Gardenwise

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Articles

Regular Features

Cover
Cookeina tricholoma, one of the cup fungi featured in this volume's edition of 'From the Earth'. *(Photo credit: Serena Lee)*

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Message from the Director

"The Singapore Botanic Gardens are unique. Civilisation would have been the poorer if they were not maintained", wrote J.W. Purseglove (Director, 1954–1957) in Volume XVII of *The Gardens Bulletin*, which marked the hundredth anniversary of the founding of the Singapore Botanic Gardens. This quote from a distinguished visitor to the Gardens, and other remarks by Purseglove as he pondered over the future of the Gardens exposed his anxiety that it would suffer the same fate of other botanic gardens in the world that had gone through decline and neglect. This was during a period of political uncertainty, when Singapore was just granted full internal self-government in 1959. Among the multiple roles of the Gardens, Purseglove emphasised the most that it must continue to generate scientific knowledge of plants for the benefit of mankind. Post-Independence, as the roles of the Gardens continued to be shaped by national priorities, the Gardens took on different functions, including playing an active and important role to support the greening of Singapore.

How different things are now for the Gardens as it celebrates its 161st anniversary this year. Its grounds have expanded to 82 ha, the largest in its history, as it adds new plant collections, expands its education and outreach efforts, and intensifies its scientific mission. The Gardens' team of researchers currently work with collaborators from about 30 countries in the world on various research projects, including the recently launched *Flora of Singapore* project, and remarkably, almost 100% of visitors recently surveyed rated that they were satisfied or highly satisfied with their overall experience in the Gardens. These important outcomes build upon our outstanding achievement in being inscribed as a UNESCO World Heritage Site on 4 July 2015, only the third botanic garden from among 3,300 in the world, and the first in the tropics to have achieved this. Being recognised as a World Heritage Site is a resounding endorsement that over its long history, the Gardens has managed to uphold its core mission and preserve its Outstanding Universal Values, not just to the nation, but also to humankind. There is also a very high awareness of this cultural value of the Gardens – almost nine in 10 visitors recognise that the Gardens is a World Heritage Site. There should be no doubt that these achievements are only possible because of the dedication and leadership of past and current staff of the Gardens and National Parks Board.

It is a tremendous honour to lead the Gardens at this juncture in its history. But unlike Purseglove who worried over its fate, I am in a much more enviable position to ask this question: how can the Gardens become even better? I share some reflections below.

First, we must embrace digitisation in managing our collections. I illustrate this with the Gardens' herbarium (SING), which houses an impressive collection of about 750,000 specimens, including a sizeable proportion of type specimens. Gone are the days when the only way taxonomists could examine plant specimens was to travel to the herbaria in which the specimens were kept. High-resolution imaging, as we have done with our type specimens, allows any researchers in the world to access our type specimens online. The rapid decrease in costs of high-resolution imaging and digital storage, and development of high throughput scanning systems mean that major herbaria in the world are already well on a path toward a complete digitisation of their preserved collections. The Muséum national d'Histoire naturelle, Paris, the Naturalis Biodiversity Center, Leiden, and the Missouri Botanical Garden with 6 to 8 million specimens, each have at least 70% of their specimens digitised. The Moscow University Herbarium digitised its 1 million specimens completely over five years between 2014 and 2018. SING must push on with its digitisation efforts, not because other herbaria are doing so, but because this will unlock and make more accessible the immensely valuable information captured by our specimens. Much paleobotanical and paleoecological research, as well as phenological studies, can be conducted through the genetic coding of our herbarium specimens, and this may also help to address some of the most important questions we have in science today. The SING collection is a treasure trove of information, and the rapid development of imaging technologies, artificial intelligence and data analytics provide the tools for us to mine this

The plants in our living collections support a variety of animals, like this Terap (*Artocarpus elasticus*) that attracted an Oriental Pied Hornbill (*Anthracoceros albirostris*) when it fruited recently. The Terap is one of the many useful trees in the Jackfruit family (Moraceae), and an exhibition on this subject is currently being held in the Gardens' Centre for Ethnobotany **(see pages 34–35).** *(Photo credit: Paul Leong)*

Our education and outreach team is working hard to instil a love for nature in young children. Here, Taufiq shares about the Oriental Pied Hornbill through a new interactive educational programme aimed at teaching preschool children about the 'Fascinating Creatures of the Singapore Botanic Gardens' (see page 31). *(Photo credit: Steffi Loe)*

information more easily. Digitisation must, of course, be extended to our living collections, historical archives and in time to come, our germplasm collection. Digitisation will make our collections more accessible, better used, and therefore, more valuable.

