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Unravelling the identity of *Sindora* (Fabaceae, Detarioideae) trees in the historical landscapes of Singapore

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ABSTRACT. *Sindora* Miq. is a noteworthy genus in Singapore, with records of its existence, both natural and cultivated, dating back to the colonial period. Among which was the iconic 'Changi Tree', an approximately 76 m tall tree at Changi that was felled in 1942 during World War II. With the recent revision of the genus in Singapore, it was timely to survey the key historical landscapes at the Singapore Botanic Gardens (SBG), Fort Canning Park (FCP) and Changi Village Estate (CVE) for *Sindora* trees that are currently found or were once present in these locations. This was done through a site survey of the three areas, a study of herbarium specimens, literature and pictorial records relating to these areas, and the carbon dating of selected trees to ascertain their ages. At least 26 mature *Sindora* trees were recorded from this study, with at least 23 from SBG, one from FCP and two from CVE. Eighteen of these trees have been lost over time, leaving a total of eight trees consisting of an individual of *Sindora siamensis* Teijsm. ex Miq. and five of *Sindora wallichii* Benth. from SBG, one *Sindora siamensis* from FCP and one *Sindora* × *changiensis* L.M.Choo et al. from CVE. The latter is a hybrid of *Sindora coriacea* (Baker) Prain and *S. echinocalyx* Prain, recently elucidated using molecular tools. The identity of the 'Changi Tree' could not be fully verified, but it was likely to have been a *Sindora echinocalyx* based on a herbarium specimen collected from Changi. This study highlights the conservation value of trees in historical landscapes in Singapore, their importance in contributing to the genetic diversity of species in Singapore outside of nature reserves, and their role as a living legacy of Singapore's rich botanical and horticultural history.

Keywords. Changi, Fort Canning Park, heritage, history, Singapore Botanic Gardens

Introduction

Sindora Miq. is a genus of legume trees (Fabaceae) of 18 or 19 species that are found in Southeast Asia, including 15 in Malesia from Sumatra, Peninsular Malaysia, Singapore, Borneo, Java, the Philippines, Sulawesi and possibly the Maluku Islands (Hou, 1996). Choo & Ngo (2020) revised *Sindora* in Peninsular Malaysia and Singapore, recognising five species in this region, namely *Sindora coriacea* (Baker) Prain, *Sindora echinocalyx* Prain, *Sindora siamensis* Teijsm. ex Miq., *Sindora velutina* Baker and *Sindora wallichii* Benth. All of these are native in Peninsular Malaysia, and all except *Sindora siamensis* in Singapore. In Peninsular Malaysia, *Sindora siamensis* is assessed as presumed nationally extinct, while the other four species are assessed

as Least Concern. In Singapore, the four native species are assessed as nationally Critically Endangered (Choo & Ngo, 2020).

In addition to the *Sindora* trees found in the forest habitats of Singapore, several *Sindora* trees were preserved as remnant trees in landscapes converted from forests or were planted later in managed landscapes. Some of these trees were, or still are, features of landscapes that date back to when Singapore was a British colony. Three prime examples of these landscapes are the Singapore Botanic Gardens (SBG), Fort Canning Park (FCP) and the Changi Village Estate (CVE). Perhaps, the most notable *Sindora* in these landscapes was the legendary 'Changi Tree', which was a landmark at Changi and was featured in pre-World War II sea navigation maps for over a century until the Japanese invasion of Malaya in 1942 (Probert, 1965; Corner, 1988). The 'Changi Tree' was located in Roberts Barracks, now the current Changi Airbase (Hack & Blackburn, 2004). It was felled by the British military in 1942 to prevent the Japanese forces from using it as a marker for artillery guns (Corner, 1988; Loo & Tan, 1997). Crouch (1969) included a photograph of the tree, which was published on the front cover of the Malayan Nature Journal. Burkill (1969) verified that the tree was felled by British forces in February 1942 and recalled seeing the stump of the tree lying near the roadside when he was a prisoner-of-war in Changi. Reid & Quaife (1970) gave a more complete account of how the Royal Engineers Sappers blew off the top 100 ft (30.48 m) of the tree, leaving behind 150 ft (45.72 m) of the trunk that was eventually severed by explosives. They estimated that the tree was about 250 feet tall (76.2 m) and 11.5 feet (3.5 m) in diameter just above the buttresses. They recalled 'finding the characteristic rounded, flattened, spiny seed pods at the foot of the ruined tree. There were also a few seedlings which [they] tried to encourage by clearing and fencing round them, but whether any survived [they did not] know'. Corner (1988) noted that this tree was probably *Sindora wallichii*, although its true identity could not be confirmed.

With the recent taxonomic revision of *Sindora* in Singapore (Choo & Ngo, 2020), we considered it timely to survey the historical landscapes at SBG, FCP and CVE for mature *Sindora* trees that could have been either remnant trees from former forest or trees planted by British botanists and administrators in charge of these landscapes. We have included *Sindora* trees that are currently found in these landscapes, as well as those for which there are records, but which no longer stand. We then identified these trees and discuss their presence in relation to the history of the various landscapes. We present the results of this survey in this paper.

Study area

The SBG, FCP and CVE are landscapes that were established and remain largely intact from when Singapore was a British colony. These landscapes were surveyed for *Sindora* trees (see Fig. 1 for location of these areas). The three areas and their history are briefly described here.

