus*, reducing under its synonymy the monotypic genera *Hybochilus* and *Goniochilus*, and proposing the respective new combinations at the specific rank.

The structural similarities between *Hybochilus* and *Leochilus* were already noted by Standley and Williams (1951). In their description of *Leochilus parviflorus* Standl. & L.O.Williams [the type: Costa Rica. Alajuela. Alajuela, Carrizal, alt. 1500 m., Mar. 12, 1950, *J. León 2325* (holotype, US; isotypes, CR, MO)], which is another name for the same species that Kränzlin mistaken for a *Rodriguezia* and erroneously renamed *R. inconspicua*, the authors compared it with *Leochilus gracilis* Schltr., a synonym of the widespread *L. labiatus* (Sw.) Kuntze (Chase 1986b).

Leochilus Knowles & Westc., Floral Cabinet 2: 143. 1838

Type: *Leochilus oncidioides* Knowles & Westc., Floral Cabinet 2: 143. 1838

Leochilus candelariae (Kraenzl.) Pupulin, **comb. nov.**

Bas.: *Rodriguezia candelariae* Kraenzl., Bot. Jahrb. Syst. 54 (Beibl. 117): 33. 1916.
Type: Costa Rica. [San José: Caraigres,] Candelaria-Gebirge [Cerros de Candelaria], Blühend im Februar, *K. Hoffmann s.n.* [holotype B, destroyed]. Neotype (designated here): Costa Rica. (Alajuela: San Ramón.) Arbres des pâturages à Naranjo de Alajuela. Alt. 960 m. IV-1921. Fl. rouge et bl., *A. M. Brenes 11* (CR 25895)]. Figure 2.

DISCUSSION

Kränzlin described *Rodriguezia candelariae* from a specimen collected in Costa Rica by the German medical doctor Karl Hoffmann (1833–1859), who explored the country and collected botanical specimens mainly between 1845 and 1857. Hoffmann's primary collection was sent to Prof. Klotzsch in Berlin, where they were studied by Reichenbach (1866) and Kränzlin. Duplicates were distributed to the herbaria of the British Museum in London, Copenhagen, Kew, Leiden, and Vienna. According to the records of B, where the types of the orchid species described by Kränzlin should be primar-

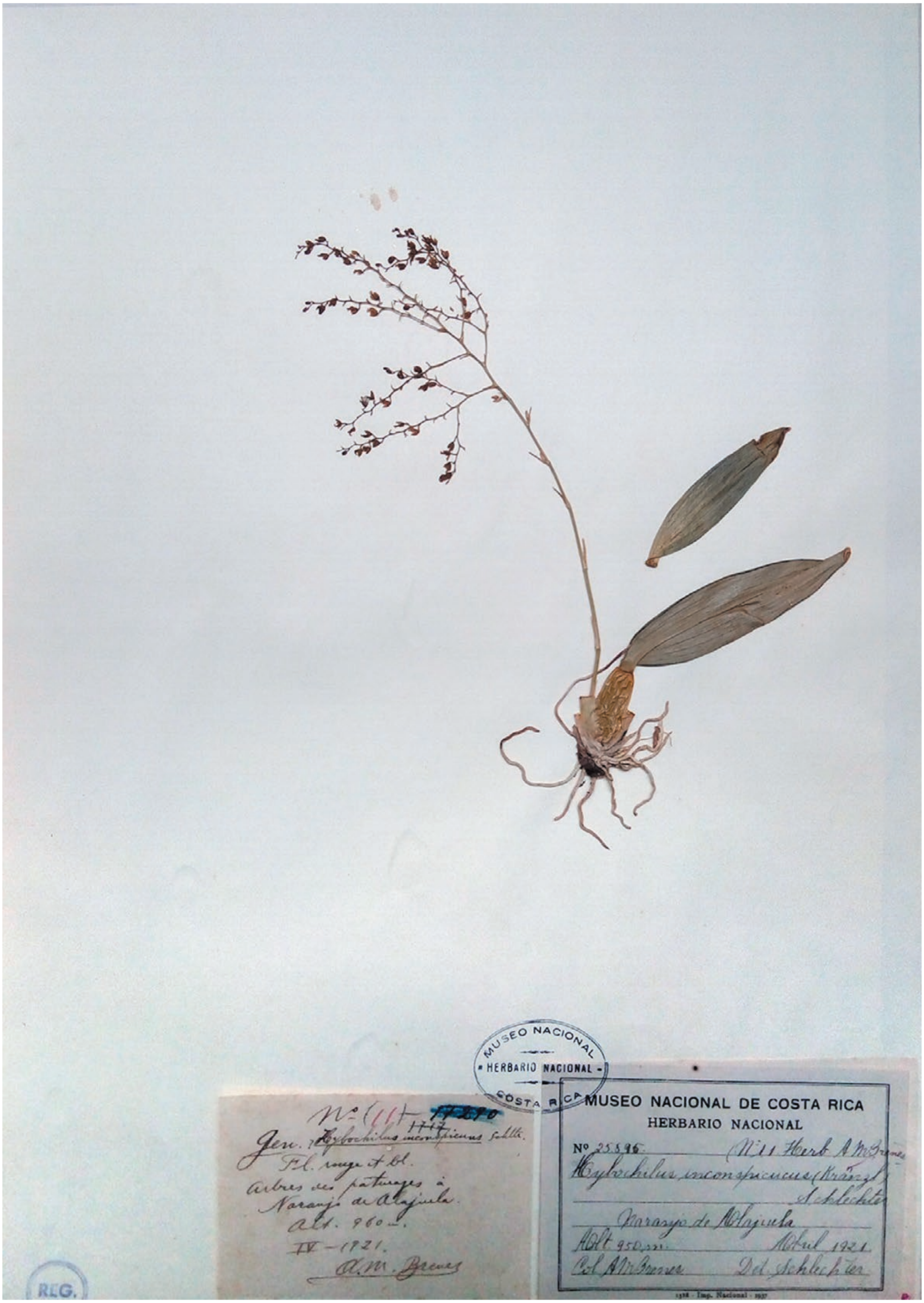

Figure 2. Neotype of *Leochilus candelariae* (CR 25895). (With the permission of the Curator of the National Herbarium, National Museum of Costa Rica).

ily searched for, no specimens of Orchidaceae collected by Hoffmann are conserved. Searches at BM, C, K, L, and W were also unsuccessful.

A relatively widespread species in Costa Rica, where populations can be found on both sides of the continental divide at 900–1500 m elevation, *R. candelariae* is here neotypified based on a collection by the Costa Rican naturalist and botanist Manuel Alberto Brenes (1870–1948). The specimen selected as the neotype is complete and fertile, and well-representative of the species.

All the relevant documentation of *R. inconspicua*, as well as the homotypic and heterotypic synonyms treated in this paper, may be found at the Epidendra webpage (University of Costa Rica 2021) (http://www.epidendra.com/taxones/Trichocentrum/Trichocentrum%20candidum/Rodriguezia%20inconspicua/index.html).