Second, the Gardens must continue to see environmental education as an opportunity and a mission, over and beyond the impressive work that our education and outreach team is already doing on nature education, gardening courses for adults and nature play for children. The reason in my view is simple – botanic gardens exist because of the understanding that plants are critical for the welfare of people, but with the unabated speed at which species are becoming extinct because of our collective actions and inaction, conservation efforts are likely to fail unless we also change human attitudes and behaviour. It is simply a race against time, and currently our ability to document much of the world's flora and fauna before they disappear forever lags behind the rate at which they are disappearing. If botanic gardens are to fulfil their mission of improving human welfare through scientific studies of plants and their ecosystems, they must also step up to shape positive human behaviour to protect and conserve what is remaining. Human attitudes influence how likely we are to adopt pro-environmental behaviour in our daily lives. Individual actions to reduce consumption of resources and generation of waste may seem small, but the collective societal impacts of these actions are large. With an estimated 380 million annual visits to botanic gardens around the world, the opportunity to rise to the occasion and inculcate a love of nature and desire to protect the environment through education and outreach programmes is an opportunity too valuable to be missed. I also want to relate this to our aim of 'Connecting Plants and People'. This is embroidered on the back of the shirts that our staff wear proudly. But we must pause and ask ourselves, for what purpose do we want to connect people to plants? The Gardens attracts more than 5 million visits each year from visitors who use the grounds for recreation, seek solace from the hustle and bustle of urban living, and find aesthetic and artistic inspiration from our beautiful landscapes, from which they derive multiple health and social benefits. All these bring fulfilment and meaning to our work, but they can also be achieved in other public gardens and parks. Therefore, I cannot think of a more deserving reason for why we connect people to plants than to shape pro-environmental behaviour based on an understanding and love of the natural world through the works of the Gardens.

Third, I suggest that the Gardens must continue to embrace environmental sustainability in all aspects of our work. This applies to the materials we procure, our resource consumption, and, linked to the point above, how we affect the actions of our visitors, both on our grounds and in their daily lives. This is a tall order, but one that is worth striving for.

Forth, we must increase the scientific value of our living collections of plants, which undergird almost everything that we seek to do in the Gardens. Botanic gardens can be seen as custodians and repositories of the world's plant diversity. A recent study by the University of Cambridge and Botanic Gardens Conservation International estimated that there are about 106,000 plant species held in botanic gardens worldwide, which represent 30% of all known plant species and 41% of known threatened species. Two additional pieces of information from the study are telling – of the remaining estimated 250,000 species that are not held in collections, 73% are tropical plants, and 93% of all species in living collections are in temperate regions. Viewed through this global perspective, the Gardens is well positioned to contribute to the conservation of tropical flora through our living collections. The priority must necessarily be placed on conserving the native species that are under threat in Singapore and the region. To be effective in this, our various teams must work seamlessly together to manage our living and research collections. We must continue to apply our horticultural skills to grow and propagate endangered plants while being disciplined and methodological in documenting observations that can also be shared with others. Our living collections should also be seen as a precious resource that can be used to conduct long-term research to better understand how plants adapt to climate change, support pollinators and other animal groups, and tolerate various abiotic and biotic stresses. Suitable plants can then be introduced to other green spaces in Singapore.

I see unlimited opportunities for the Gardens to continue to make meaningful contributions to the nation, science and humankind. This edition of *Gardenwise* gives a glimpse of our work in research, education and outreach, horticulture and new additions to the Gardens, most of which have occurred in an eventful and busy 2019. I look forward to sharing with our readers new and exciting events and achievements of the Gardens in many more issues to come.