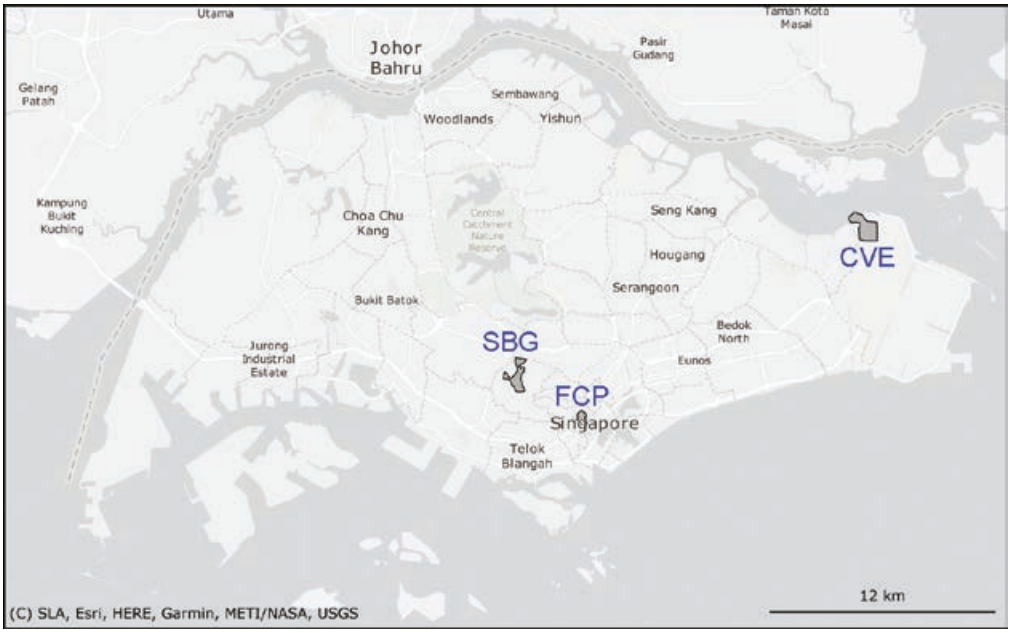

Fig. 1. Map of Singapore, with SBG, FCP and CVE indicated by the shaded areas. (Image from OneMap Base Map)

Singapore Botanic Gardens

Singapore Botanic Gardens (SBG) was established in Tanglin in 1859 by an Agri-Horticultural Society. The ownership of SBG was transferred to the British Colonial Government in 1874, and a series of Kew-trained botanists led the management and administration of SBG from 1875. These included notable past directors of the Botanic Gardens, such as H.N. Ridley, I.H. Burkill and R.E. Holttum. SBG was transformed from its initial beginnings as a recreational garden to a premier botanical institution with an extensive collection of plants from all over the world, some of which contributed to the economic development of the region, e.g., rubber and orchids. Throughout its history, SBG has also been involved in providing horticultural advice, including on the introduction of trees and shrubs as ornamental plantings in parks and streetscapes throughout Singapore (Tinsley, 2009). Singapore Botanic Gardens is currently 82 ha and includes 6.2 ha of lowland rain forest that was part of the original site established in 1859.

Fort Canning Park

Fort Canning Park (FCP) was the site of the first Botanical and Experimental Garden, which was established in 1822 by Sir Stamford Raffles. The garden served as an experimental site for the trial planting of spices such as nutmeg and cloves, and other plants of potential economic value (Zumbroich & Chay, 2004). In 1860, the hill was converted into a fort, and was renamed as Fort Canning, after Viscount Charles John Canning, the Governor-General and first Viceroy of India. In the 1920s and 1930s,

it was further developed into an artillery fort with barracks, officers' quarters, a hospital, and even an underground bunker, which served as the command centre for British military operations in Southeast Asia until 1942 (Diagana & Angresh, 2013). It is today a park of 18 ha, with gardens reflecting the botanical and cultural history of the site.

Changi Village Estate

Located on the north-eastern coast of Singapore, Changi Village Estate (CVE) is today known to be a botanically interesting area, due to the presence of remnant primary forest plant species which reflect its history as part of the Changi Forest Reserve established in 1884 (Ridley, 1890; Corlett, 1992). The lowland forests of Changi were largely cleared by the British to make way for military barracks and an airbase from 1927 to 1941 (Probert, 1965; Corlett, 1992), although a few large rain forest trees were retained, including the iconic Changi Tree that was a key landmark in this area until it was felled in 1942 (Probert, 1965). Some of the large lowland rain forest trees which are still standing today, such as *Dipterocarpus sublamellatus* Foxw., *Shorea gibbosa* Brandis and *Syzygium syzygioides* (Miq.) Merr. & L.M.Perry, reflect Changi's rich botanical past. In recognition of the rich natural heritage of the area, a part of Changi was gazetted as a Tree Conservation Area in 2001. The area, which encompasses the region bounded by Netheravon Road, Cranwell Road, Loyang Avenue, Loyang Way, Upper Changi Road North, and Changi Village Road, is about 200 ha.

Methods

Site survey

A site survey of SBG, FCP and CVE was conducted between June 2020 and August 2021. The location and status (naturally occurring or planted) of all *Sindora* trees in these study areas were noted. Only trees that were present before the independence of Singapore in 1965 were included in the study. Where it was not possible to determine this, only sufficiently large individuals with a diameter at breast height (dbh) of more than 30 cm were included, as a rough proxy for age. The trees were identified to species using the taxonomic key in Choo & Ngo (2020).

Herbarium records

All herbarium specimens of *Sindora* from SING, KEP and K, which were collected from Singapore, particularly in the three study areas, were examined and identified to species using the taxonomic key in Choo & Ngo (2020).

Literature and pictorial records

Literature records pertaining to the introduction of plants in Singapore were checked for *Sindora* species. This was especially relevant for SBG because of the comprehensive records kept. The literature checked included the Annual Reports of the Singapore Botanic Gardens, which were written by the various SBG directors over the years;

and the Plants and Seeds Inward Register, which was a record of the plants and seeds received from overseas from 1926 to 1997. The current Plant Inventory at SBG was also referred to. Various guides to the plants of SBG (Fox, 1889; Singapore Botanic Gardens, 1974, 1984; Tay et al., 1989; Turner, 1990) were also used, along with other literature pertaining to the flora of the region, such as Corner (1988).

Pictorial records such as old maps were used to determine the location of old locality names. Aerial photographs were used to determine if trees were already present in a particular location at a certain time point, and also whether they were part of the original vegetation or were planted. These include a series of aerial photographs taken by the British Royal Air Force from 1940 to the 1970s, currently housed at the National Archives of Singapore, which were used to check the status of trees in the CVE. Old maps for the Changi area were used to confirm the location of the Changi Tree. Lawn maps of SBG over time were used to verify the location of lawns in the past as previous designations do not always correspond to current usage.