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Wood micro-morphological characteristics of the Tribe Dalbergieae in Nigeria

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Abstract. The present study examined the wood micro-characters of 18 species of the tribe Dalbergieae across 4 genera in Nigeria, following previously described methods by other authors. The species are distributed across all geo-ecological zones of the country but more abundant in the southern area which is characterized by higher precipitation. Findings clearly showed that members of the tribe Dalbergieae have more generic/tribal characteristics than delimiting characters. The species have certain unifying characters such as diffuse pore porosity, simple perforation plates, oblique to orthogonal vessel transverse wall inclination, prismatic/styloid crystals, and non-septate fibres. Vessels were longest and widest in *D. saxatilis*, about 197.89x104.23µm. On the contrary, the shortest was observed in *D. hostilis* - 67.62 µm while the narrowest was in *D. oligophylla* (28.4 µm). While fibre length was highest in *P. mildbraedii* (331.22 µm±7.5) and smallest in *D. saxatilis* (0.69 µm±0.0), the ray cells were longest in *D. saxatilis* (185µm) and shortest in *P. santalinoides* (41.82µm) respectively. We confirm here that anatomical studies should not be neglected in plant systematics, even though molecular approaches have been the focus in recent times.

Keywords: Dalbergieae, ecology, taxonomy, Nigeria, wood anatomy.

INTRODUCTION

The family Papilionaceae comprises 470 genera and about 14,000 diverse species; and includes small herbs from temperate regions as well as large tropical rainforest trees (Wojciechowski 2003). Together with Caesalpinaceae and Mimosaceae, they form the legume family (Leguminosae), and constitute the third-largest land plant family after Orchidaceae and Asteraceae (Mabberley 1997; Lewis et al. 2005). The Legume Phylogeny Working Group - LPWG (2013) reported some early taxonomists like De Candolle (1825) and Bentham (1865) who had worked on this family as a result of its ecological and economical importance. To date, taxonomists have continued to work on this family and in a more recent work by LPWG (2017), six subfamilies were recognized namely: Caesalpinioideae, Cercidoideae, Detarioideae, Dialioideae, Duparquetioideae, and Papilionoideae (with 503 genera and approximately 14,000 species). Evidence from molecular studies confirms the monophyly of legumes and their closeness to the other members of Fabales, which include Polygalaceae, Surianaceae, and Quillajaceae (Lewis et al. 2005).

The tribe Dalbergieae is not a monophyletic clade and comprises 19 tropical woody genera (Polhill 1981; Lavin et al. 2001). It comprises trees, shrubs, and lianas (Gillett et al. 1971). According to Corby (1981) who was the first researcher to consider nodule morphology as a useful character in legume taxonomy, members of Dalbergieae tribe have unique root nodule morphology often referred to as an "Aeschynomenoid" or "Dalbergioid" nodule (Doyle et al. 2000; Kajita et al. 2001; Cardoso et al. 2013).Sprent and James (2007) had ealier noted that approximately 25% of legume species adapts to crack-entry; a characteristic feature for certain legumes from sub-tropical regions whuch belong to Dalbergioid/ Genistoid clades like species of *Aeschynomene, Arachis,* and *Stylosanthes*. As a result of direct access of rhizobia to the cells in the cortex, nodule primordial are developed and repeated cell division of infected cells forms aeschynomenoid nodules. Nevertheless, there are usually no uninfected cells present in the infected zone. Thus, in Aeschynomenoid nodules, the infected regions are always separated from uninfected cells (Fabre et al. 2015; Sharma et al. 2020).

In the work of Lavin et al. (2001), it was reported that within the Dalbergioid clade, there are three well-supported subclades marked as the *Adesmia*, *Dalbergia*, and *Pterocarpus* clades. Polhill (1981) noted that there appear to be two centres within the Dalbergieae: one around *Andira* with *Hymenolobium*, *Vatairea*, *Vataireopsis*, *Dalbergia*, and *Machaerium*; and another one around *Pterocarpus*. He highlighted evidence from wood anatomy (Baretta-Kuipers, 1981) which showed that *Andira*, *Hymenolobium*, *Vatairea*, and *Vataireopsis* have coarser wood structures more typical of members of the Sophoreae than the remaining members of the Dalbergieae. The study of fruit and seedling morphology by Lima (1990) further supported these two centres within the Dalbergieae: one including *Andira*, *Hymenolobium*, *Vatairea*, and *Vataireopsis*, and the second the remaining genera. Several recent molecular and morphological studies (Lavin et al. 2001; Pennington et al. 2001; Wojciechowski et al. 2004) confirm that these four genera do not belong in the Dalbergioid clade. In Nigeria, the tribe is represented by four genera viz: *Andira* Lam., *Dalbergia* L. f, *Machaerium* Pers. and *Pterocarpus* Jacq. (Soladoye and Lewis 2003). Generally, all the genera comprise species of great economic importance such as food, oils, fibre, fuel, timber, medicinal uses, amongst others (Wojciechowski 2003).

Herendeen and Miller (2000) had earlier emphasized the importance of wood taxonomy in the identification and classification of flowering plants. LPWG (2013) also reported that morphology can be incorporated into legume phylogeny to address issues in comparative biology and classification. This was reiterated by Maiti et al. (2016) who noted that in phylogenetic studies, the importance of the anatomical features of wood cannot be overemphasized. Given these submissions, only a few documented descriptions are available on the wood anatomical characteristics of African species including those of Leguminosae. Consequently, this study aimed at investigating the wood anatomy of members of the tribe Dalbegieae in Nigeria, in an attempt to identify additional diagnostic characters that could be used for their identification; as well as determining whether the variations in the wood anatomical characters of the members reflect the current circumscription of the tribe. Results obtained may also provide more information on the delimitation of members of this group.

MATERIALS AND METHODS

Species distribution

Preliminary species examination was done using previously deposited herbarium specimens at the Forest Herbarium Ibadan (FHI) and University of Ibadan Herbarium (UIH), both listed in Holmgren et al. (1990) from which useful ecological data were obtained and carefully recorded. Additional information was obtained from the Global Biodiversity Information Facility portal (GBIF.org). These were combined, carefully checked for duplicates using the Remove Duplicate tool implemented in Microsoft Excel© and thereafter used to generate a generic distributional map of the tribe Dalbergieae in Nigeria (Figure 1) using ArcMap version 10.3.1 (ESRI, Redlands, CA, USA).

