3. HISTORY OF TAXONOMIC RESEARCH IN SINGAPORE

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All that we know about the plant diversity of Singapore begins with people going out into the field and collecting plants, preparing those plants for the herbarium (and laboratory), studying them, and publishing the fruits of their labours in scientific journals and books. Singapore has by far the highest plant collection density in Southeast Asia and one of the highest in the world (Middleton et al., 2019). The more collections that are made over as wide an area as possible, the more likely the plant diversity of Singapore is properly accounted for. In this chapter we shall discuss the history of botanical collections in Singapore, the people who have been influential in botanical research in Singapore, and the seminal publications that arose from this research.

Beginnings

We cannot be sure when the first botanical collections intended for research were made in Singapore. Cowan (1954), in a work on the collections of the Scottish collectors Archibald Menzies (1754–1842) and William Jack (1795–1822), noted the possibility that Menzies collected in Singapore in 1789. Menzies is most celebrated for his pioneering botanical work in North America (Galloway & Groves, 1987) but earlier in his life he sailed aboard the *Prince of Wales* which visited Sumatra in 1789 and from which a small number of collections are extant and now housed in the herbarium of the Royal Botanic Garden Edinburgh. Cowan (1954) noted that there was an undated Menzies collection in the Royal Botanic Garden Edinburgh from Singapore which, if collected by Menzies himself, could only have been collected in 1789 on the *Prince of Wales* expedition as that was his only visit to the region. Menzies accumulated material from many collectors throughout his life and there is a possibility that this example is but a poorly labelled specimen from a later collector. Unfortunately, Cowan did not say what this specimen was of and it cannot now be located and identified despite an extensive search.

Christopher Smith, who died in 1806 or 1807 in Penang, was employed by the East India Company to collect and introduce valuable plants such as nutmegs and cloves into Penang. In June and July 1796 he collected on what he called ‘Barn Island, Straits of Sincapore’ and which is today called Pulau Senang, one of the southernmost islands of Singapore. So far, five specimens in the herbarium of the Linnean Society have been attributed to Barn Island, and one from the Natural History Museum in London (BM). These are the oldest verified collections from Singapore.

Van Steenis-Kruseman (1950) reported undated nineteenth century collections from Singapore by a ‘Dawood’ in Wight’s Herbarium, now in Kew, which she suggested would likely have been from a now-unknown Malay collector called Daud. Van Steenis-Kruseman

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(1950) also reported undated collections by John Prince from Singapore. Prince was known to have been in Sumatra before 1814 but it is likely he only collected in Singapore from 1819 or even later after he became resident in Singapore in 1826.

The earliest verifiable botanical collections made on the mainland of Singapore are those of William Jack although Jack himself says that the honour actually belongs to Sir Stamford Raffles (see Gage & Burkill, 1916). Jack reported that Raffles collected specimens in Singapore and brought them to Penang in 1819 where Jack studied them, pronounced them to be of new species and wrote that he decided to name one after Raffles (Gage & Burkill, 1916). It is possible that the collections of *Nepenthes rafflesiana* Jack and *N. ampullaria* Jack in the herbaria of the Singapore Botanic Gardens (SING) and the Natural History Museum in London might actually be the specimens collected by Raffles in Singapore in February 1819, even though they are attributed to Jack. Alternatively, they may simply be collections made by Jack later in 1819 when he travelled to Singapore himself. Merrill (1952), in a paper on Jack's collections, wrote of the specimens in the BM herbarium that 'These Jack Singapore *Nepenthes* specimens were manifestly sent by him to Robert Brown in London, supplementing a larger lot sent to him from Penang previous to Jack's departure for Singapore.' It is quite possible, however, that the *Nepenthes* collections from Singapore were part of the original package of specimens sent to Brown from Penang before Jack ever set foot in Singapore, Jack having received them from Raffles.

Raffles (Fig. 1) was appointed as the Lieutenant-Governor of Bencoolen in Sumatra in 1817 and took with him the botanist Joseph Arnold. Unfortunately, Arnold died soon thereafter and Raffles appointed William Jack as his replacement. Jack had earlier begun a correspondence with Nathaniel Wallich (Fig. 2), the Superintendent of the Calcutta Botanic Garden, when Jack was stationed as a medical doctor in India and Nepal. Jack and Wallich struck up a close friendship and Jack wrote to his family of how kind Wallich had been to him and, crucially for the early botanical history of Singapore, how much Wallich mentored him in his botanical investigations (Gage & Burkill, 1916). It was Wallich who introduced Jack to Raffles. Jack entered into Raffles' service and accompanied him first to Penang and then to Singapore. Jack arrived in Singapore on the 31st May 1819 and in his letter to Wallich shortly thereafter wrote that 'It is impossible to conceive anything more beautiful than the approach to this place through the Archipelago of Islands that lie at the Eastern extremity of the Straits of Malacca…The forests that now form my delight will gradually give place to man and his habitations, but they are more interesting to me in the present state. Flora here luxuriates in endless varieties, where she finds soil, climate and everything congenial.' He also noted that Singapore was likely to usurp Bencoolen in importance, a prescient statement indeed. He left Singapore on the 28th June for Bencoolen, having spent less than one month on the island. During this one month, however, he collected material that led to the description of 16 new species (Merrill, 1952). He spent two years in Sumatra but died in 1822 in Bencoolen, only in his late twenties. Most of his collections, papers and drawings of plants from Southeast Asia were then lost due to a fire on board the ship *Fame* in 1824, the same fire from which Stamford Raffles and his wife were rescued and in which Raffles lost his own papers and over 2000 natural history drawings. Merrill (1952) suggested that if it had not been for this fire, Jack would certainly now be remembered as perhaps amongst the greatest of Southeast Asia's botanists. However, in his short lifetime, and for a few years after his untimely death, Jack's publications on the botany of Penang, Singapore and Sumatra were amongst the earliest and most detailed on the plants of the region. Merrill (1952) notes that Jack was the first

Figure 1. Sir Thomas Stamford Raffles. (Engraving by J. Thompson, from a miniature in the possession of Mrs O.M. Raffles. Published in 1824. From the collection of Dr W. Rushton Parker. Reproduced with the kind permission of the Director and the Board of Trustees, Royal Botanic Gardens, Kew).

Figure 2. Portrait of Nathaniel Wallich. (Drawn by Daniel Macnee, coloured chalk on paper, mounted on card. Part of Sir William Hooker's Collection, purchased by the Commissioners of Her Majesty's Works & Public Buildings for Kew in 1866. Reproduced with the kind permission of the Director and the Board of Trustees, Royal Botanic Gardens, Kew).

post-Linnaean botanist to work in the region and that, at that time, it was very likely that 75% of the plants he would have encountered would have had no name and most would not have had a stable generic structure. Jack's legacy was that he revelled in the challenge to understand this diversity rather than be intimidated by the sheer scale of the task to describe and name it. Although most of his collections were lost in the fire, his collaboration with Wallich, and his desire to share his findings and specimens with his mentor in small despatches whenever the possibility arose, at least ensured that some of his specimens remain for study today, including several from Singapore. These are incorporated into the East India Company Herbarium, usually more simply referred to as the Wallich Herbarium, now housed in the Royal Botanic Gardens Kew. Merrill (1952) also notes that there are small numbers of Jack collections in the herbaria in Geneva, Edinburgh, Leiden and London's Natural History Museum. The collection in Edinburgh was later elaborated in more detail by Cowan (1954) and would appear to all be specimens from Sumatra rather than from his earlier stay in Singapore.