Carbon dating of selected trees

To obtain an estimate of the age of the trees, four mature trees were carbon dated: one *Sindora siamensis* located at the National Orchid Gardens (NOG) within SBG, one *Sindora wallichii* tree in the SBG Rain Forest that had fallen a few years before and was left as a stump, one *Sindora siamensis* from FCP, and the *Sindora* Heritage Tree at CVE. In Singapore, Heritage Trees are mature trees, which are recognised and conserved for their botanical, social, historical, cultural or aesthetic value (National Parks Board, 2022). Wood samples from the trunks of the trees were obtained using a 40 cm-long increment borer, between 70 cm to 1 m above the ground. The depths of the 1-cm long core sections from the outer, middle and inner trunk of the tree were measured and the cores sent for carbon dating. As part of the stump of the *Sindora wallichii* from the SBG Rain Forest had already rotted and was soft, it was not possible to accurately gauge the depth of the increment borer. A 6-cm long section of wood from an undetermined depth towards the interior of the trunk was obtained and this was divided into three segments of 2 cm each and sent for carbon dating as the outer, middle and inner section respectively. Replicate measurements were made for the SBG Rain Forest *Sindora wallichii*, the *Sindora siamensis* from FCP and the *Sindora* Heritage Tree at CVE to compare the reproducibility of the carbon dating results. All samples were sent to Vilnius Radiocarbon, Lithuania for accelerator mass spectrometry (AMS) C-14 radiocarbon dating.

Results

Summary of Sindora trees in the colonial landscapes of Singapore

A survey of SBG, FCP and CVE resulted in a total of at least 26 mature *Sindora* trees, of which at least 23 trees are found in SBG, one tree in FCP and the remaining two trees at CVE. In some cases, it was not possible to determine if multiple herbarium specimens collected from different points in time were from the same or different

individuals, so we have taken the conservative approach and assumed that they could be repeat collections from the same tree, thereby listing the lowest possible number of trees. We have not included *Sindora* trees that were planted post-independence in 1965, or those with a dbh of less than 30 cm. The trees are detailed in Table 1 and in Fig. 2.

Of these 26 trees, 18 trees have been lost over time. These included 17 trees from SBG, viz., one *Sindora coriacea*, two *S. wallichii* and at least six *S. siamensis* from the Arboretum and the Economic Gardens, one *S. siamensis* that was planted in the lawn near the Bandstand (Lawn G) in the 1890s, at least two *S. echinocalyx* and one *S. siamensis* from Lawn T, one *S. supa* that was received from the Philippines as a seed and planted in Lawn T, one *S. wallichii* in the Rain Forest, another *S. siamensis* received as a seed and planted at an unknown location, and one *Sindora* of an unknown species at Lawn XJ. For the one tree lost from CVE, which is the 'Changi Tree', it cannot be conclusively identified to species, but could have been *Sindora echinocalyx* if it was the tree from which an old herbarium specimen was collected at Changi in 1893 when the tree still stood.

For the eight extant trees, six of them are in SBG, one at FCP and one at CVE. Based on herbarium specimens and field characters of the leaves, flowers and fruits, we confirmed the identity of these eight trees, although some of these were earlier erroneously identified as other species (see Table 1). In SBG, there are five extant *Sindora wallichii* trees and one *S. siamensis*, while in FCP there is one extant *S. siamensis*. The tree from CVE could not be conclusively assigned to any of the other known *Sindora* species based on morphology initially. A molecular genetic study using double-digest restriction site-associated DNA sequencing (ddRAD) found that it was a hybrid between two native species, *Sindora coriacea* and *Sindora echinocalyx* and has been described as a new taxon, *Sindora* × *changiensis* (Choo et al., 2022).

Carbon dating

Raw data obtained from radiocarbon dating was processed by Vilnius Radiocarbon using the program OxCal v.4.4.2 (Bronk Ramsey, 2020) which was calibrated with atmospheric data from Hogg et al. (2020). The processed data (see Table 2) is expressed as Radiocarbon Age BP (before present), which is defined as the number of years before 1950. This is because between the 1940s and 1960s, the use and testing of atomic bombs artificially increased the level of radioactive carbon in the atmosphere, and this deviates from the rate at which radioactive carbon is naturally produced in the atmosphere (Stenhouse & Baxter, 1977).

Radiocarbon Age BP is next converted to an actual 'calendar' age by adding the number of years between the current year and 1950 to the measured radiocarbon age (i.e., 2022–1950 = 72). Negative values of radiocarbon age, such as for the trees S15 and F1, indicate that the sample was formed after 1950, but this value does not directly correlate to the number of years after 1950. Instead, we report all samples with a negative radiocarbon age to be more recent than 1950, or less than 72 years old as of

2022.
For S22, a core of the remaining stump was obtained horizontally, although the exact depth of the sampled wood could not be accurately determined as parts of the stump were already decomposing. A 6 cm-long section of intact wood was obtained from the core, and the range of radiocarbon ages obtained from this section showed that the stump was at least between 173-259 years old. For tree C2, the innermost section of the core was dated to be the oldest as expected, between 228-366 years old (Table 2).

Discussion and detailed notes

Tracing the history of Sindora trees at the Singapore Botanic Gardens

A total of at least 23 native and introduced *Sindora* trees have been identified from SBG. Of these trees, only six are extant. Fortunately, we have been able to trace the history of these trees using herbarium specimens and written records of the trees that were introduced and planted. This is detailed and discussed here.

Arboretum and Economic Gardens. One *Sindora coriacea*, two *Sindora wallichii* and six *Sindora siamensis* (S1–S9, Table 1) trees have been recorded from the SBG Arboretum and Economic Gardens although none are now extant. The Economic Gardens was established in 1879 as an experimental site for growing plants with economic potential, for example for timber, oils and latex. However, much of the garden, along with many of the trees, was lost in the 1920s to make way for Raffles College, which is now the location of the National University of Singapore Law Faculty (Shee et al., 2014; Barnard, 2016). The comparatively large number of *Sindora siamensis* trees suggests that this species, which is a native of northern Peninsular Malaysia, Thailand, Laos, Vietnam and Cambodia, was probably planted experimentally as a street tree. Indeed, Cantley (1883) included *Sindora siamensis* in a list of trees found suitable for roadside planting.