Wood microscopic studies

Fresh wood samples used for this study were collected from the wild. It comprises 18 species as detailed in Table 1. Upon collection, specimens were carefully identified at the Forest Herbarium Ibadan (FHI). Small blocks of about 1cm^3 were obtained from the mature stem of each species; and boiled in water for about two hours to enhance softening of tissues. Three types of sections - transverse section (TS), tangential longitudinal section (TLS), and radial longitudinal section (RLS);

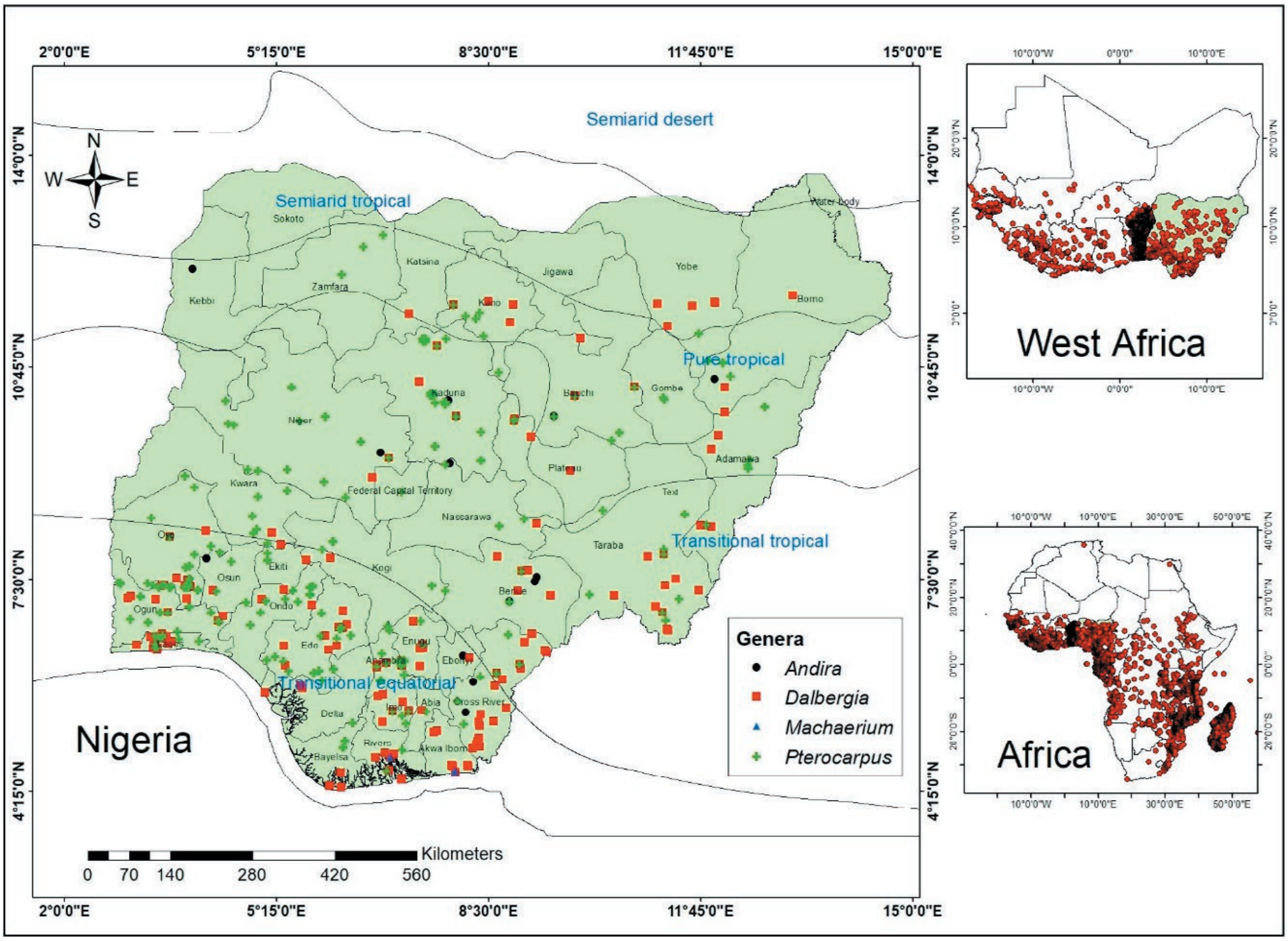

Figure 1. Distribution of Dalbergieae species in Nigeria.

all 10 µm thick were obtained with the aid of a sledge microtome, and thereafter preserved in 50% ethanol. The sections were stained with Safranin O and left for about three minutes, rinsed in clear water and counter-stained with Alcian blue, and also left for about three minutes before they were rinsed again in water. For dehydration and differentiation, the counter-stained sections were treated with series of ethanol - 50%, 70%, 80%, 90%, and 100% (absolute ethanol) respectively. For the removal of traces of water and ethanol, the differentiated sections passed through two series of absolute xylene.

For maceration of tissues, slices of each wood sample were put in a beaker containing Schulz's fluid (obtained by mixing equal volume of 10% chromic acid and 10% nitric acid as described by Ogbonnaya et al. (1997), Akinloye et al. (2012), and Oladipo and Oyaniran (2013). The macerated specimens were rinsed in water about five times and later preserved in 50% ethanol. They were then stained first with Safranin O, left for about three minutes; rinsed in water, and then counter-stained with Alcian blue, left for another three minutes, and then rinsed. They were also subjected to series of treatments in ethanol (50%, 70%, 80%, 90%, and 100%) for dehydration and differentiation.

All mounted slides were carefully studied under an Olympus© light microscope, while quantitative and qualitative data were observed and recorded accordingly. Some of the quantitative data include pore diameter, pore per square, ray height, ray width, fibre length, fibre width, fibre lumen, fibre wall thickness, vessel length, and vessel width. All microscopic measurements were taken with the aid of ocular and stage micrometers. Qualitative data include pore shape, dominant vessel type, inclination, type of axial parenchyma amongst others. Photomicrographs of all slides were also taken using a Sony digital camera mounted on the microscope. All terminologies used for the description of microscopic features follow the International Association of Wood Anatomists' list of microscopic features for hardwood identification (IAWA Committee 1989).

Table 1. List of Dalbergieae species studied.

S/n	Species	Habit	**Location**
1.	*Andira inermis* (W.Wright.) Kunth ex DC	Tree	Ago-Are, Oyo State
2.	*Dalbergia albiflora* A. Chev. ex Hutch. & Dalziel	Shrub	Calabar, Cross River State
3.	*Dalbergia ecastaphyllum* (L.) Taub.	Shrub	Lagoon Front, UNILAG
4.	*Dalbergia hostilis* Benth.	Shrub/small tree	Obudu, Cross River State
5.	*Dalbergia lactea* Vatke	Shrub	New Bussa, Niger State
6.	*Dalbergia latifolia* Roxb.	Tree	Ibadan, Oyo State
7.	*Dalbergia melanoxylon* Guill. & Perr.	Tree	Bauchi
8.	*Dalbergia oligophylla* Bak. ex Hutch. & Dalz.	Shrub	Obudu Cattle Ranch, Cross River State
9.	*Dalbergia rufa* G. Don	Shrub/liana	Ibadan
10.	*Dalbergia saxatilis* Benth.	Shrub	Efon-Alaye, Ekiti State
11.	*Dalbergia sissoo* Roxb. ex DC.	Tree	Ibadan, Oyo State
12.	*Machaerium lunatum* (L.f.) Ducke	Shrub/small tree	Okitipupa, Ondo State
13.	*Pterocarpus erinaceus* Poir.	Tree	Olokemeji, Ogun state
14.	*Pterocarpus lucens* Lepr. ex Guill. et Perrott.	Shrub	Mokwa road, Niger State
15.	*Pterocarpus mildbraedii* Harms	Tree	FRIN Premises, Ibadan
16.	*Pterocarpus osun* Craib	Tree	Ibadan, Oyo State
17.	*Pterocarpus santalinoides* L'Hérit. ex DC	Tree	Olokemeji, Ogun state
18.	*Pterocarpus soyauxii* Taub.	Tree	Umuahia, Abia State

Data analysis

All quantitative data were subjected to multivariate analyses using PAlaeontological STatistics version 4.02 (PAST; Hammer et al. 2001).