Wallich himself came to Singapore in 1822. Wallich, a Danish surgeon and botanist, was the Superintendent of the East India Company's Calcutta Botanic Garden from 1815 to 1846. In 1822 persistent ill health forced him to request leave for a sea voyage in the hopes of recovery. He sailed to Penang and then Singapore where he ended up staying for a five-month convalescence. During this period, Raffles encouraged Wallich to write a report on the feasibility of establishing a Botanic Garden which he did so in glowing terms (Tinsley, 2009). This is the Garden that was established on and beside what is now Fort Canning Hill although it was abandoned in 1829, partly revived again in 1836, but finally abandoned in 1846. A new Botanic Garden was established on a different site in Tanglin in 1859 which today is the UNESCO World Heritage Site of Singapore Botanic Gardens.

Wallich was a prolific collector and a gatherer of specimens from other collectors (e.g. Jack), thereby enlarging the herbarium established by William Roxburgh in Calcutta. In 1828 he sought and received permission to bring this collection to London in order to deliver it to the Court of Directors of the East India Company (De Candolle & Radcliffe-Smith, 1981). He arrived in London with 30 large crates of specimens. He began the task of sorting, naming and listing the material, to which were added further specimens already sent to London. Wallich summarised his collection in what is most commonly referred to as the *Wallich Catalogue* but is more formally called *A numerical list of dried specimens of plants in the East India Company's Museum: collected under the superintendence of Dr. Wallich of the Company's botanic garden at Calcutta*, usually abbreviated to *Numerical List*. The top set of the East India Company's herbarium in Kew is maintained in numerical order rather than being superseded by a taxonomic structure. There were also many duplicates sent by Wallich to other researchers and which are today housed in a large number of herbaria. A search on the Kew database (accessed 26th March 2019) reveals 685 Wallich specimens from Singapore, these being Wallich's own collections in the East India Company's herbarium and in Kew's general collection, plus a few from other collectors such as Jack. There are likely to be many more in the general collection that have not yet been databased. As Ridley (1900a) warned, however, many of the Wallich collections supposedly from Singapore are actually labelled 'Singapore et Penang', presumably as the original labels were lost, and it is certain that some of these cannot have been collected from Singapore, being species of higher altitudes than occur on the island.

Jack and Wallich laid the foundations for botanical exploration and study in Singapore and as Singapore grew in importance over the following decades many collectors passed through, stayed awhile and made small collections of plants (see Table 1). Most of these

Table 1. A selection of collectors in Singapore before 1900, arranged chronologically by their collection dates in Singapore, their birth and death dates, places of birth, and where their collections are to be found. For herbaria acronyms see Thiers (continuously updated).

Name	Dates	Place of Birth	Collection dates	Herbaria
Smith, Christopher	?–1806/1807	?	1796	BM, LINN
Jack, William	1795–1822	Aberdeen, Scotland	1819	E, K-W
Potts, John	?–1822	?	1821	OXF?
Finlayson, George	1790–1823	Thurso, Scotland	1822	K-W etc
Wallich, Nathaniel	1786–1854	Copenhagen, Denmark	1822	K-W, K, BM, CGE, OXF etc
Baume, Joseph	1810–?	Toulon, France	1830	P
Hügel, Carl Alexander Anselm [Freiherr von]	1795–1870	Regensburg, Germany	1834	W, M
Walker, George Warren	1778–1843	Northallerton, England	1837	BM, K, G
Hombron, Jacques Bernard	1798–1852	Paris, France	1839	P
Hinds, Richard Brinsley	1811–1846	Aldermaston, England	1841	K, CGE
Wilkes, Charles	1798–1877	New York, USA	1842	US, GH, NY, MO etc.
Yvan, Melchior	1806–1873	Digne-les-Bains, France	1843	G
MacGillivray, John	1822–1867	Aberdeen, Scotland	1845	BM, K
Didrichsen, Didrick Ferdinand	1814–1887	Copenhagen, Denmark	1846	C, B, KIEL
Montigny, Louis Charles Nicolas Maximilian de	1805–1868	Hamburg, Germany	1847	P
Andersson, Nils Johan	1821–1880	Gärdserum, Sweden	1853	S
Wallace, Alfred Russel	1823–1913	Usk, Wales	1854	K, P, E
Schomburgk, Robert Hermann	1804–1865	Freiburg, Germany	1857	K, B
Jagor, Fedor	1816–1900	Berlin, Germany	1858	B
Jel(l)inek, Anton	1820–?	Litomyšl, Czech Republic	1858	W
Vriese, Willem Hendrik de	1806–1862	Oosterhout, Netherlands	1858	L
Anderson, Thomas	1832–1870	Edinburgh, Scotland	1861	CAL, BM, K, B, L
Kurz, Wilhelm Sulpiz	1834–1878	Augsburg, Germany	1863	CAL, L, BO, U
Stoliczka, Ferdinand	1838–1874	Hukvaldy [Hochwald], Czech Republic	1869	W
Xántus, János (Johann)	1825–1894	Csokonyavisonta, Hungary	1869	BP
Steere, Joseph Beal	1842–1940	Rollin, USA	1875	MICH, K

Table 1. Continuation.

Name	Dates	Place of Birth	Collection dates	Herbaria
Veitch, Peter Christian Massyn	1850–1929	Cape of Good Hope, South Africa	1877	K, BM
Augustinovicz, Thoma Matvehevich	coll. 1871–1885	Russia	1879	LE
King, George	1840–1909	Peterhead, Scotland	1879	CAL
Kesslitz, Rainer	?	?	1885	W
Balansa, Benjamin	1825–1892	Narbonne, France	1886	P
Scortechini, Benedetto	1845–1886	Cupramontana, Italy	1886	CAL, BM, K
Hollrung, Udo Max	1858–1937	Hosterwitz, Germany	1887	B
Tschirch, Wilhelm Oswald Alexander	1856–1939	Guben, Germany	1888	BERN
Strubell, Adolf	1861–1927	Frankfurt, Germany	1889	FR
Radde, Gustav Ferdinand Richard	1831–1903	Nowy Dwór Gdański [Tiegenhof], Poland	1891	TB, LE
Veitch, James Herbert	1868–1907	Chelsea, England	1892	K, BM
Schiffner, Victor Félix	1862–1944	Česká Lipa [Böhmisch Leipa], Czech Republic	1893	FH, PR, W
Langlassé, Eugène	?–1900		1894	P
Lauterbach, Carl Adolf Georg	1864–1937	Wrocław [Breslau], Poland	1896	B, WRSL
Möller, Hjalmar August	1866–1941	Ystad, Sweden	1897	LD
Fleischer, Max	1861–1930	Plaśniki, Poland	1898	FH, B, BM etc. (mosses)
Seligman(n), Charles Gabriel	1873–1940	London, England	1898	K
Giesenhagen, Karl	1860–1928	Teterow, Germany	1899	M (ferns & mosses)
Raciborski, Marian	1863–1917	Brzóstowa, Poland	1899	K
Romburgh, Pieter van	1855–1945	Leiden, Netherlands	1899	BO

collections were deposited in European herbaria, primarily the herbarium of the Royal Botanic Gardens Kew. Amongst them were prolific collectors in the wider Southeast Asian region such as Hugh Cuming (collected in Singapore in 1836 and sporadically in the period 1839–40), Thomas Lobb (1845), Alexander Maingay (1862–68) and Odoardo Beccari (1865–78). Alfred Russel Wallace arrived in Singapore in 1854 and explored the wider region over the next eight years, returning frequently to Singapore. Although his collections were mostly zoological, he did also collect plants, the specimens of which can be found in a number of herbaria such as the Royal Botanic Gardens Kew and the Royal Botanic Garden Edinburgh. When all of these

collectors were in Singapore, there was no herbarium on the island for them to deposit their specimens and so all of the collections were sent to Europe. A very small number were later returned to Singapore due to specimen exchanges or purchases.