Heritage Garden (formerly Lawn G from the 1880s to 1925). A *Sindora siamensis* (S10, Table 1) was recorded in Lawn G in 1889 in Fox (1889). Walter Fox was the head gardener of the botanic gardens at that time. The Lawn G of 1889 is the current SBG Heritage Garden, which is located between the Bandstand and Swan Lake (Wijedasa, 2014). It is likely that the same tree was collected as a herbarium specimen by Ridley in 1893 (*Ridley 2087*, K [K001129691]), as the sheet was annotated by Ridley on a later date that the tree ‘grew in the centre of the grass plot near Bandstand possibly planted, was eventually killed by lightning’. This matches another mention of a *Sindora* tree by Ridley (1909), where he noted that there was a fine specimen of *Sindora wallichii* by the lake that was found to be dead. Even though Ridley identified the tree as a *Sindora wallichii* in his report, specimens of *Sindora siamensis* have often been erroneously identified as *Sindora wallichii*, so this tree could have been the same tree in Lawn G and in the lawn by the Bandstand.

Table 1. Details of all known *Sindora* trees from SBG (S + number), FCP (F + number) and CVE (C + number), with their locality, former and current identification, status, and any available specimen and historical evidence on each tree. For trees for which it was not possible to ascertain if they were a unique individual or a repeat collection of an already recorded tree, an asterisk (*) is assigned in place of a number. Locations of the extant trees are indicated in Fig. 2.

No.	Location	Former ID	Current ID	Extant	Evidence and remarks
S1	SBG Arboretum	*S. intermedia* = *S. echinocalyx*	*S. wallichii*	No	*Mhd Nur 1738*, SING [SING0261533], 1 Mar 1918
S2	SBG Arboretum	*S.* sp.	*S. siamensis*	No	*Mhd Nur 1589*, SING [SING0261535], 1 Mar 1918
S3	SBG Arboretum	*S. intermedia* = *S. echinocalyx*	*S. siamensis*	No	*Mhd Nur 1591*, SING [SING0261536], 1 Mar 1918
S4	SBG Arboretum	*S.* sp.	*S. siamensis*	No	*Mhd Nur 1737*, SING [SING0261542], 1 Mar 1918
S5	SBG Economic Gardens	*S. coriacea*	*S. coriacea*	No	*Mhd Nur s.n.*, SING [SING0261529], 13 Nov 1924
S6	SBG Economic Gardens	*S.* sp.	*S. wallichii*	No	*Mhd Nur s.n.*, SING [SING0261534], 14 Jun 1924
S7	SBG Economic Gardens	*S.* sp.	*S. siamensis*	No	*Mhd Nur 151* or *1589*, SING [SING0261539], 13 Jun 1924, small tree, 10–15 ft
S8	SBG Economic Gardens (Old Tamil Lines)	*S. wallichii*	*S. siamensis*	No	*Mhd Nur 152* or *1590*, SING [SING0261541] & K, 13 Jun 1924, 20–30 ft high

Table 1 (continued).

No.	Location	Former ID	Current ID	Extant	Evidence and remarks
S9	SBG Economic Gardens (Old Tamil Lines)	*S.* sp.	*S. siamensis*	No	*Mhd Nur s.n.*, SING [SING0261531], 13 Jun 1924
*	SBG Economic Gardens (Old Tamil Lines)	*S. wallichiana* = *S. wallichii*	*S. siamensis*	No	*Deshmukh s.n.*, SING [SING0261540], 13 Jan 1920, 30–35 ft high
*	SBG Economic Gardens (Old Tamil Lines)	*S. intermedia* = *S. echinocalyx*	*S. siamensis*	No	*Mhd Nur 1303*, SING [SING0261532], KEP [KEP220015] & K, 24 Sep 1917
S10	SBG Heritage Garden (formerly Lawn G)	*S. siamensis*	*S. siamensis*	No	*Ridley 2087*, K [K001129691], Year 1893, 'This tree grew in the centre of the grass plot near bandstand possibly planted, it was eventually killed probably by lightning HNR'; Fox (1889); Ridley (1909)
S11	SBG Lawn XJ	*S. wallichii*	Cannot be verified	No	Turner (1990); Fig. 3
S12	SBG Lawn T	*S. supa*	*S. supa*	No	*Kiah s.n.*, SING [SING0261563], 1 Dec 1953; Holttum (1932); Singapore Botanic Gardens (1936)
*	SBG Lawn T	*S. wallichii*	*S. echinocalyx*	No	*Kiah s.n.*, SING [SING0261547], 1 Dec 1953; not possible to tell if this tree is the same as the other *Sindora echinocalyx* from Lawn T
S13	SBG Lawn T	*S. wallichii*	*S. echinocalyx*	No	*Ang AGC19*, SING [SING0261546], KEP [KEP196828] & K, 29 Aug 1966, T-36

Table 1 (continued).

No.	Location	Former ID	Current ID	Extant	Evidence and remarks
S14	SBG Lawn T	*S. wallichii*	*S. echinocalyx*	No	*Ang AGC20*, SING [SING0261544, SING0261545, SING0261548], KEP [KEP121435] & K, 29 Aug 1966, T-51; *Samsuri SA 1297*, SING [SING0261549, SING0261550], 22 Jul 1976, T-51
S15	SBG Lawn T	*S. siamensis*	*S. siamensis*	Yes	*Sng SING2020-1187*, SING [SING0291145, SING0291146], 3 Mar 2020; sampled for carbon dating (Table 2); Fig. 2A, 4
S16	SBG Lawn T	*S. siamensis*	*S. siamensis*	No	*Burkill 1149T*, SING [SING0261530], KEP [KEP220015] & K, 12 Sep 1917
*	SBG Lawn T	*S. cochinchinensis* = *S. siamensis*	*S. siamensis*	Unknown	*Whitmore s.n.*, KEP [KEP196733], 28 Jan 1967, Tree 45, Lawn T, below Director's House at Singapore Botanic Gardens (cultivated as *S. cochinchinensis*); not possible to tell if tree is same as either of the two *Sindora siamensis* in Lawn T, the *S. cochinchinensis* tree mentioned by Holttum (1930, 1931) that was planted in 1928 (see S23 below), or if this represents a different individual
S17	SBG Rain Forest	*S. wallichii*	*S. wallichii*	Yes	SBG Plant Inventory, V1-175, 20111474*A; *Choo & Lau SING2021-571*, SING [SING0341184], 11 Aug 2021; Fig. 2A
S18	SBG Rain Forest	*S. wallichii*	*S. wallichii*	Yes	SBG Plant Inventory, N2-426, N2-20121376*A; *Choo & Lau SING2021-334*, SING [SING0291151, SING0291152], 31 May 2021; Fig. 2A
S19	SBG Rain Forest	*S. wallichii*	*S. wallichii*	Yes	SBG Plant Inventory, N2-109, 20121097*B; *Choo & Lau SING2021-568*, SING [SING0341181], 11 Aug 2021; Fig. 2A

Table 1 (continued).