RESULTS

The preliminary diversity studies showed that members of the tribe Dalbergieae are distributed across all the geo-ecological zones of Nigeria (Figure 1). Specifically, the transitional equatorial climatic zone of Nigeria appears to be the region of the widest distribution.

Qualitative and quantitative wood characteristics of the studied Dalbargieae species are presented in tables 2 and 3 respectively, while illustrations are presented in figures 2-5. Diffuse porosity, oblique to transverse vessel inclination, and simple perforation plates were observed in all the species, while the vessel pore was generally circular, oval, and short cylindrical in all but *P. mildbraedii* and *P. santalinoides*. Other variations in vessel pore observed were short rectangular, arc, polygonal and triangular types. The pitting of the vessel was commonly simple in all the species but also alternate in most of the species including *P. mildbraedii, P. santalinoides, P. erinaceus*, *D. albiflora, D. oligophylla, D. sissoo, Dalbergia lactea, D. ecastaphyllum*, *D. hostilis*, *D. lunatum*, *P. osun* and *D. latifolia;* and in addition, spiral in *D. latifolia* and *A. inermis*. Tyloses, which are outgrowths from adjacent ray or axial parenchyma cell through a pit in a vessel wall, were also seen in 13 of the species but absent in *P. santalinoides, D. melanoxylon*, *D. rufa*, *D. latifolia* and *M. lunatum*. Only *P. osun* had secretory ducts present; while ray type was mainly uniseriate, non-storied and heterogeneous (Table 2; Figures 2-4).

Fibres were generally non-septate and non-storied (Figure 5), with narrow walls about 1.0µm thick except in *D. saxatilis* (2.75 µm± 0.2); and large lumen with no pitting. Fibre length ranged between 0.69 µm±0.0 (*D. saxatilis*) and 331.22 µm±7.5 (*P. mildbraedii*) while lumen diameter was between 3.69 µm±0.1 (*D. oligophylla*) and 6.53 µm±0.1 (*P. soyauxii*) as shown in Table 3.

Pore diameter was generally small in all the species studied ranging from 0.04µm (in *M. lunatum* and *D. malanoxylon*) to 0.09µm (in *P. osun* and *P. souyauxii*). Ray cells observed were longer than wide, ray height measurements were between 41.82µm in *P. santalinoides* and 185µm in D*albergia saxatilis* while ray width measured between 4.33µm in *D. rufa* and 26.93µm in *D. saxatilis*. Vessel length measured after maceration was between 67.2µm in *D. hostilis* and 197.89 µm in D*albergia saxatilis*. However, the widest vessel was observed in *D. saxatilis* (104.23µm) while the least was seen in *D. oligophylla* (28.4µm), as noted in Table 3. Correlation coefficients of the examined wood characters are also presented in Table 4.

Further results as revealed through the dendrogram and scatter plot of species showed that there are three (3)

Table 2. Qualitative Wood Anatomical Characters of Some Members of the Tribe Dalbergieae.

Species	Porosity	Vessel pore shape	Perforation plate	Vessel inclination	Vessel pitting	Tylose	Secretory ducts	Axial parenchyma	Ray type	Crystal	Fibre
A. inermis	Diffuse	Circular, oval, short rectangular, short cylindrical to arc	Simple	Oblique to transverse	Simple, alternate and spiral	Present	Absent	Winged aliform, confluent, diffuse	Mainly multiseriate and biseriate, few uniseriate	Prismatic and styloid	Non-septate
D. albiflora	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Diffuse	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. ecastaphyllum	Diffuse	Circular, oval, short rectangular, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Absent	Absent	Diffuse in aggregate	Uniseriate, biseriate, multiseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. hostilis	Diffuse	Circular, oval, short rectangular, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. lactea	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Absent	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. latifolia	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple, alternate and spiral	Absent	Absent	Winged aliform confluent, diffuse	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. melanoxylon	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse		Absent	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. oligophylla	Diffuse	Circular, oval, short cylindrical, short rectangular to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. rufa	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple	Absent	Absent	Absent	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. saxatilis	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple	Present	Absent	Diffuse	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
D. sissoo	Diffuse	Circular, oval, short cylindrical, triangular to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
M. lunatum	Diffuse	Circular, oval, short rectangular, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Absent	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
P. erinaceus	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
P. lucens	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse		Present	Absent	Diffuse in aggregate	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate
P. mildbraedii	Diffuse	Circular, oval to arc	Simple	Oblique to transverse	Simple and alternate	Present	Absent	Diffuse in aggregates	Mainly uniseriate, non-storied and heterogeneous	Prismatic	Non-septate
P. osun	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse	Simple and alternate	Present	Present	Diffuse in aggregate	Heterogeneous	Prismatic and styloid	Non-septate
P. santalinoides	Diffuse	Circular, oval, short rectangular, arc to polygonal	Simple	Oblique to transverse	Simple and alternate	Absent	Absent	Paratracheal aliform confluent, diffuse	Mainly uniseriate, non-storied and heterogeneous	Styloid	Non-septate
P. soyauxii	Diffuse	Circular, oval, short cylindrical to arc	Simple	Oblique to transverse		Present	Absent	Aliform confluent,	Mainly uniseriate, non-storied and heterogeneous	Prismatic and styloid	Non-septate

Table 3. Quantitative wood anatomical characters of some members of the tribe Dalbergieae (Mean±S.E).