During this period amateur plant collecting was very popular in Europe and several British people who came to work in Singapore brought their passion with them. This included Richmond William Hullett who lived in Singapore from 1871 to sometime after 1906 (died in England in 1914). Ridley (1900a) and Burkill (1927) reported that Hullett gave his collection to the Singapore Botanic Gardens which by then had established its own herbarium. Collectors in Singapore no longer had to send their collections to Europe if they wished them to be preserved for posterity, they could now remain in Singapore and botanical research could begin in earnest on the island. Today, there are 683 Hullett specimens from Singapore in the herbarium of the Singapore Botanic Gardens.

Singapore Botanic Gardens

Although Singapore Botanic Gardens was founded in 1859, it was not until 1875 that the herbarium and library were established under Henry James Murton (Fig. 3A), the first Superintendent of the Gardens after the Gardens came under the administration of the colonial government (Kiew, 1999). Barnard (2016) notes that 'Murton oversaw the early phases of the transition of the Singapore Botanic Gardens from a pleasure ground to a scientific institution'. In 1879, Murton reported that the herbarium held 3000 specimens from Singapore and Malaya plus a few old collections from India and Nepal (Kiew, 1999), although these specimens were kept in his office for lack of a dedicated herbarium facility. Most of these collections were later sent to Kew (Ridley, 1900a) or were destroyed (Van Steenis-Kruseman, 1950; Barnard, 2016). New offices and a herbarium were built in 1882 when Nathaniel Cantley (Fig. 3B) was the Superintendent. There are 951 Cantley specimens from Singapore in the SBG herbarium but Ridley (1900a) warns us that 'many labelled from Singapore in the herbarium, are either cultivated plants or from some part of the peninsula'.

With the establishment of a herbarium in Singapore, there was a renewed incentive for collection and study of the local flora. Singapore's climate, however, is not conducive to the easy preparation of herbarium specimens, nor kind to herbarium specimens once they are pressed, dried and mounted. For specimens to be useful for scientific study they must be dried quickly so that the plant parts do not begin to decay and so they remain free of fungal contamination. Nowadays we can use an electric oven to dry them quickly and then store them in air-conditioned rooms to keep them dry and free of pests. The early collectors reported on their struggles to dry and store their collections in suitable conditions (Kiew, 1999). Nevertheless, they persisted and the collections remain for us to study today. The most prolific of these early collectors for Singapore Botanic Gardens was Henry Nicholas Ridley (Fig. 3C, 4A).

Ridley arrived in Singapore in 1888 as the first Director of the Botanic Gardens (his initial title was Director of Gardens and Forest, Straits Settlements). Van Steenis-Kruseman (1950), in her monumental work on collectors in the Malesian archipelago, described him succinctly as 'a man of great ability' and the praise of the man and his works only increased from there (see Barnard (2016) for a more thorough discussion of the range of Ridley's work and achievements). He was the Director of the Gardens until 1912 by which time he

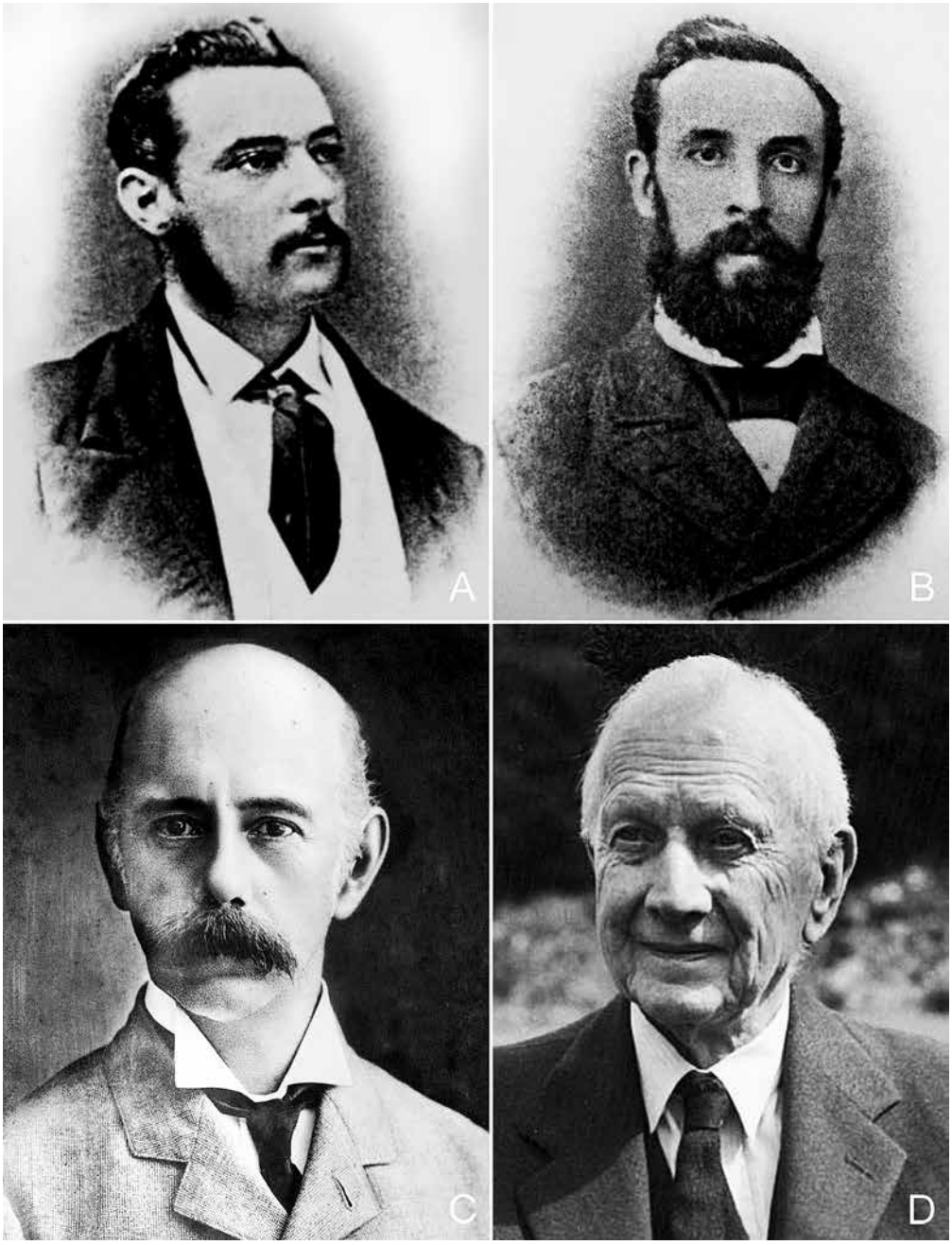

Figure 3. A. Henry James Murton, Superintendent of Singapore Botanic Gardens (SBG) 1875–1880. **B.** Nathaniel Cantley, Superintendent of SBG 1880–1888. **C.** Henry Nicholas Ridley, Director of SBG 1888–1912. **D.** Isaac Henry Burkill, Director of SBG 1912–1925. (Photos: A–D, Archives of the Singapore Botanic Gardens).

had collected over 50,000 specimens from Singapore, Malaya and the wider region. In the Singapore Botanic Gardens' herbarium there are over 8000 Ridley specimens from Singapore, the rest being from what is now Peninsular Malaysia and the surrounding regions.