No.	Location	Former ID	Current ID	Extant	Evidence and remarks
S20	SBG Rain Forest	*S. wallichii*	*S. wallichii*	Yes	SBG Plant Inventory, N2-166, 20121146*A; *Choo & Lau SING2021-569*, SING [SING0341182], 11 Aug 2021; Fig. 2A
S21	SBG Rain Forest	*S. wallichii*	*S. wallichii*	Yes	SBG Plant Inventory, N2-254, 201121213*A; *Choo & Lau SING2021-570*, SING [SING0341183] 11 Aug 2021; Fig. 2A
S22	SBG Rain Forest	*S. wallichii*	Cannot be verified	No	SBG Plant Inventory, U4-28, 20104910*A, stump remaining; sampled for carbon dating (Table 2); Fig. 2A
*	SBG Rain Forest	*S. wallichii*	*S. wallichii*	Unknown	*Ang s.n.*, KEP [KEP196983], 20 Feb 1967, Gardens' Jungle Singapore Botanic Gardens; not possible to tell if tree is same as any of the six *Sindora wallichii* trees known from the SBG Rain Forest or if this represents a different individual
S23	SBG (no detailed locality)	*S. siamensis*	Cannot be verified	No	Holttum (1931) mentions a *Sindora siamensis* (then known as *S. cochinchinensis*) introduced from Saigon, Vietnam in 1928, which is planted and growing well; Singapore Botanic Gardens (1936)
*	SBG (no detailed locality)	*S. siamensis*	*S. siamensis*	No	*Ridley 2079*, SING [SING0036456], 20 Aug 1890; no other notes, not able to verify if the same as any of the other abovementioned trees
*	SBG (no detailed locality)	*S. siamensis*	*S. siamensis*	No	*Ridley 2078*, SING [SING0036454, SING0229964, SING0261537, SING0261538], Year 1897; no other notes, not able to verify if the same as any of the other abovementioned trees
*	SBG (no detailed locality)	*S. siamensis*	*S. siamensis*	No	*Unknown Collector s.n.*, SING [SING0036455], n.d.; no other notes, not able to verify if the same as any of the other abovementioned trees

Table 1 (continued).

No.	Location	Former ID	Current ID	Extant	Evidence and remarks
F1	FCP Sally Port	*S. wallichii*	*S. siamensis*	Yes	*Choo et al. SING2020-1353*, SING [SING0369161], 28 Dec 2020; FCP Plant Inventory HC2006.006489; likely planted after the fort was built in the 1920s, as the tree is growing on top of the fort; sampled for carbon dating (Table 2); Fig. 2B, 5
C1	CVE Digby Road	*S. intermedia*	Likely *S. echinocalyx*	No	Crouch (1969), image of the original Changi Tree; Burkill (1969); Reid & Quaife (1970), eyewitness accounts of the original Changi Tree; possibly represented by the herbarium specimen *Bakar s.n.*, SING [SING0044593], Year 1893
C2	CVE Cranwell Road	*S. wallichii*	*S.* × *changiensis*	Yes	*Choo et al. SING2020-1186*, SING [SING0291155], 9 Aug 2020; *Choo et al. SING2021-223*, SING [SING0291148], 16 Apr 2021; *Choo et al. SING2021-265*, SING [SING0291149, SING0291150], 6 May 2021; *Choo et al. SING2021-627*, SING [SING0291154], 28 Aug 2021; Heritage Tree Register HT2003-115; aerial photos (Fig. 5); sampled for carbon dating (Table 2); Fig. 2C, 6, 7