Species	PD	PPS	RH	RW	FL	FW	FLU	FWT	VL	VW
A. inermis	0.08±0.8	2.47±0.1	99.03±4.8	13.58±1.2	185.08±5.4	6.43±0.2	4.45±0.2	1±0	76.23±2.4	31.14±0.9
D. albiflora	0.06±0.6	3.57±0.2	55.75±2.1	5.47±0.2	165.8±3.5	6.33±0.1	5.07±0.7	0.99±0	77.24±2.7	29.64±1.0
D. ecastaphyllum	0.08±0.8	2.00±0.1	61.47±2.3	7.53±0.2	206.01±4.2	7.21±0.1	5.23±0.1	1±0	82.64±2.4	36.85±1.1
D. hostilis	0.06±0.6	2.4±0.1	58.9±2.3	5.08±0.1	231.7±4.5	6.69±0.1	4.69±0.1	1±0	67.62±1.8	30.67±0.8
D. lactea	0.07±0.9	1.78±0.1	67.03±2.3	5.7±0.2	199.59±6.6	7.51±0.2	5.44±0.2	1±0	84.11±3.1	35.84±1.2
D. latifolia	0.08±0.7	1.71±0.1	0	0	271.79±7.1	6.57±0.1	4.6±0.1	1±0	78.12±2.0	47.92±1.9
D. melanoxylon	0.04±0.4	9.42±0.5	43.88±1.8	5.21±0.2	183.64±3.7	6.44±0.1	4.42±0.1	1±0	76.17±2.9	35.32±1.0
D. oligophylla	0.06±0.6	2.64±0.1	104.74±5.3	7.7±0.3	150.98±4.1	5.67±0.1	3.69±0.1	1±0	73.53±2.2	28.4±0.7
D. rufa	0.06±0.5	3.35±0.2	49.29±2.1	4.33±0.1	166.41±4.7	6.63±0.1	4.55±0.1	1±0	105.42±4.8	31.83±0.9
D. saxatilis	0.06±3.7	3.2±0.2	185.13±12.6	26.93±8.8	0.69±0.0	10.2±0.2	4.69±0.4	2.75±0.2	197.89±8.1	104.23±3.7
D. sissoo	0.07±0.6	3.16±0.2	56.97±2.7	6.7±0.2	220.52±4.3	6.12±0.1	4.19±0.1	1±0	59.57±1.3	31.15±0.8
M. lunatum	0.04±0.3	3.23±0.1	57.7±1.9	4.56±0.1	247.33±8.6	7.34±0.2	5.21±0.2	1±0	91.65±3.2	39.15±1.5
P. erinaceus	0.08±1.2	3.66±0.2	59.56±2.7	4.6±0.1	297.64±7.1	6.83±0.1	4.84±0.1	1±0	86.2±1.2	56.74±1.6
P. lucens	0.07±0.6	5.22±0.2	46.92±2.3	5.46±0.2	213.31±4.5	7.65±0.1	5.66±0.1	1±0	72.37±1.9	30.07±1.0
P. mildbraedii	0.07±0.8	2.22±0.1	55.86±3.1	7.33±0.3	331.22±7.5	7.05±0.1	5.06±0.1	1.01±0	75.47±1.8	37.27±1.5
P. osun	0.09±0.9	2.02±0.1	0	0	274.95±9.5	6.4±0.1	4.4±0.1	1±0	82.84±2.6	37.95±1.1
P. santalinoides	0.08±1.1	3.58±0.2	41.82±1.6	4.78±0.1	262.84±5.5	7.29±0.1	5.6±0.1	1±0	83.04±1.7	47.29±1.1
P. soyauxii	0.09±0.9	2.88±0.1	48.77±2.3	6.9±0.2	259.86±5.3	8.56±0.1	6.53±0.1	1±0	90.76±2.5	54.15±2.7

Key: PD: Pore diameter; PPS – Pore per square; RH – Ray height; RW – Ray width; FL- Fibre length; FW – Fibre width; FLU – Fibre lumen; FWT – Fibre wall thickness; VL- Vessel length; VW – Vessel width. All measurements in μm.

Table 4. Pearson's correlation coefficients of the examined wood anatomical characters.

	PD	PPS	RH	RW	FL	FW	FLU	FWT	VL	VW
PD	1.00									
PPS	-0.515	1.00								
RH	-0.306	-0.028	1.00							
RW	-0.157	-0.006	**0.943***	1.00						
FL	0.461	-0.171	-0.779	-0.756	1.00					
FW	0.066	-0.039	0.527	0.665	-0.401	1.00				
FLU	0.330	-0.041	-0.168	-0.064	0.276	0.553	1.00			
FWT	-0.172	-0.008	0.772	**0.865***	-0.732	0.765	-0.082	1.00		
VL	-0.162	-0.034	0.694	0.778	-0.687	**0.805***	0.038	**0.940***	1.00	
VW	0.080	-0.048	0.563	0.685	-0.429	**0.826***	0.153	**0.880***	**0.890***	1.00

Key: PD: Pore diameter; PPS – Pore per square; RH – Ray height; RW – Ray width; FL- Fibre length; FW – Fibre width; FLU – Fibre lumen; FWT – Fibre wall thickness; VL- Vessel length; VW – Vessel width.

main clusters (Figure 6, 7). 7 species formed cluster 1, 10 species formed cluster 2, while *D. saxatilis* occupied an isolated position, thereby representing an outlier.

Similarity indices (euclidean distance) for the species of the tribe Dalbergiae based on the wood anatomical characters is shown in Table 5. The least coefficient was observed between *D. lactea* & *D. ecastaphyllum* (8.88), followed by *P. osun* & *D. latifolia* (11.48), and then *P. souyauxii* & *P. santalinoides* (13.09); while the highest was observed between *P. mildbraedii* & *D. saxatilis* (381.89). This was closely followed by *P. osun* & *D. saxatilis* (357.59), and *D. saxatilis* & *D. latifolia* (355.01) respectively. Interestingly, the dissimilarity coefficients between *D. saxatilis* and the remaining species were very high compared to other taxa when compared; and this observation is also in support of the illustrations on the dendrogram and scatter-plot of the species where it occupied isolated positions.

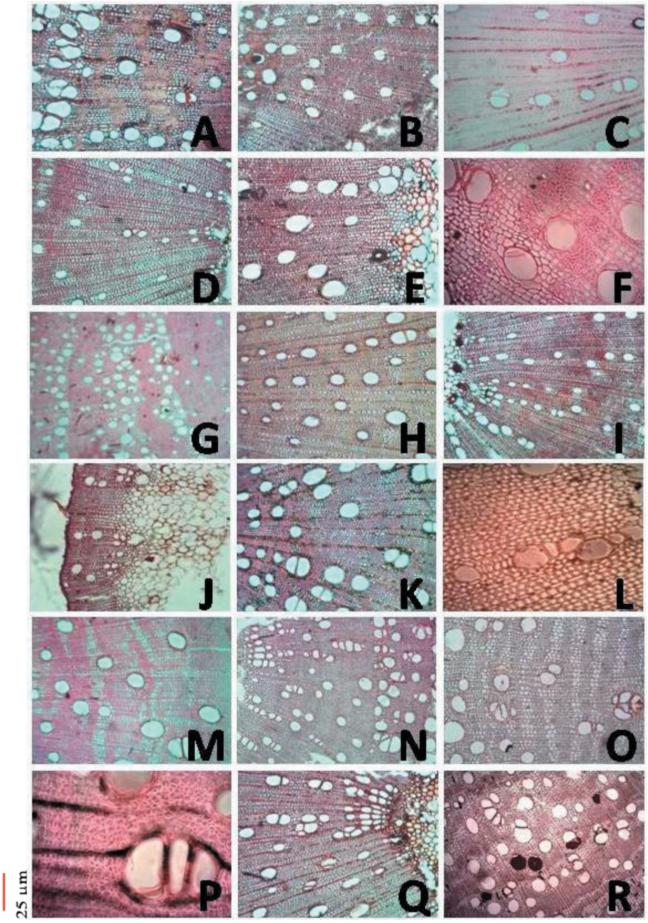

Figure 2. Transverse Sections (TS) of Dalbergieae species in Nigeria. Mg.*x400*. **A**- *Andira inermis;* **B**- *Dalbergia albiflora*; **C**- *Dalbergia ecastaphyllum*; **D**- *Dalbergia hostilis*; **E**-*Dalbergia lactea*; **F**-*Dalbergia latifolia*; **G**-*Dalbergia melanoxylon*; **H**-*Dalbergia oligophylla*; **I**-*Dalbergia rufa*; **J**-*Dalbergia saxatilis*; **K**-*Dalbergia sissoo*; **L**-*Machaerium lunatum*; **M**-*Pterocarpus erinaceus*; **N**-*Pterocarpus lucens*; **O**-*Pterocarpus mildbraedii;* ***P***-*Pterocarpus osun*; **Q**-*Pterocarpus santalinoides*; **R**-*Pterocarpus soyauxii*