This was the beginning of a Golden Age of botanical exploration in Singapore and Malaya. In 1889, Tassim Daud was employed as Herbarium Keeper followed by Ahmad Kassim in 1895 (Kiew, 1999). The Keepers of the herbarium were able to bring order to the collections and Ridley used the enormous number of specimens, along with those collected by his contemporaries, to publish an astonishing number of papers. In 1935, before Ridley had stopped working, Henderson & Van Steenis (1935) estimated that he had published over 500 books and papers and over 10,000 printed pages. Over the course of his career in Singapore and his 'retirement' to Kew, Ridley published over 4000 new species (data from the International Plant Names Index), over 100 of which were new species described from Singapore. Though rarely acknowledged on the collection labels, Ridley was ably assisted by local collectors such as Ahmad bin Hassan (Fig. 4A, B). Ridley was also responsible for bringing the de Alwis brothers to Singapore from Sri Lanka. They were two gifted artists who Ridley engaged to illustrate and paint the plants of the region. These paintings are now primarily housed in the archives of the Singapore Botanic Gardens. Ridley retired from the Directorship of the Singapore Botanic Gardens in 1912 but he did make return visits to the region and continued work on the *Flora of the Malay Peninsula* at the Royal Botanic Gardens Kew.

Ridley's successor as Director was Isaac Henry Burkill (Fig. 3D). Burkill was primarily interested in economic botany and his name is strongly associated with his *Dictionary of the Economic Products of the Malay Peninsula*. In 1922, Richard Eric Holttum (Fig. 4C) was appointed as Assistant Director under Burkill. Holttum was a fern specialist, but also had interests in orchids, bamboos and gingers. In 1923, Caetano Xavier Furtado (Fig. 4D) joined the staff of the Gardens. Originally from Goa in India, he was a specialist on palms and aroids and also had a strong interest in botanical nomenclature. Murray Ross Henderson (Fig. 5A) became Curator of the Herbarium in 1924 and worked on various tree groups including *Eugenia* L. (the ones in the region are now mostly in the genus *Syzygium* P.Browne ex Gaertn. and *Calophyllum* L. In 1925, Burkill retired and Holttum became Director. Edred John Henry Corner (Fig. 5B), known as John Corner, was then recruited as Assistant Director in 1929. Although primarily employed to work in mycology, Corner had a strong interest in the ecology and systematics of trees and, though publishing relatively little while in Singapore, he went on to revise *Ficus* L. in the Asia-Pacific region and also produced many mycological publications. In addition, while Professor of Tropical Botany at Cambridge University, he supervised research students, such as Chang Kiaw Lan (Fig. 5C) and Chew Wee Lek, who would go on to play their own part in the history of botany in Singapore.

The dramatic fall of Singapore in 1942 to the Japanese army precipitated a remarkable period in Singapore Botanic Gardens. The Japanese authorities appointed Kwan Koriba as Director, but also permitted Holttum, Corner and Furtado to remain at work in the Gardens. Holttum and Corner would certainly have been otherwise interned and far less likely to have survived the war. After the war, Corner departed Singapore, but by 1946 Holttum was back as Director. The first new staff member of note after the war was James Sinclair. He took up the post of Curator of the Herbarium in 1948. Sinclair's career was largely dedicated to the Annonaceae and Myristicaceae. In 1956 Chew Wee Lek joined the Gardens' staff. A Singaporean by birth, he was sent on a scholarship to Cambridge to do a PhD with Corner and returned to work on the Urticaceae. He became the Director of the Botanic Gardens in 1970.

Figure 4. A. Henry Nicholas Ridley and Ahmad bin Hassan in the Singapore Botanic Gardens' Jungle (nowadays called the SBG Rain Forest). **B.** Ahmad bin Hassan who worked for SBG for 60 years. **C.** Richard Eric Holttum, Director of SBG 1925–1949. **D.** Caetano Xavier Furtado, Chief botanist at SBG, 1923–1960. (Photos: A–D, Archives of the Singapore Botanic Gardens).

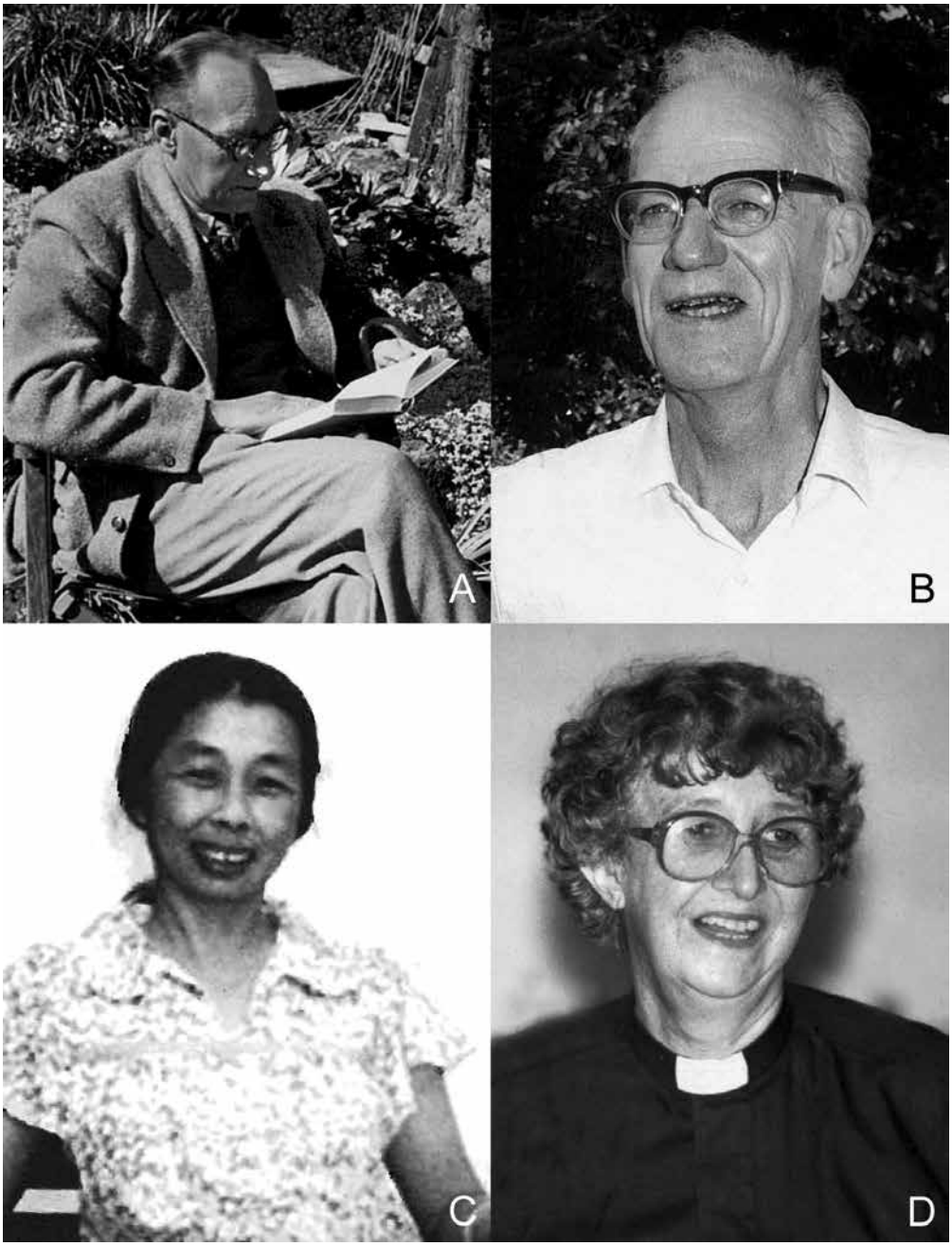

Figure 5. A. Murray Ross Henderson, botanist at Singapore Botanic Gardens (SBG) from 1924 and Director 1949–1954. **B.** Edred John Henry Corner, Assistant Director of SBG 1929–1945. **C.** Chang Kiaw Lan, botanist at SBG 1959–1987 and editor of *Gardens' Bulletin Singapore*. **D.** Anne Johnson, botanist at the University of Malaya and Nanyang University 1951–1980, before becoming a minister of the Presbyterian Church in Singapore. (Photos: A–C, Archives of the Singapore Botanic Gardens; D courtesy of P. Johnson).