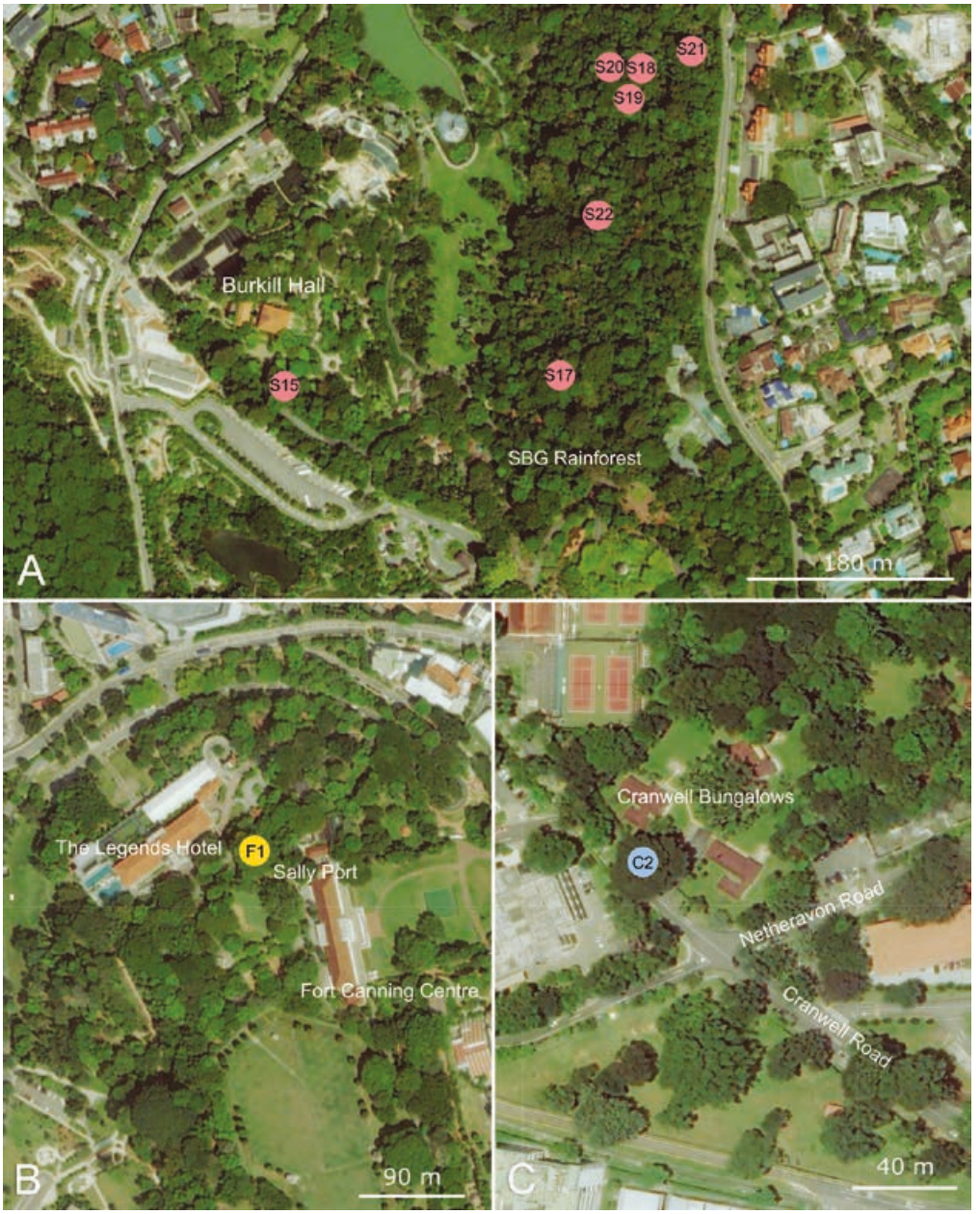

Fig. 2. Aerial views of the three study areas with location of the extant trees and their numbers as in Table 1 indicated in the coloured circles. **A.** SBG, showing the Lawn T *Sindora siamensis* (S15) and the SBG Rain Forest *Sindora wallichii* trees (S17–S21; S22 is no longer extant but is the tree stump sampled for carbon dating). **B.** FCP, with the Sally Port *Sindora siamensis* indicated as F1. **C.** CVE, with the *Sindora* × *changiensis* indicated as C2. (Imagery ©2021 Maxar Technologies)

Table 2. Summary of carbon dating results for the four selected trees. They are referred to using the same specimen numbers as in Table 1. The radiocarbon age is reported as the age Before Present (BP) which is defined as the year 1950. The calendar age range is calculated by Radiocarbon Age + (2022–1950) ± Error. Results of the replicates for S22, F1 and C2 are listed on separate lines, while the calendar age range is taken from the combined range of both replicates.

No.	Location	Species	Depth sampled (cm)	Radiocarbon age (BP) ± error	Overall calendar age range (as of 2022)
S15	SBG Lawn T	*S. siamensis*	36–37	-115 ± 29	Less than 72 years old
S22 Replicate 1	SBG Rain Forest	*S. wallichii*	Undetermined	128 ± 27	At least 173–259 years old
S22 Replicate 2	SBG Rain Forest	*S. wallichii*	Undetermined	159 ± 28	At least 173–259 years old
F1 Replicate 1	FCP Sally Port	*S. siamensis*	32–33	-1067 ± 28	Less than 72 years old
F2 Replicate 2	FCP Sally Port	*S. siamensis*	32–33	-1597 ± 28	Less than 72 years old
C2 Replicate 1	CVE Cranwell Bungalows	*S.* × *changiensis*	37–38	266 ± 28	At least 228–366 years old
C2 Replicate 2	CVE Cranwell Bungalows	*S.* × *changiensis*	37–38	184 ± 28	At least 228–366 years old

Fig. 3. The Lawn XJ *Sindora* (S11) at SBG. **A.** Habit and form of the tree. **B.** Close-up of the leaves. (Photos: S.L. Koh)

Lawn XJ. A *Sindora wallichii* tree (S11, Table 1, Fig. 3) was recorded from Lawn XJ (then Lawn XH) in Turner (1990). Eyewitness accounts from K.B.H. Er and photographs from 2004–2005 (Fig. 3) confirm the existence and location of this tree, but unfortunately its identity cannot be confirmed as there are no herbarium specimens available. The tree fell during a storm in 2018.

Lawn T (outside the National Orchid Gardens). A *Sindora supa* (S12, Table 1) was recorded by Kiah (*Kiah s.n.*, SING [SING0261563]) in 1953. Even though the specimen was sterile, it could still be differentiated from the other *Sindora* species present in Singapore by the long, golden, tightly adpressed hairs on the midrib of the lower leaflet surface. This species is known to be endemic to the Philippines. The species was also mentioned in the Plants and Seeds Inward Register for the year 1931 (Singapore Botanic Gardens, 1936), where it was recorded that *Sindora supa* seeds were received from the Department of Forestry, Manila, Philippines. In the following year, Holttum (1932) reported that *Sindora supa* had been planted in the Gardens and it is likely that this was an individual grown from the seeds from Manila. Unfortunately, it is no longer present today. There were at least another two *Sindora echinocalyx* trees (S13, S14, Table 1) present in Lawn T, based on the herbarium specimens present. A *Sindora siamensis* (S16) has also been recorded as a specimen collected by I.H. Burkill in 1917 where he noted that the tree was in 'Area T [of the] Gardens, upper of trees on way to Director's House [which is now known as Burkill Hall]'. This matches the locality of the current *Sindora siamensis* in Lawn T (S15, Table 1, Fig. 2A, 4). However, the carbon dating of this tree (Table 2) showed that the tree was likely planted after 1950, which meant that it could not have been the same individual collected by Burkill in 1917.