Tan Puay Yok
Group Director
Singapore Botanic Gardens

The Mingxin Foundation Rambler's Ridge and OCBC Arboretum at the Gallop Extension

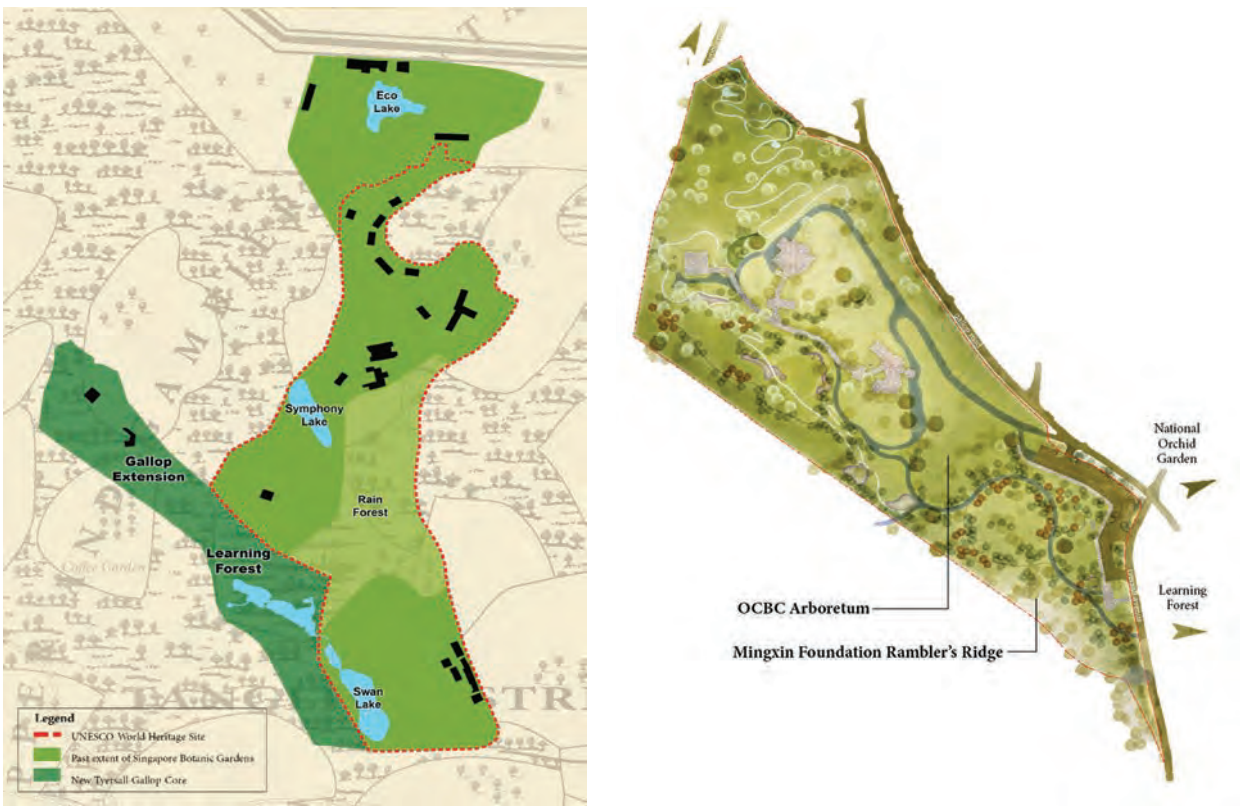
The Mingxin Foundation Rambler's Ridge and OCBC Arboretum are the first two features of the Gardens' new Gallop Extension to be opened to the public. Launched on 19 October 2019, they showcase some of the tropical plants and habitats that can be found in Southeast Asia. The Gallop Extension is the newest part of the Tyersall-Gallop Core, which was created with the opening of the Learning Forest in 2017.

Mingxin Foundation Rambler's Ridge

The Mingxin Foundation Rambler's Ridge introduces a pair of unique habitats to the Gardens' visitors, an oak-laurel forest and a heath forest. In nature, these habitats are found in areas that experience harsh environmental conditions. As a result, the plants that inhabit them have evolved fascinating adaptations that enable their survival.

At around 1,000 to 1,500 m above sea level, oak-laurel forests are found at higher elevations than lowland rainforests. They are usually shrouded in clouds for a large part of the day and experience strong winds and poor soils. This habitat is dominated by trees from the Oak and Laurel families (Fagaceae and Lauraceae, respectively), which are often associated with temperate forests but also occur in the tropics, where they are incredibly diverse. Some of the tree species found in Southeast Asia's oak-laurel forests are the Shining Oak (*Lithocarpus lucidus*) and the Medang Tandok (*Actinodaphne macrophylla*). Due to the constantly high humidity, epiphytes and ferns are also abundant in these forests.