Holttum retired from the post of Director in 1949 to become the first Professor of Botany at the university in Singapore, then called the University of Malaya. This initiated a second institution for botanical research in Singapore. In 1951, Anne Johnson (Fig. 5D) started work as a demonstrator with a research interest in bryophytes and pteridophytes, and went on to hold various scientific posts in Singapore and Kuala Lumpur. When Holttum retired from the university in 1955, he was replaced as professor by Hamish Boyd Gilliland (Fig. 6A), a plant taxonomist and ecologist who had grown up and trained in Southern Africa. Gilliland's taxonomic research was focussed on the grasses. Hsuan Keng (Fig. 6B) joined the staff of the Botany Department at the university in 1960. Keng had an excellent grasp of angiosperm systematics, as reflected in his works on higher-level classification in the floras of Malaya and China, but also specialised in the Theaceae and Lamiaceae. James Maxwell (Fig. 6C) arrived in Singapore in 1976 and spent the next eight years as a student at the university and employee of the Parks and Recreation Department. He worked on the taxonomy of the Melastomataceae and collected widely in Singapore. Wee Yeow Chin (Fig. 6D) joined the Botany Department of the University of Singapore in 1977. As a student he had worked under Gilliland on Annonaceae and Myristicaceae, but his career was largely devoted to ferns. Hugh Tan (Fig. 7A) joined the Botany Department in 1982. He, and his many students, have made numerous contributions to the study of the flora of Singapore. Ian Turner (Fig. 7B), an English botanist and ecologist, was first appointed to the Botany Department in 1989, and later joined the National Parks Board at Singapore Botanic Gardens in 1998.

There was rather a downturn in taxonomic research at the Botanic Gardens in the 1970s and 1980s as priorities were switched elsewhere but, as noted by Wong (2012), one effect of this was to greatly widen the international scope of the Gardens' botanical journal, *Gardens' Bulletin Singapore* (in that period primarily edited by Chang Kiaw Lan and Geh Siew Yin [also known as Ng Siew Yin, Fig. 7C]) which could no longer rely on in-house staff for content. Fortunes for taxonomic research began to revive at the Gardens with the appointments of Tan Wee Kiat in 1983, Tay Eng Pin (Fig. 7D) in 1990, Chin See Chung (Fig. 8A) in 1993 and Ruth Kiew (Fig. 8B.) in 1997.

The Collections

No collector since Ridley has come even close to matching the number of specimens from Singapore that he amassed. Table 2 lists the top 10 collectors of specimens from Singapore that are held in the Singapore Botanic Gardens herbarium (SING) (with the caveat that only the first-named collector of a team is credited). These top 10 collectors between them collected in every decade from when Ridley first arrived in Singapore in 1888. Two of these collectors are still on the staff of the Botanic Gardens. Collectors such as Mohamad Noor bin Jumaat (Fig. 8C), Sidek bin Kiah (Fig. 8D) and Samsuri bin Ahmad (Fig. 9A) were all collecting, and curating the collection, until relatively recently. Mohamed Nur bin Mohamed Ghose and his son Mohamad Shah (Fig. 9B) spanned much of the period between Ridley and the recent collectors. Many of these collectors lived in quarters in the Botanic Gardens until this accommodation was discontinued in 1979 (Waterson, 2003). For much of the colonial period, positions as collectors and curators became more or less hereditary, passing from fathers to sons (and often also mothers to daughters for other duties in the Gardens) (Waterson, 2003).

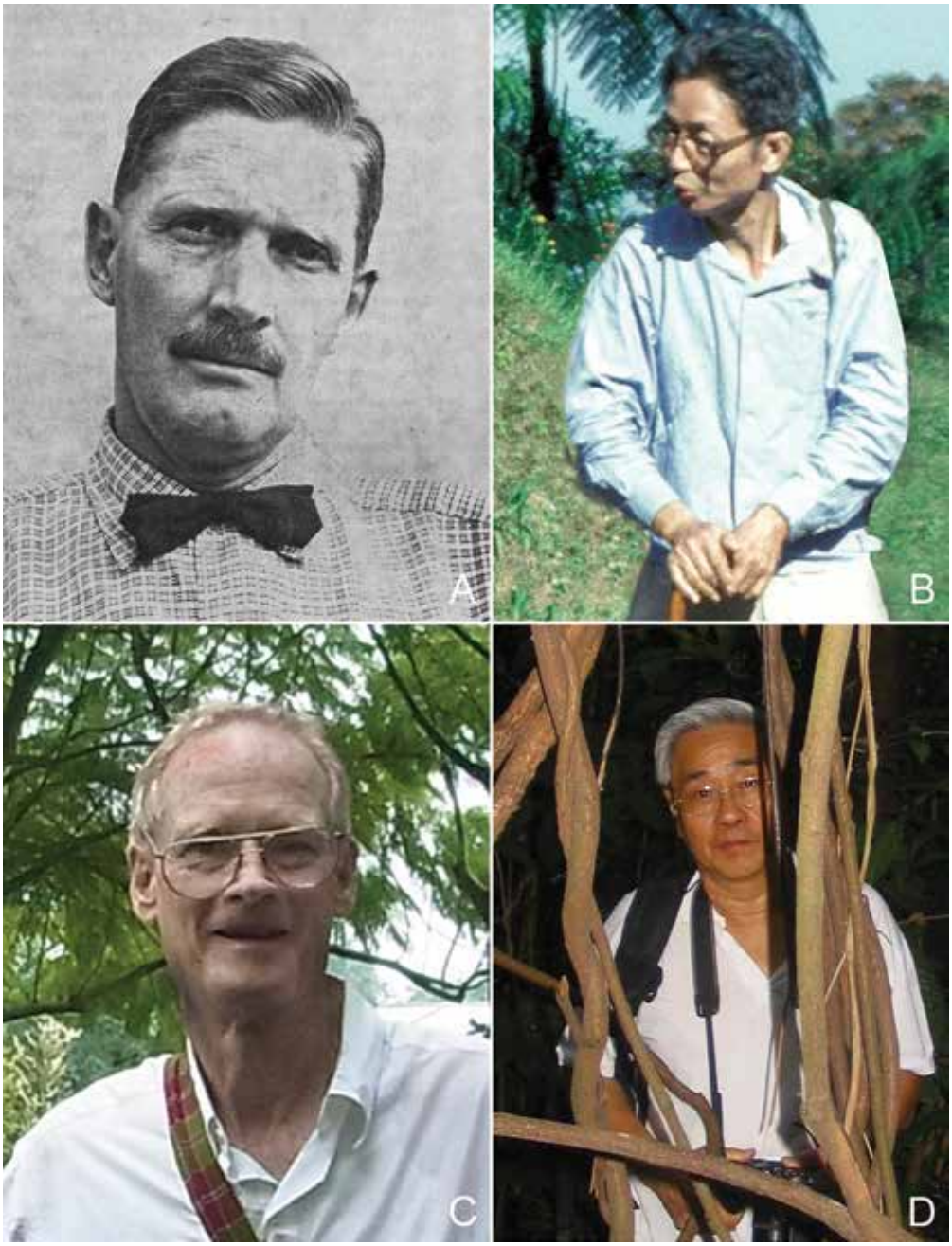

Figure 6. A. Hamish Boyd Gilliland, Professor of Botany at the University of Malaya/University of Singapore 1955–1965. **B.** Hsuan Keng, plant taxonomist at the University of Malaya/University of Singapore 1960–1984. **C.** James Maxwell, research student and taxonomist at the Parks and Recreation Department 1976–1984. **D.** Wee Yeow Chin, plant taxonomist at the University of Singapore/National University of Singapore 1977–1997. (Photos: A, courtesy of Botany Department, National University of Singapore; B, D, courtesy of Y.C. Wee; C courtesy of Ali Ibrahim).