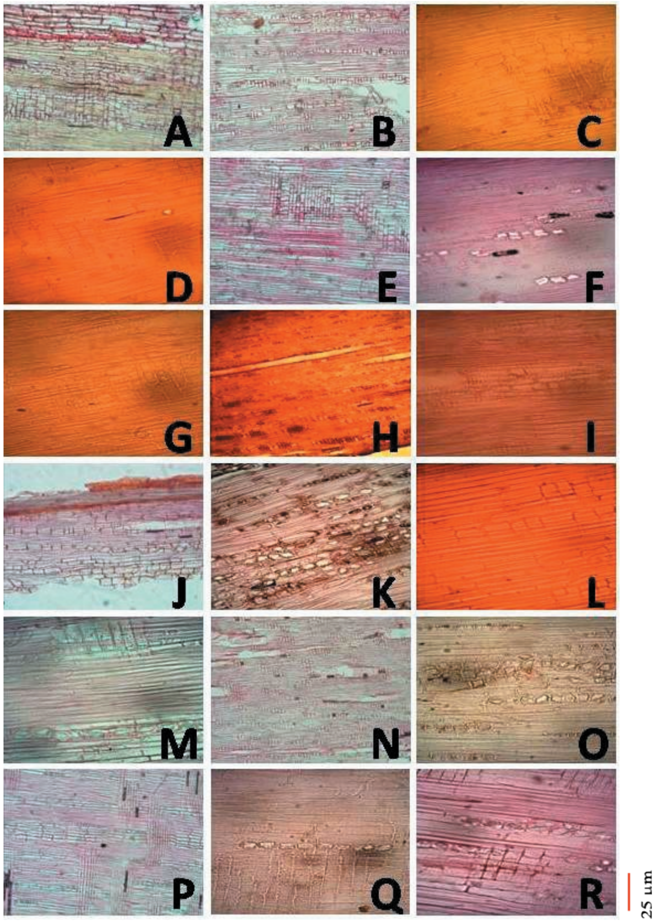

Figure 3. Radial Longitudinal Sections (RLS) of Dalbergieae species in Nigeria. Mg.*x400*. **A**- *Andira inermis;* **B**- *Dalbergia albiflora*; **C**- *Dalbergia ecastaphyllum*; **D**- *Dalbergia hostilis*; **E**-*Dalbergia lactea*; **F**-*Dalbergia latifolia*; **G**-*Dalbergia melanoxylon*; **H**-*Dalbergia oligophylla*; **I**-*Dalbergia rufa*; **J**-*Dalbergia saxatilis*; **K**-*Dalbergia sissoo*; **L**-*Machaerium lunatum*; **M**-*Pterocarpus erinaceus*; **N**-*Pterocarpus lucens*; **O**-*Pterocarpus mildbraedii;* ***P***-*Pterocarpus osun*; **Q**-*Pterocarpus santalinoides*; **R**-*Pterocarpus soyauxii*

DISCUSSION

Shreds of evidence from anatomical studies have been used for the delimitation of taxa as reported by Metcalfe and Chalk (1979); Aguoru and Okoli (2008), Arogundade and Adedeji (2019). Carlquist in 1961 had earlier submitted that wood anatomical characters are of taxonomic and phylogenetic importance, while more recently, Liu et al. (2020) noted that anatomical properties of wood relate closely to several factors amongst which is their genetic origin. In the current study, the wood anatomy of the 18 species of the tribe Dalbergieae studied provided more information on their taxonomic placement rather than characters that can be used for their delimitation. Generally, porosity is diffuse; perforation plate simple; tyloses present in all except *P. santalinoides, D. melanoxylon, D. rufa, D. ecastaphyllum, M. lunatum*, and *D. latifolia*; secretory ducts absent in all except *P. osun,* while fibre is non-septate in all the examined species. In furtherance, crystal is prismatic in *P. mildbraedii*, styloid in *P. santalinoides*, but a combination of both in the remaining 16 species studied. Vessel inclination is oblique to transverse while pitting is simple and alternately positioned. The presence of solitary vessels as also observed in this work is an indication of species primitiveness earlier reported by Oladipo and Oyaniran (2013).

Certain wood characters have more importance than others in the taxonomic understanding of the taxa stud-

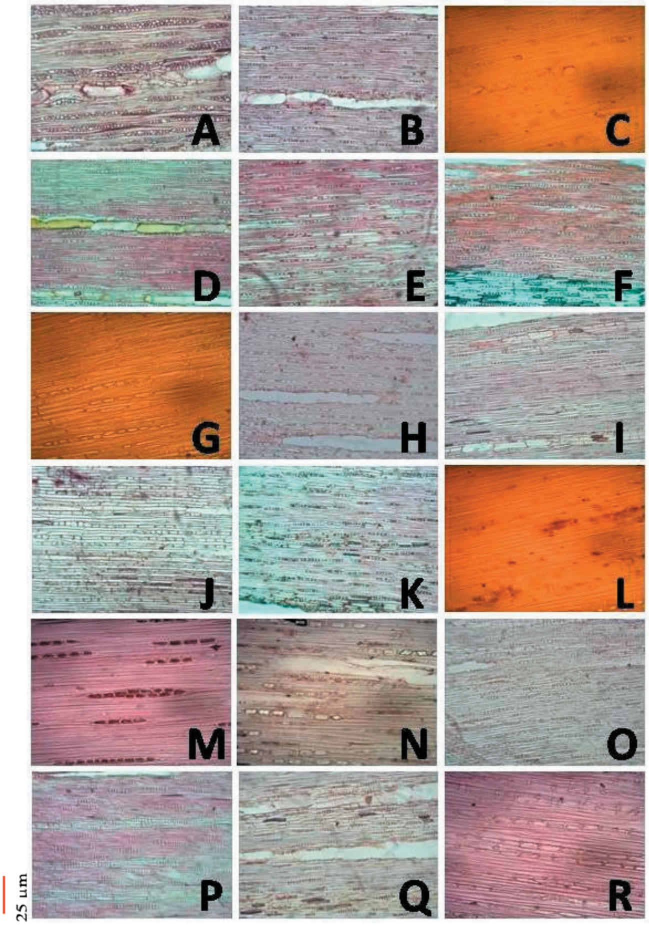

Figure 4. Tangential Longitudinal Sections (TLS) of Dalbergieae species in Nigeria. Mg.*x400.* **A**- *Andira inermis;* **B**- *Dalbergia albiflora*; **C**- *Dalbergia ecastaphyllum*; **D**- *Dalbergia hostilis*; **E**-*Dalbergia lactea*; **F**-*Dalbergia latifolia*; **G**-*Dalbergia melanoxylon*; **H**-*Dalbergia oligophylla*; **I**-*Dalbergia rufa*; **J**-*Dalbergia saxatilis*; **K**-*Dalbergia sissoo*; **L**-*Machaerium lunatum*; **M**-*Pterocarpus erinaceus*; **N**-*Pterocarpus lucens*; **O**-*Pterocarpus mildbraedii; **P**-Pterocarpus osun*; **Q**-*Pterocarpus santalinoides*; **R**-*Pterocarpus soyauxii.*