Fig. 4. The Lawn T *Sindora siamensis* (S15) at SBG, as seen from Burkill Drive leading down from Burkill Hall. (Photo: L.M. Choo)

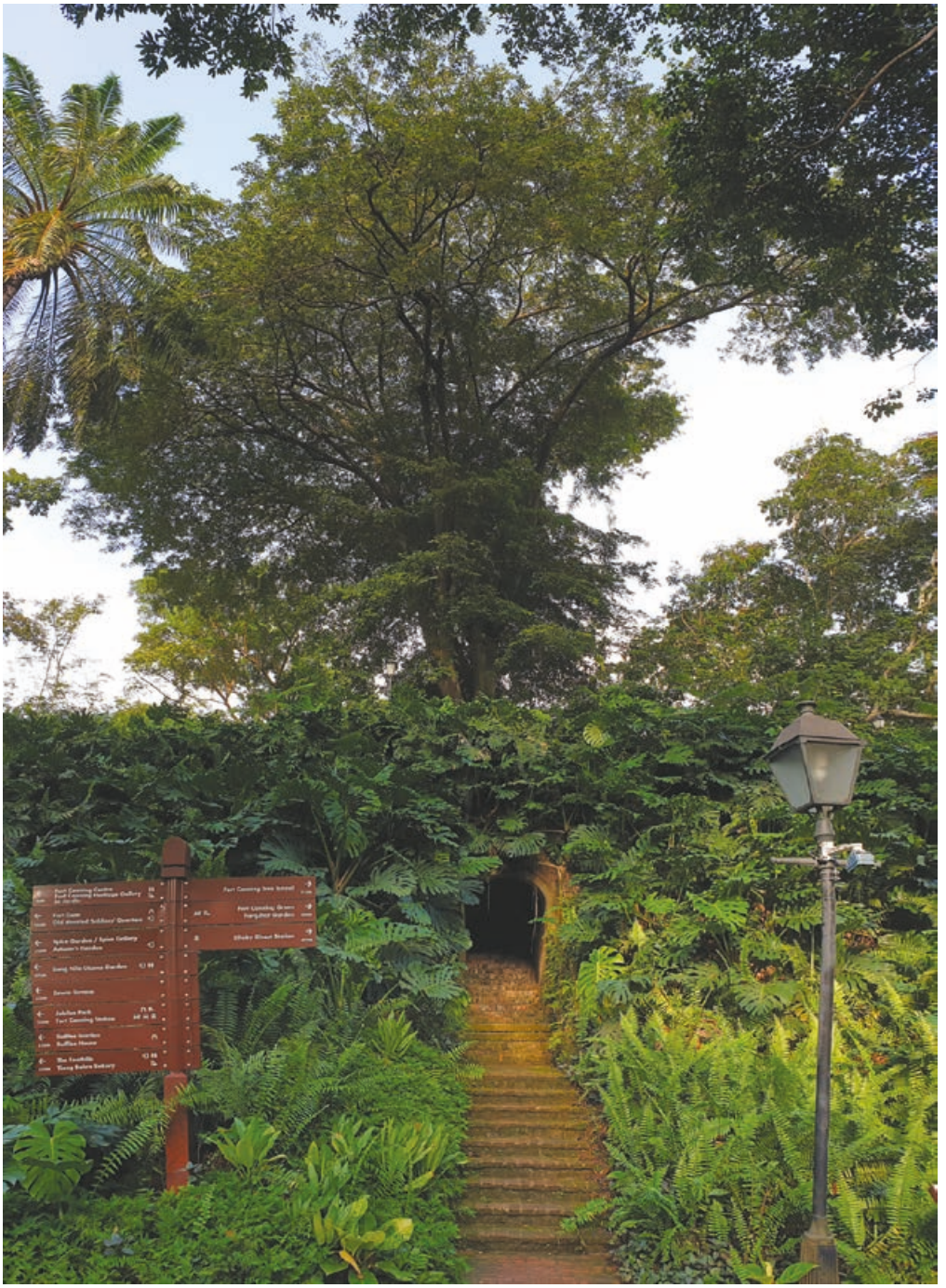

Fig. 5. The Sally Port *Sindora siamensis* (F1) at FCP, as seen from the entrance of the Sally Port. (Photo: L.M. Choo)

Fig. 6. The CVE *Sindora* × *changiensis* at Cranwell Road, pictured in the middle between the Cranwell Bungalow buildings. (Photo: K.B.H. Er)

Fig. 7. A series of aerial photographs showing the presence of the Cranwell Road *Sindora* × *changiensis* (circled in yellow) over time. **A.** Aerial photograph on 17 Feb 1946, which is the earliest archival aerial photo of the Changi area. **B.** Aerial photo on 14 Jul 1950, showing the Cranwell Bungalows which have been constructed on the left and right of the tree. **C.** Aerial photo on 5 Mar 1963. **D.** Present day aerial photo. Figure reproduced from Choo et al. (2022). (Photos: A–C, Aerial photos by the British Royal Air Force between 1940 to 1970s, from a collection held by the National Archives of Singapore, Crown copyright, reproduced in part; D, Imagery ©2021 Maxar Technologies, Map data ©2021 Google)

Rain Forest. The six trees from the SBG Rain Forest were all recorded and verified as *Sindora wallichii*. Of these six, five (S17–S22 Table 1, Fig. 2A) are still extant, and one is dead (S22, Table 1, Fig. 2A) having fallen, likely due to old age or other natural causes, leaving behind a stump with a dbh of 70 cm. The dead tree was carbon-dated and it was found to be at least between 173–259 years old (Table 2), which pre-dates the formation of SBG, and shows that it was naturally occurring and not planted. All other extant specimens of *Sindora* in the rain forest have a dbh between 30 to 55 cm, and are clustered close together in the rain forest, suggesting that they are younger and could be progenies of the dead tree.

Linking the Sindora tree at Fort Canning Park to Singapore Botanic Gardens

Sally Port. This tree (F1, Table 1, Fig. 2B, 5) was originally thought to be *Sindora wallichii*, but has now been identified as *Sindora siamensis*. It stands above the tunnel that the Sally Port leads out of and is located on elevated ground above the Battle Box and next to the current Fort Canning Centre. The fort was decommissioned in 1907 and the area of the fort where the tree currently stands was demolished in 1926 to make way for the British Far East Command HQ. The British Far East Command HQ included an underground bunker (today the Battle Box), an administrative building (today the Fort Canning Centre), and barracks (which is now the Legends Hotel), and was completed in the 1930s (Diagana & Angresh, 2013). Carbon dating estimated that the tree was planted after the end of the war, likely after 1950 (Table 2). As *Sindora siamensis* is a cultivated species and was also known to be cultivated in SBG at that time, it could have been possible that the seed or sapling was sourced from SBG before being planted out at FCP.