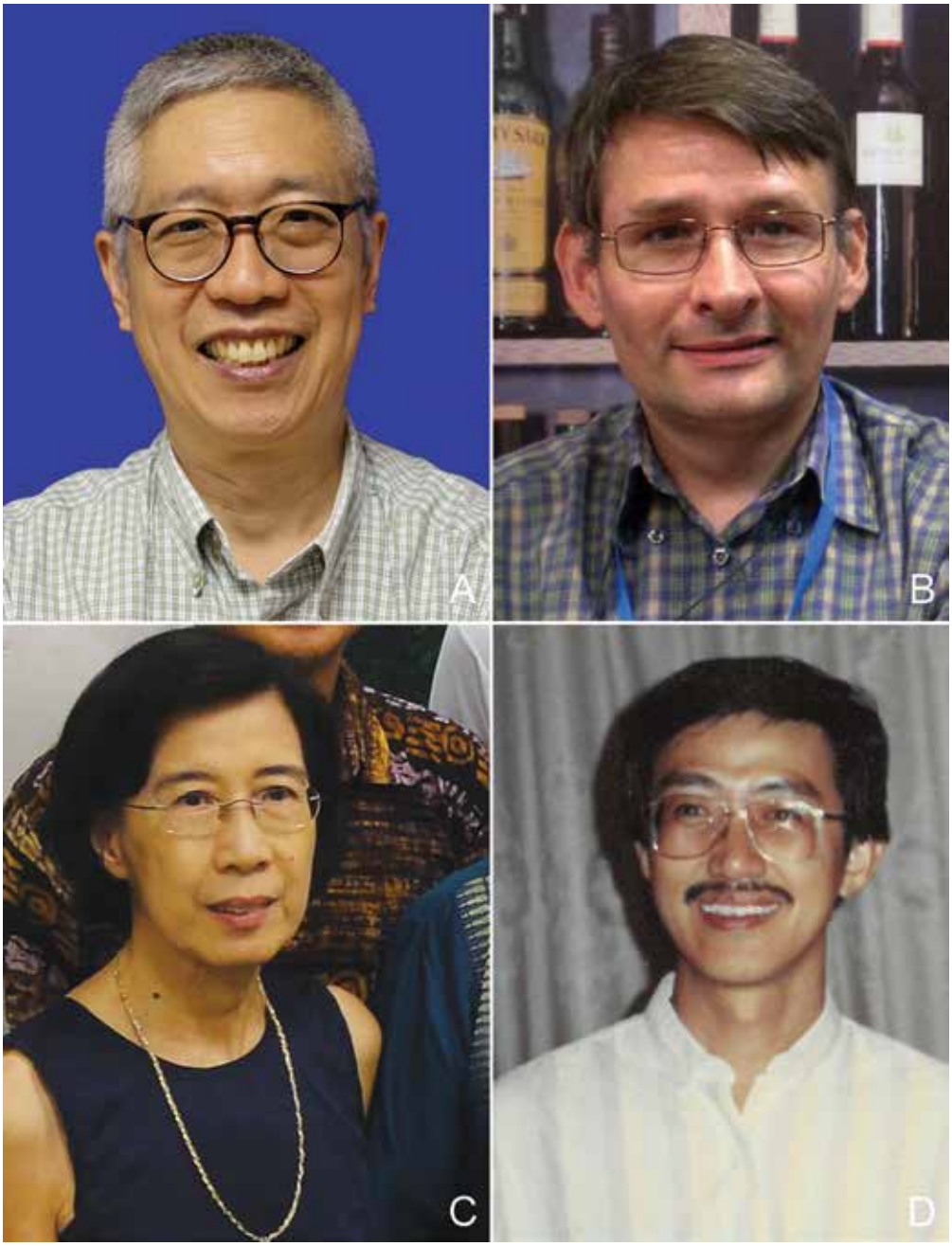

Figure 7. A. Hugh T.W. Tan, botanist at the National University of Singapore 1982–present. **B.** Ian Turner, National University of Singapore 1989–1997, Singapore Botanic Gardens (SBG) 1998–2004. **C.** Ng Siew Yin [née Geh Siew Yin], botanist at SBG from 1971, chief administrator from 1976–1987. **D.** Tay Eng Pin, botanist at SBG 1990–1996. (Photos: A, courtesy of H.T.W. Tan; B, C, courtesy of S. Lee; D, Archives of the SBG).

Figure 8. A. Chin See Chung, Keeper of the Herbarium at the Singapore Botanic Gardens (SBG) from 1993 and Director 1996–2010. **B.** Ruth Kiew, Keeper of the Herbarium at SBG 1997–2006. **C.** Mohamad Noor bin Jumaat, plant collector, ranger and herbarium assistant 1958–2015. **D.** Sidek bin Kiah, plant collector between the 1940s and 1980s. (Photos: A, C, Archives of the Singapore Botanic Gardens; B, S. Lee; D, K.M. Wong).