Heath forests have shallow, acidic soils that are low in nutrients and oxygen content. As a result, trees in heath forests are much shorter and skinnier than in rainforests. Many heath forest plants have thick, tough leaves to limit water loss and make them less appealing to predators. Ant plants such as the Baboon's Head Ant Plant (*Hydnophytum formicarum*) are among the most interesting plants found in heath forests. Known as myrmecophytes, these plants



(Left) Together with the Learning Forest, the Gallop Extension makes up the Gardens' newest core, Tyersall-Gallop. (Right) The Mingxin Foundation Rambler's Ridge and OCBC Arboretum are the first two features of the Gallop Extension to be open to the public; visitors can access them easily from the Learning Forest and National Orchid Garden.

An oak-laurel forest habitat on Mount Santubong in Kuching, Malaysia. This is one of the habitat types represented at the Mingxin Foundation Rambler's Ridge. *(Photo credit: Ooi Zong Zu)*

(Top) Acorns from the Shining Oak (*Lithocarpus lucidus*), and (bottom) the foliage of the Medang Tandok (*Actinodaphne macrophylla*), two species found in oak-laurel forests in Southeast Asia and on display at Mingxin Foundation Rambler's Ridge. *(Photo credits: Ang Wee Foong)*

The cross-sectioned tuber of a Baboon's Head Ant Plant (*Hydnophytum formicarum*) showing the cavities used by ants, taken in a heath forest habitat at Bako National Park, Malaysia. This species is on display at the Mingxin Foundation Rambler's Ridge. *(Photo credit: Ooi Zong Yu)*

The Slender Pitcher Plant (*Nepenthes gracilis*) at the Mingxin Foundation Rambler's Ridge.
(Photo credit: Ang Wee Foong)

have a mutualistic association with ants. They provide ant colonies with food and shelter in exchange for protection from herbivores. This symbiotic relationship is possibly due to adaptations such as modified roots, stems and/or leaves that are hollow, which provide a network of tunnels for the ants to live in. Many ant plants also produce food bodies and extra-floral nectaries on their leaves and stems, which help to attract and provide food for ants throughout the year, even when the plants are not flowering.

Pitcher plants are other interesting plants that grow in heath forests, oak-laurel forests, and other nutrient-poor soils in the tropics. They have devised an ingenious way to harvest additional nutrients. They have specially modified leaves that form pitchers to trap small insects, and the pitchers may have grooves or slippery surfaces on the inside to prevent insects from climbing out. The plants produce enzymes that dissolve the trapped insects, releasing nutrients for the plants to absorb. Some species with larger pitchers can even trap small mammals and reptiles! The Raffles' Pitcher Plant (*Nepenthes rafflesiana*) and Slender Pitcher Plant (*Nepenthes gracilis*) are two species of pitcher plant found in Singapore.

OCBC Arboretum

Trees of the family Dipterocarpaceae are featured at the OCBC Arboretum. Dipterocarps are hardwood trees that occur in tropical forests around the world. They are most diverse in Southeast Asia, with over 500 accepted species and possibly more that have yet to be described. Many forest types in the region, such as the coastal hill dipterocarp forest and lowland mixed dipterocarp forest, are named after them, as they dominate the landscape in both sheer number and size.






Flowers, foliage and fruits of some of the dipterocarps planted at the OCBC Arboretum. From top to bottom, left to right: *Dipterocarpus baudii*, *Dryobalanops aromatica*, *Anisoptera costata*, *Dipterocarpus grandiflorus*, *Dipterocarpus kunstleri* and *Dryobalanops aromatica*. *(Photo credits: Lai Simin, except for top right, Benjamin Tan, and bottom right, Jessica Teo)*

Dipterocarps grow to be amongst the tallest trees in rainforests, and they provide homes for a rich diversity of fauna and other flora. They have an unusual reproductive cycle, in which they fruit copiously at intervals of several years. During these events, known as 'masts', dipterocarps in the forest and trees of many other species flower and fruit at the same time. This strategy promotes the survival of the trees, as together they produce too many fruits for wild animals to completely consume and thus many seeds are left to germinate and grow into trees.