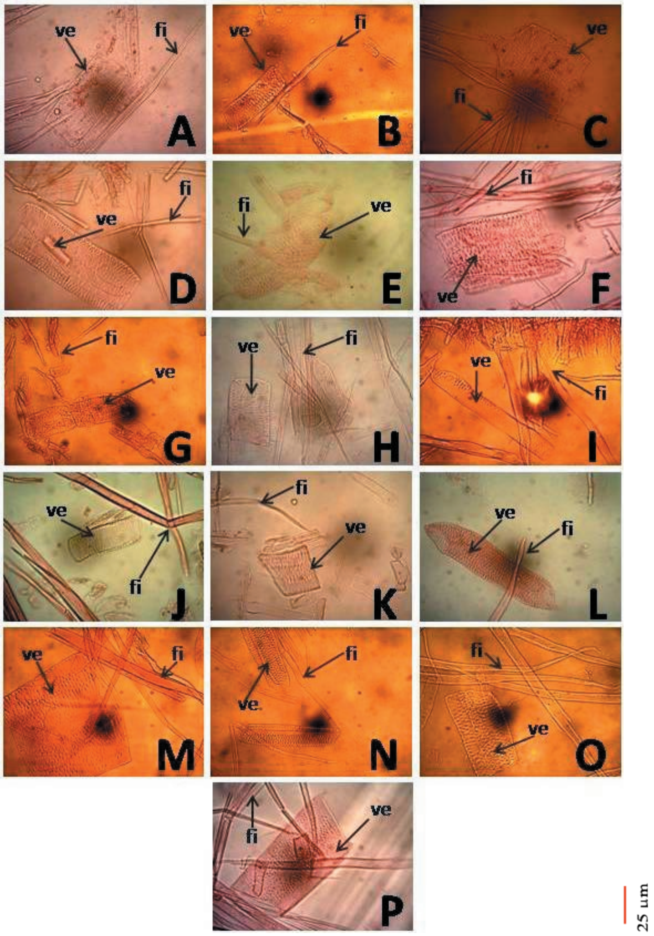

Figure 5. Wood macerates of Dalbergieae species in Nigeria. Mg.*x400.* **A**- *Andira inermis;* **B**- *Dalbergia albiflora*; **C**- *Dalbergia ecastaphyllum*; **D**- *Dalbergia hostilis*; **E**-*Dalbergia lactea*; **F**-*Dalbergia latifolia*; **G**-*Dalbergia melanoxylon*; **H**-*Dalbergia oligophylla*; **I**-*Dalbergia rufa*; **J**-*Dalbergia saxatilis*; **K**-*Dalbergia sissoo*; **L**-*Machaerium lunatum*; **M**-*Pterocarpus erinaceus*; **N**-*Pterocarpus lucens*; **O**-*Pterocarpus mildbraedii; **P**-Pterocarpus osun.* **fi**- fibre; **ve**- vessel elements.

ied. Pearson's correlation of the wood characters in Dalbergieae showed that ray height is highly correlated with ray width, ray width is highly correlated with fibre wall thickness, fibre width is highly correlated with vessel length and vessel width. Further, fibre wall thickness is very highly correlated with vessel length and vessel width, while vessel length and vessel width are also highly correlated. These combinations could be used to distinguish the taxa. It was also observed that all species studied have similar vessel shapes at a transverse plane, from circular, oval, short cylindrical, short rectangular, arc to polygonal. Kribs (1937) in Metcalf and Chalk (1989) considered the lack of axial parenchyma in the wood of plants as a primitive character, on the contrary, the species studied have axial parenchyma except for *D. rufa* and *D. lactea*. In *P. mildbraedii, P. erinaceus, P. lucens, P. osun, D. melanoxylon, D. oligophylla, D. sissoo, D. ecastaphyllum, D. hostilis,* and *M. lunatum*, it is diffuse in aggregate while in others it was either winged or paratrecheal aliform, confluent and diffuse. According to Wickremasinghe and Herat (2006), features of wood ray tissues are important in deducing evolutionary sequences within angiosperm groups. In the present study, ray type varied from heterogenous in *P. osun* to a combination of uniseriate, biseriate, multiseriate, non-storied, and heterogeneous in other species. Simply put, the presence of uniseriate ray cells observed in almost all the species except *D. ecastaphyllum* and *A. inermis*, is a diagnostic feature of phylogenetically

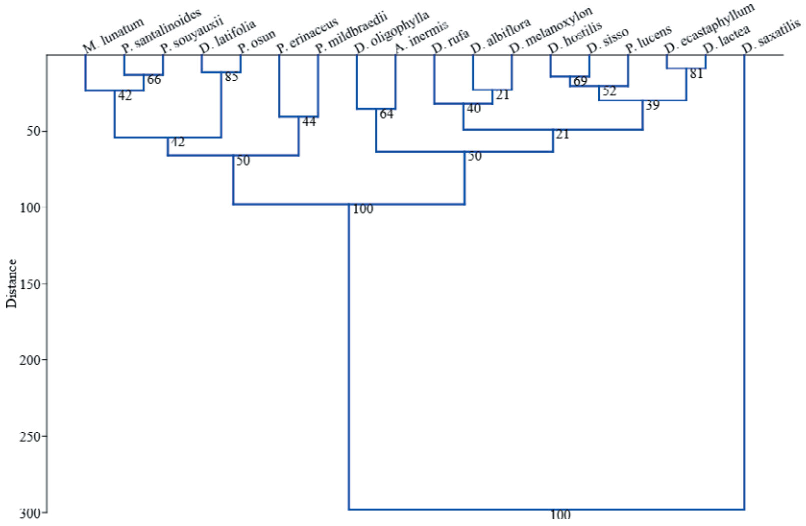

Figure 6. Dendrogram (UPGMA) of Dalbergieae species based on euclidean distance.