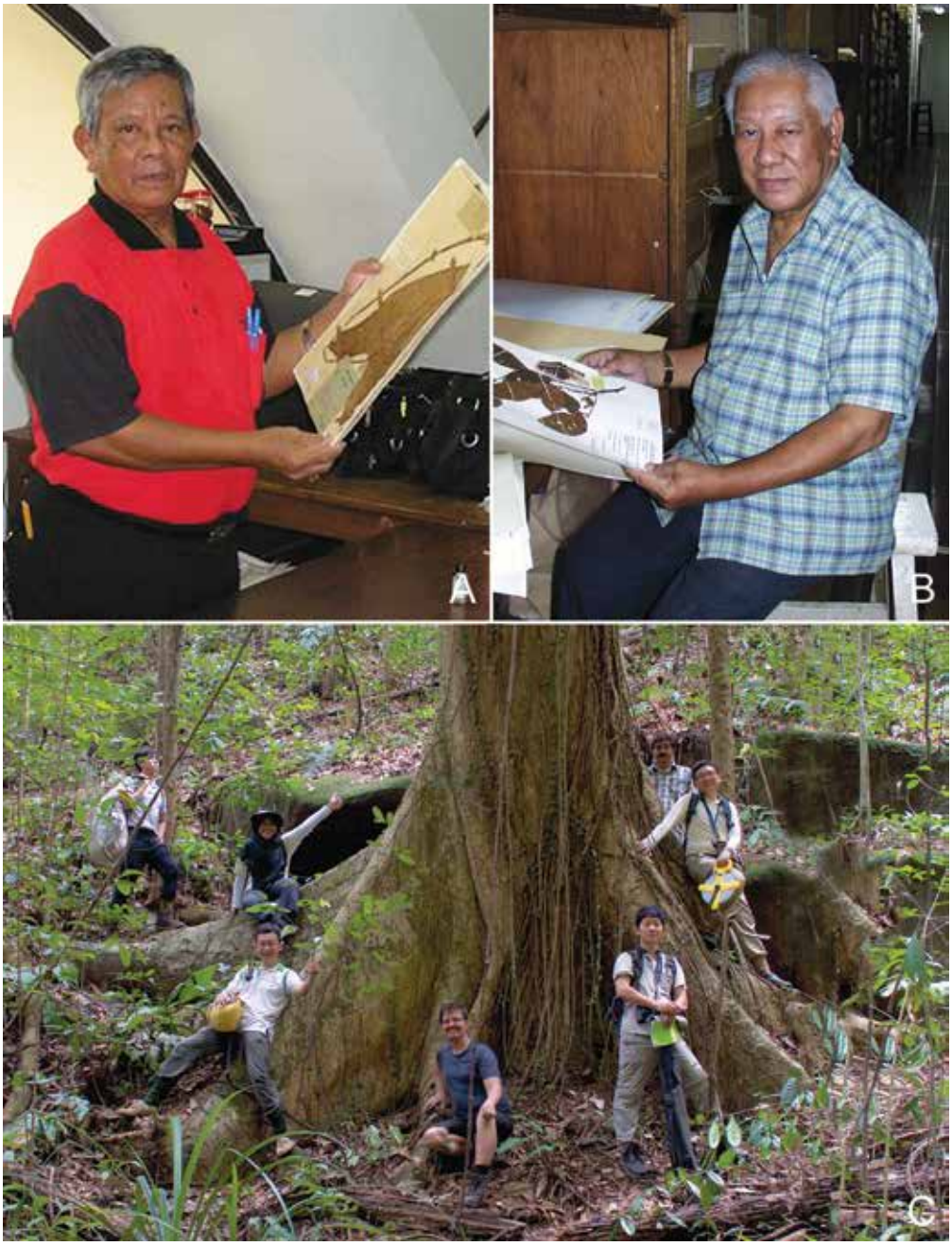

Figure 9. A. Samsuri bin Ahmad, gardener, plant collector and herbarium assistant 1952–2012. **B.** Mohamad Shah bin Mohamad Nur, plant collecter, herbarium and museum assistant and research officer 1955–2003. **C.** Singapore Botanic Gardens and NParks' National Biodiversity Centre staff in Bukit Timah Nature Reserve in 2017 (A, courtesy of S. Lee; B, Archives of the Singapore Botanic Gardens; C, courtesy of M. Niissalo).

With lifetimes of learning from their parents and even older generations, the accumulated knowledge of the plants of the region was quite phenomenal.

It was very common in the past for colonial collectors to send specimens abroad, particularly to Kew (K), without necessarily leaving a duplicate in the herbarium of Singapore Botanic Gardens. For example, more than half of all collections of Apocynaceae made in Singapore are not housed in SING. For species collected in the very early period of botanical collecting in Singapore but presumed to have become extinct soon thereafter, there is often no material in Singapore's herbaria at all. Examples include *Ochrosia oppositifolia* (Lam.) K.Schum. and *Hoya finlaysonii* Wight in the Apocynaceae, both of which are known for Singapore only from collections in Kew's East Indian Company collection. De Kok (unpublished data) has estimated that 68% of Lamiaceae collections made in Singapore are housed in SING and the rest mostly in Kew and London's Natural History Museum. A similar percentage of Gesneriaceae are housed in SING. This demonstrates that a study of the plant diversity of Singapore requires examination of the material in a number of other herbaria, particularly Kew and the Natural History Museum.

Some care must be exercised when using the early collections from Singapore in botanical research. Van Steenis-Kruseman (1950) includes sections in her work on Malesian collectors entitled 'Intentional falsification of labels' and '[Malesian] botanical collections in which errors occur'. As noted above, some of the Wallich collections supposedly from Singapore are actually labelled 'Singapore et Penang' and several of these are species which undoubtedly do not occur in Singapore. These collections fall into the latter category of 'errors' as it is likely the original labels were lost but it was known the batch was from both Singapore and Penang. Thomas Lobb, a collector in the region in the period 1843–1860, is accused by Merrill (1926) and Van Steenis-Kruseman (1950) of deliberately falsifying label data in order to extract higher payments from his employer, Veitch Nurseries in the UK. Suspicions arise due to the fact that the same species with the same collection number is labelled as being from different localities in different herbaria. For example, *Lobb 364*, the type collection of *Drosera lobbiana* Turcz., has duplicates labelled as being from both Singapore and Moulmein in Myanmar. The genus is not otherwise known to occur in Singapore and it is assumed the label is false. Merrill (1926) lists other Lobb specimens supposedly collected from Singapore that he asserts were actually collected in the Philippines. Ridley (1900a), however, rather more charitably, notes only that Lobb's labels 'were all mixed up in distribution, so that his localities as listed in books are quite doubtful'. Ridley (1900a) further notes label irregularities for Maingay collections, with some of his Singapore collections more likely to have actually been collected in Malacca or Penang. Likewise, Ridley (1900a) notes that the labels with 'Singapore' prominently displayed on Cantley's collections masks the fact that many were collected from non-native species in cultivation in Singapore and some were mislabelled plants from Malaya. These issues are highlighted to authors of the accounts for the *Flora or Singapore* and if a species is known in Singapore only from these problematic collections great caution must be exercised.

Despite these slight complications, Singapore Botanic Gardens, along with the herbarium of the National University of Singapore, the Royal Botanic Gardens Kew and a number of other international herbaria, have accumulated a very large number of specimens from what is a small country. This has led to Singapore being arguably the most densely collected country in the world, as calculated by the number of specimens in the herbaria of the world per unit area. Niissalo et al. (2014) calculated that Singapore has a collection density of 5721 specimens

Table 2. The number of specimens collected by the top 10 collectors in the herbarium of the Singapore Botanic Gardens (SING). When a collection is attributed to a team of collectors, this list only attributes that collection to the first collector.

Rank	No. of specimens	Collector
1	8105	Ridley, H.N.
2	2601	Gwee, A.T.
3	1808	Mhd Noor
4	1766	Samsuri, A.
5	1478	Mhd Nur
6	1390	Furtado, C.X.
7	1338	Tang, E. (almost always with Sidek, K.)
8	1291	Corner, E.J.H.
9	1128	Ho, B.C.
10	967	Sinclair, J.

per 100 km^2, which is orders of magnitude higher than the neighbouring countries, which range from only 10 to 200 specimens per 100 km^2 (Middleton, 2003; Middleton et al., 2019). Given that so much of Singapore's native flora was already lost by the late nineteenth century (Cantley, 1885), the collection density in the remaining forest patches is even higher than an even spread would suggest. Nevertheless, new species, new records and rediscoveries of species presumed to be nationally extinct continue to be found (see Chapter 7).

Publications on the plants of Singapore

Jack and Wallich were the first botanists to name large numbers of new species from Singapore although very many of the names Wallich gave to the plants that he collected were actually only published by contemporary or later authors. Botanical works of that era, and even much later in the nineteenth century, tended to include Malaya and Singapore, sometimes even further east to the Moluccas, within a concept of 'India'. Therefore, when the former Superintendent of Calcutta Botanic Garden, William Roxburgh, died and left his unpublished manuscript on the plants of 'India', this included species found in Malaya and Singapore. Roxburgh was a Scottish surgeon who worked assiduously on the plants of the region until ill health in 1813 forced him to leave India, taking with him his substantial manuscript on the Indian flora. After his death, Roxburgh's manuscript was edited and published by his friend William Carey after having been extensively added to by Wallich. Edition 1 was published in two volumes in 1820 and 1824. In volume 1 (Roxburgh, 1820), there does not appear to be any reference to species found in Singapore in the section written by Roxburgh himself, nor in the additions by Wallich. The only Jack collections cited in the work are those Jack made in Nepal before he had visited Singapore in 1819. Volume 2 (Roxburgh, 1824), however, was published after Wallich's visit to Penang and Singapore and includes, therefore, very many additions by Wallich of species

described by him and by Jack, including a number of new species from Singapore. The earliest descriptions of new species of bryophytes from Singapore were also described from Wallich collections by Hooker & Greville (1826).