Uncovering the iconic Sindora trees at Changi Village Estate

Cranwell Road. The *Sindora* tree present within the Cranwell Bungalows compound is a Heritage Tree (C2, Table 1, Fig. 2C, 6), which is 27 m tall and has a dbh of 1.4 m. Genetic analyses have determined that this tree is a hybrid between two native species of *Sindora*, *Sindora coriacea* and *Sindora echinocalyx*, and has been named as *Sindora* × *changiensis* (Choo et al., 2022). The carbon dating results have indicated that this tree is at least between 228–366 years old (Table 2). While we do not know of any other mature *Sindora* tree that has been carbon dated other than in this study, the age of the *Sindora* × *changiensis* tree falls within the range of other dominant lowland tropical rain forest trees in Southeast Asia, such as a *Shorea superba* Symington tree in Sabah that was carbon dated to be approximately 316–341 years old (Robertson et al., 2004). Given the size and age of the tree, together with pictorial evidence from old aerial photographs of the Changi area (Fig. 7), this Heritage Tree is confirmed as being a remnant of the original lowland rain forest before the area was cleared to make way for a military base.

Digby Road. This is the legendary 'Changi Tree' (C1, Table 1), which has been described as 76 m in height and whose great height was captured in an old photograph published in Crouch (1969). However, while the tree was known to be a *Sindora*, and it was thought to be probably a *Sindora wallichii* by Corner (1988), the exact identity of the tree cannot be confirmed. Reid & Quaife (1970) described the pods as 'rounded, flattened, and spiny', which could refer to *Sindora echinocalyx*, *Sindora wallichii*, or even the recently described hybrid *Sindora* × *changiensis*. A *Sindora echinocalyx* specimen (*Bakar s.n.*, SING[SING0044593]) was collected from Changi in 1893, which also happens to be the only *Sindora* specimen collected from Changi amongst the herbarium specimens in SING, KEP and K. However, there is insufficient detail on the sheet to determine whether this collection is related to the Changi Tree. However, if Bakar collected this specimen from the most iconic *Sindora* tree in Changi, it might be possible that the Changi Tree was a *Sindora echinocalyx*.

Singapore Botanic Gardens' role in urban amenity planting in Singapore

Singapore Botanic Gardens has played a leading role in the introduction of tree species for the greening of Singapore, in addition to the establishment of a living collection of trees native to Singapore and the region within the grounds of the botanic gardens itself. From the 1870s to the 1960s, SBG supplied plants for reforestation and amenity planting in major public spaces and parks, such as the Istana, the Esplanade Park and the former People's Park near Chinatown (Ridley, 1889; Lim, 2018). Roadside trees, such as the Angsana (*Pterocarpus indicus* Wall.) and Rain Tree (*Samanea saman* (Jacq.) Merr.), were introduced along major roads such as Connaught Drive, Tanglin Road and Jalan Besar (Lim, 2018, 2022). Reforestation programmes using *Syzygium grande* (Wight) Walp. and *Gluta renghas* L. trees to act as firebreaks were also undertaken on degraded forest land or along the edges of nature reserves such as at Chan Chu Kang and Bukit Mandai (Ridley, 1891, 1892; Barnard, 2014). In these programmes, SBG did not just supply saplings to the Municipality, but also provided guidance on the choice of tree species and advice on plant care and maintenance. This arrangement was formalised in 1925, when the Assistant Curator of SBG was appointed to be the Superintendent of Roadside Trees to provide the Municipality with horticultural advice (Holttum, 1926; Barnard, 2016; Lim, 2018). Remnants of these tree planting programmes can still be seen at certain locations in Singapore, e.g., the mature Rain Trees along Connaught Drive and Tanglin Road (near Ridley Park). While *Sindora siamensis* was once listed as a recommended species for roadside trees (Cantley, 1883), it has not been found to be planted elsewhere in Singapore outside of the three study areas, SBG, FCP and CVE. The species may not have been eventually selected as a roadside tree because it can only be propagated by seed, and grows slowly with a long generation time, as compared to the other more commonly used species such as the Angsana and Rain Tree, which can be readily propagated by cuttings and have the added advantage of having a consistent growth form, which is an important characteristic for roadside trees. Notwithstanding the above limitations of *Sindora* species, the introduction of *Sindora siamensis* to FCP was likely for ornamental purposes as there is a history of

ornamental trees and shrubs being planted in FCP (Zumbroich & Chay, 2004). As FCP was under the management of the Municipality during the colonial years, SBG might have similarly recommended the planting of the *Sindora siamensis* and could also have provided the sapling. All these point to the role of SBG in shaping the treescape of Singapore throughout colonial history.

Conclusion

This study, which has unearthed the rich history of *Sindora* trees in Singapore, both natural and cultivated, highlights the conservation value of botanical living collections in botanic gardens and across historical landscapes. The five extant *Sindora wallichii* trees in the SBG Rain Forest and the recently described hybrid *Sindora* × *changiensis* of Cranwell Road show that historical landscapes play a part in preserving the genetic diversity of native rain forest trees in Singapore. The discovery of this hybrid also reveals the possibility of hybrid swarms and hybridisation events that require further study through molecular methods. The extensive use of literature records and herbarium specimens from SBG underscores the importance of good record keeping in botanic gardens to trace the origins of species introductions, such as for *Sindora siamensis* and *Sindora supa*. The cultivated *Sindora siamensis* trees in SBG and FCP, while non-native, are a living legacy of the history of tree planting trials and plant introductions by SBG in Singapore. Last but not least, the recent discovery that the heritage tree in Cranwell Road is a hybrid shows the importance of the heritage trees scheme in the conservation of large and old trees outside of SBG and the nature reserves in Singapore. These heritage trees serve as reminders of the rich botanical past of Singapore, both natural and through cultivation.

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