The OCBC Arboretum is both a conservation and research project for dipterocarps. Over 200 species are present here, many of which are threatened by deforestation in the wild. The Arboretum acts as a living gene bank, as the seeds produced by these trees will be propagated for use in reforestation projects. Through smart technology collectively termed the Ecological Network of Tree Sensors (ENTS), we are able to monitor the environmental conditions and growth of trees in the OCBC Arboretum to facilitate research in ecology and arboriculture. ENTS uses remote sensing, environmental sensors and the Internet of Things to conduct ecological and conservation research in the Arboretum. ENTS also regularly measures tree growth and health in response to the environment, and the data collected by the system will enable us to better understand and care for the trees in Singapore's parks and urban forests.

Ooi Zong Yu
Horticulture and Operations

Publication of the *Flora of Singapore*

Three volumes of the new *Flora of Singapore* were published on 19 October 2019, in conjunction with the opening of the first two features of the Gardens' Gallop Extension. These mark the first of the planned 14 volumes to cover all species of mosses, liverworts and hornworts; clubmosses and their relatives; ferns; conifers and their relatives; and flowering plants found in the wild in Singapore. The background to this project was discussed in *Gardenwise* 49 (pages 25–26). In short, the *Flora of Singapore* will catalogue the plant diversity found in the country and provide users with the means to identify both the native and naturalised species through descriptions and keys to all genera and species, along with copious photographs and line drawings. The ability to identify all plants in Singapore is crucial to understand the conservation needs of native species and to monitor the naturalised and potentially invasive ones.

Volumes 1, 7 and 13 of the *Flora of Singapore*. *(Photo credit: Tok Yin Xin)*

All of the plant families found in Singapore are preassigned to one of the 14 volumes and each volume will only be published once all of the content for that volume is complete. We have just published volumes 1, 7 and 13, which are the introductory volume, the volume on the grasses, sedges and their relatives, and the volume on the Coffee family, Frangipani family and their relatives, respectively. Altogether the three volumes include over 1,300 pages of text, illustrations and photographs on the plant diversity of Singapore.

Volume 1 is the Introduction and includes an overview, a chapter on the plant orders and families found in Singapore, the history of taxonomic research in Singapore, the plant diversity of Singapore in relation to the diversity of the surrounding region, the vegetation of Singapore, and two chapters on the conservation of plants in Singapore, from a historical and legislative background on the one hand and the practical implementation of conservation measures on the other. The cover has four paintings by artist Waiwai Hove, one on the front and three on the back. The painting on the front is of *Kopsia singapurensis*, those on the back of *Zingiber singapurense*, *Tectaria singaporiana* and *Riccardia singapurensis*. These species, which are just four of the more than 40 plant species named after Singapore (see *Gardenwise* 46, pages 25–27), represent the breadth of the plant diversity to be covered in the *Flora* from liverworts to flowering plants. The front and back covers of volumes 7 and 13 are also adorned with paintings by Waiwai Hove of plants contained in each volume.

Volume 7 includes the order Poales which is made up of the families Typhaceae, Xyridaceae, Eriocaulaceae, Mayacaceae, Cyperaceae, Flagellariaceae and Poaceae. Five of these families have only one or two species in Singapore but the Cyperaceae, the sedges, has 18 genera and 102 species, and the Poaceae, the bamboos and grasses, has 61 genera and 129 species. The Typhaceae and Mayacaceae are only known in Singapore from species that have been introduced and escaped into the wild (i.e. are naturalised here). Likewise, 14 genera and 39 species of grasses are naturalised in Singapore. The Poaceae is the world's most economically and culturally important plant family as it includes cereals (rice, wheat, maize, barley, oats, rye, etc.), sugar cane, bamboos, and fodder and lawn grasses.