In the late nineteenth century the Royal Botanic Gardens Kew became the major centre for documenting the plant diversity of the British Empire, leading to the publication of major floras of the African and Asian colonies. The *Flora of British India* (Hooker, 1875–1897), under the leadership of Sir Joseph Hooker, Director of the Royal Botanic Gardens Kew, was the first comprehensive account to include the Malay Peninsula and Singapore. The work, as far as Singapore is concerned, was based largely on the collections amassed in the major herbaria in London, including the East India Company collections and those made by collectors such as Hugh Cuming, William Griffith and Alexander Maingay.

Focus then shifted from Kew to Calcutta, with Sir George King, the Director of the Royal Botanic Gardens Calcutta, who began work on the *Materials for a Flora of the Malayan Peninsula*. The herbarium in Calcutta contained many specimens from Malaya and Singapore which were used in preparing the *Materials*, which also covered the Andaman and Nicobar Islands. During his early years in Singapore, Ridley sent many duplicates of his collections to Calcutta for King and his associates to use. The *Materials* were published as a series of papers in the *Journal of the Asiatic Society of Bengal*. Twenty-five instalments were published in the period 1889–1915 (Ng & Jacobs, 1984), with a final paper on part of the Euphorbiaceae in 1936. The complex history of publication of the original papers, and as reprinted compiled volumes, is outlined by Ng & Jacobs (1984). King and his co-workers covered most, but not all the dicot families. Ridley collaborated on the project by writing up the monocots (Ridley, 1907). These preliminary works provided very solid foundations for Ridley to publish his *Flora of the Malay Peninsula* (Ridley, 1922–1925) which remains the only completed major flora for Peninsular Malaysia and Singapore. It did not, however, include bryophytes, lycophytes or ferns.

Ridley also published the first *Flora of Singapore* (Ridley, 1900a), though this is more of a checklist with notes than a flora. Nevertheless there was no attempt to publish an update until Hsuan Keng began the *Annotated list of seed plants of Singapore* that appeared in 11 parts in the *Gardens' Bulletin* in the period 1973–1987. Keng went on to publish the *Concise Flora of Singapore* (Keng, 1990; Keng et al., 1998). Turner et al. (1990) published a checklist with a more complete nomenclatural account by Turner (1993). More recently, the checklist was revised again and expanded to include all cultivated plants as well (Chong et al., 2009). In the 1990s, a series of papers appeared in *Gardens' Bulletin Singapore* under an umbrella title of 'The Angiosperm Flora of Singapore' and a limited number of accounts appeared on the families Philydraceae (Saunders, 1995), Plantaginaceae (Chua et al., 1995), Schisandraceae (Saunders, 1998a), Burmanniaceae (Saunders, 1998b), Caesalpiniaceae (Loo & Tan, 1998), Limnocharitaceae (Choo & Tan, 1998) and Cannaceae (Tanaka, 1998). In addition, stand-alone books were published on Connaraceae (Goh & Tan, 2000), Erythroxylaceae (Chung & Tan, 2006) and Cannaceae (Tanaka, 2007).

It is nearly 100 years since Ridley completed the *Flora of the Malay Peninsula* in 1925. There was an attempt to update Ridley's work with *A Revised Flora of Malaya*, but while valuable and detailed contributions in themselves, the volumes on orchids (Holttum, 1953), ferns (Holttum, 1955) and grasses (Gilliland, 1971) fell well short of replacing the original flora. Various other regional floras have also been commenced that explicitly or implicitly include Singapore. *Flora Malesiana* covers the floristic region from the Malay Peninsula and

Sumatra to New Guinea. Though far from completion, many families have now been treated and they are an invaluable source of information on the plant diversity of Singapore. The *Tree Flora of Malaya* was completed in four volumes (Whitmore, 1972, 1973; Ng, 1978, 1989) and includes the trees that also occur in Singapore. The ongoing *Flora of Peninsular Malaysia* also provides useful information, including on the ferns and lycophytes that were not covered in Ridley's *Flora of the Malay Peninsula*.

As has almost always been the case in plant systematics, bryophytes have received rather less attention than they should have. The liverworts and hornworts of Singapore have been documented by Piippo et al. (2002) and Zhu et al. (2018). The mosses of Peninsular Malaysia and Singapore have been documented by Dixon (1926), Haji Mohammed & Tan (1988) and Yong et al. (2013), whilst Wee (1979) and Tan & Ho (2008) listed the species specifically for Singapore. Many of the general plant collectors included bryophytes amongst their collections. There have also been specialist collectors of bryophytes such as Victor Schiffner (collected in Singapore in 1893), Hjalmar Möller (1897) and Max Fleischer (1898). The bryologist Benito Tan was a lecturer at the National University of Singapore from 1997 and then Keeper of the Singapore Botanic Gardens' Herbarium from 2006 to 2010.

Unlike the bryophytes, lycophytes and ferns are usually included in checklists and floristic work under a general category of vascular plants. The *Flora of the Malay Peninsula* by Ridley (1922–1925) is, however, a notable exception. They were also not included in Keng (1990) and Keng et al. (1998). They were, however, dealt with by Ridley (1908, 1919, 1926) and in more detail by Holttum (1955) as part of his work on the species in Peninsular Malaysia and Singapore, and also by Johnson (1959) and Wee (1984) more specifically on the ferns and 'fern allies' of Singapore.

The present

Over the decades, floristic research in Singapore has ebbed and flowed with the relative strengths and size of the research teams at Singapore Botanic Gardens (see Kiew, 1999) and the universities in Singapore. Collaboration with overseas researchers has continued throughout, even when research in Singapore was minimal. For example, the Smithsonian Institution has had a long working relationship with the National Institute of Education/Nanyang Technological University and the National Parks Board, the parent organisation of the Botanic Gardens, on a plot set up in Bukit Timah Nature Reserve as part of the ForestGEO (formerly Center for Tropical Forest Science) network of plots to study the ecology of tropical forests across the world (see Ho et al., 2019). For taxonomic research, the collections in the SING herbarium have always been an essential resource for researchers working on the plants of the wider region, particularly for projects such as *Flora Malesiana*, *Tree Flora of Malaya* and the ongoing *Tree Flora of Sabah and Sarawak* and *Flora of Peninsular Malaysia*. The National Parks Board has established several Memoranda of Understanding with other botanic gardens and research establishments for Singapore Botanic Gardens to collaborate more effectively on projects of mutual interest. Notable amongst these overseas collaborations is the one with the Royal Botanic Gardens Kew which has been working with the Singapore Botanic Gardens for almost 150 years and which now has a Singapore Botanical Liaison Officer on its staff.

The research team at the Botanic Gardens (Fig. 9C) has also maintained a wider research remit to explore the plant diversity of the wider Southeast Asian region, with the understanding that this is necessary to also better assess the plant diversity in Singapore. The taxonomic research team in Singapore Botanic Gardens has never before been as large and productive as it is now and has reached a critical mass that allows a project such as the *Flora of Singapore* to be possible.

Floristic research at the Botanic Gardens has widened to include phylogenetic research, particularly through the use of DNA sequence data. These data help to create a more robust taxonomic framework for projects such as the *Flora of Singapore*. The research team has also begun a project, in collaboration with Nanyang Technological University, to sequence the entire genome of all plant species in Singapore. Through all of these projects and initiatives it is recognised that research work is essential to underpin and inform conservation action (see also Chapter 7).