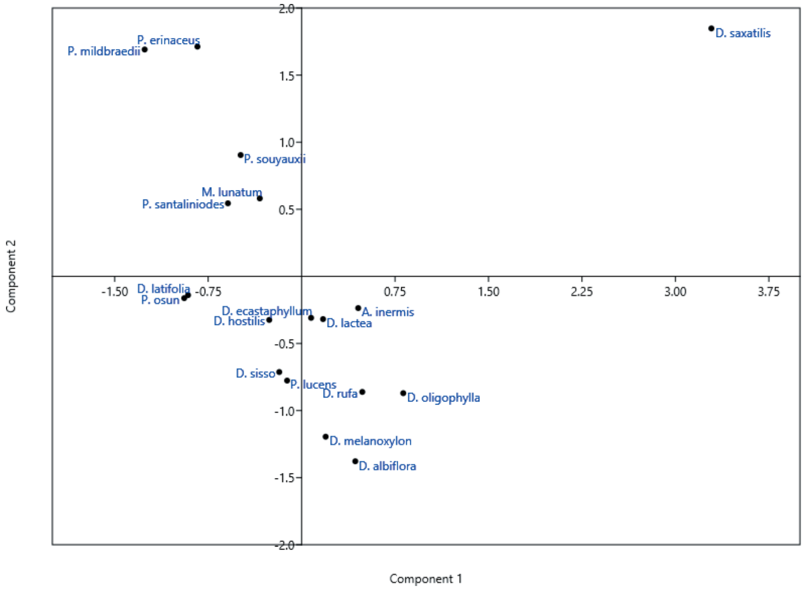

Figure 7. Scatter plot of species of Dalbergieae studied based on the wood anatomical characters.

advanced taxa (Metcalfe and Chalk, 1989), and important in depicting the evolutionary sequence of specialization within angiosperms (Kribs, 1935). However, the rays are non-storied which is quite different from the observations of Lavin et al. (2001), who earlier recorded storied rays and axial parenchyma in legumes; but conforms to their report of heterogeneous rays in juvenile wood samples as used in this study.

All studied species have crystals that were either prismatic or styloid or both and this may not be a diagnostic feature. It was also observed that most of the studied species have tylose except *P. santalinoides, P. erinaceus, D. melanoxylon, D. rufa, D. ecastaphyllum, D. latifoila, M. lunatum*. This character is also considered an indication of evolutionary primitiveness (Bonsen and Kucera, 1990 in: Wickremasinghe and Herat, 2006). The presence of non-septate, non-storied fibres observed in all of them is of no taxonomic importance, unlike septate fibres which are important taxonomic tools (Metcalfe and Chalk, 1989).

Quantitative features as observed in this study revealed that the average number of vessels per square millimeter may not be taxonomically important as a classificatory and diagnostic character for this taxon;

Table 5. Similarity indices (Euclidean) for the examined species of Dalbergieae based on wood anatomical characters.

Species	*A. inermis*	*D. albiflora*	*D. ecastaphyllum*	*D. hostilis*	*D. lactea*	*D. latifolia*	*D. melanoxylon*	*D. oligophylla*	*D. rufa*	*D. saxatilis*	*D. sisso*	*M. lunatum*	*P. erinaceus*	*P. lucens*	*P. mildbraedii*	*P. osun*	*P. santalinoides*	*P. souyauxii*
A. inermis	0																	
D. albiflora	48.12	0																
D. ecastaphyllum	44.28	41.69	0															
D. hostilis	62.69	66.69	30.61	0														
D. lactea	37.19	36.87	**8.88**	37.39	0													
D. latifolia	133.40	121.29	91.14	74.23	99.61	0												
D. melanoxylon	56.39	22.96	30.26	51.76	30.24	99.73	0											
D. oligophylla	35.30	51.41	71.13	93.09	62.96	161.34	69.85	0										
D. rufa	61.33	29.03	47.68	76.07	43.49	120.67	35.09	65.99	0									
D. saxatilis	248.52	254.18	275.08	303.62	267.59	**355.01**	271.15	225.10	245.44	0								
D. sisso	57.88	57.56	28.28	14.05	34.20	80.91	43.20	85.57	71.38	299.43	0							
M. lunatum	77.26	83.37	42.64	29.95	49.37	64.90	67.39	109.34	82.84	305.14	42.66	0						
P. erinaceus	122.74	134.95	93.91	73.32	100.58	66.21	117.62	156.61	135.34	345.25	85.58	53.61	0					
P. lucens	60.04	48.62	20.77	22.68	27.85	77.57	30.86	85.16	57.51	293.34	18.12	41.63	90.43	0				
P. mildbraedii	152.64	165.62	125.54	100.12	132.41	82.63	148.27	186.98	167.76	**381.89**	112.02	85.53	40.56	118.56	0			
P. osun	134.75	123.11	92.69	75.17	101.06	**11.48**	101.96	163.03	121.57	**357.59**	82.72	64.77	66.71	78.84	79.98	0		
P. santalinoides	98.53	99.79	61.12	42.17	69.08	43.38	80.65	130.13	100.48	**325.89**	53.28	25.17	40.32	53.79	70.99	44.84	0	
P. souyauxii	94.40	98.43	58.57	44.64	65.96	52.69	80.35	126.35	97.27	316.49	55.93	21.71	39.79	55.66	75.27	54.67	**13.09**	0

as neither very low nor very high measurements were obtained, the range is between 1.71 µm ± 0.1 (*D. latifolia*) and 9.42 µm ±0.5 (*D. melanoxylon*) (Metcalfe and Chalk (1989). Mean pore diameter ranges between 0.04 µm±0.3 in *M. lunatum* and 0.09 µm±0.9 in *P. soyauxii* and *P. osun*. On average, the longest fibre was observed in *P. midbraedii* (331.22 µm±7.5) while the shortest fibre was seen in the macerated wood of *D. oligophylla* (150.98 µm±4.1). According to Maiti et al. (2016), the presence of big vessels in plants makes them susceptible to drought and therefore may possess a deep root system to adapt to this condition. However, all studied species have relatively small vessels because they are not found in arid habitats. As evidenced in this study, the woods of members of the tribe Dalbergieae have more generic/tribal characteristics than delimiting characters. Distributional information also clearly showed that members of the tribe occur in all the geo-ecological zones of Nigeria but are most widely distributed around the Southern region. This could be attributed to the high rainfall or precipitation characterized by this area which also enhances species growth and development compared to species in the Northern area. Given the continuous habitat degradation in the south however, the distribution of the species may decline further. Hence, it is imperative to consider the sustainable collection and use of plant genetic resources on one hand, and the conservation of our remaining forest estates on the second hand, else we loose our biodiversity to climate change.

CONCLUSION

The present study examined the wood anatomical features of some species of the tribe Dalbergieae in Nigeria. Results have shown that the porosity of the wood of all species studied was diffuse and the vessels have simple perforation plate. All except *P. osun* lacked secretory ducts; and possess non-septate fibres. However, few of the species lacked tylose. Crystals were either prismatic, styloid or a combination of both. Generally, wood micro- characteristics across all the species overlapped, yet, certain characters can be utilized in distinguishing the taxa. While we recognize the importance of molecular data in recent studies, we advocate that other aspects such as macro and micro-morphology should not be ignored, as they provide supplementary information to aid the taxonomic understanding of species.

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