Volume 13 includes the order Gentianales which is made up of the families Rubiaceae, Gentianaceae, Loganiaceae, Gelsemiaceae and Apocynaceae. All of these families are native in Singapore but five of their genera and 15 species are considered naturalised. This is a much lower percentage of the total number of species in the order than for Poales (6% vs 19%). The Rubiaceae, the Coffee family, is the largest yet treated in the *Flora of Singapore* with 52 genera and 158 species. The Apocynaceae, the Frangipani family, is also fairly large with 32 genera and 76 species. The other three families in the order are fairly small with nine

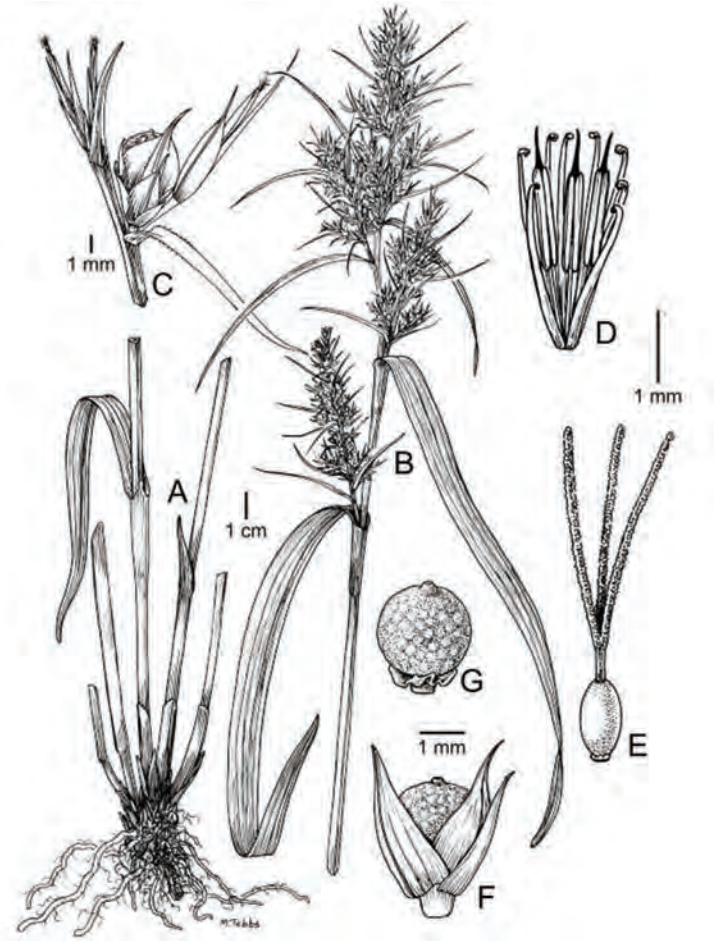


Illustration of *Scleria ciliaris* in the Cyperaceae with various parts highlighted. *(Drawn by Margaret Tebbs)*

***Jackiopsis ornata* in the Rubiaceae with its showy young inflorescences.** *(Photo credit: Wong Khoon Meng)*

***Myrmecodia tuberosa* in the Rubiaceae with its large, ant-inhabited, chambered tuber.** *(Drawn by Evonne Tay)*

genera and 19 species between them. The order includes economically important plants such as coffee and many medicinally important plants in several of the families (e.g. plants that are the source of quinine, strychnine and several cardiac and cancer drugs). In Singapore, many species are used to liven up our parks and streetscapes due to their beautiful flowers.

The necessary research and the writing of these first three volumes has been a truly international effort with contributions from researchers and writers based in Singapore, the UK, the Netherlands, Malaysia, Thailand, Indonesia and China. Between the three volumes, the largest contribution has been by the staff of the National Parks Board (particularly Singapore Botanic Gardens, the Native Plant Centre and the National Biodiversity Centre) in terms of chapters written, genera and species described, and the large amount of work involved in editing and production.

As well as the research and writing necessary for the text, the volumes include large numbers of photographs and line drawings. For the photographs, we have drawn from a large pool of people in the National Parks Board and further afield, with the identifications of the species being verified by the authors of each family. For the line drawings, we have engaged a team of talented artists at the Singapore Botanic Gardens along with a number of artists abroad who have worked with our overseas contributors. Each volume includes an extensive acknowledgements section which demonstrates the large collaborative effort that this *Flora* has been so far and will continue to be.

We were greatly saddened when Jan-Frits Veldkamp, better known as JeF, passed away after delivering his first draft of the grasses to the editor-in-chief. We were fortunate that with the support of his home institution, Naturalis in the Netherlands, and his colleague Leni Duistermaat, we were

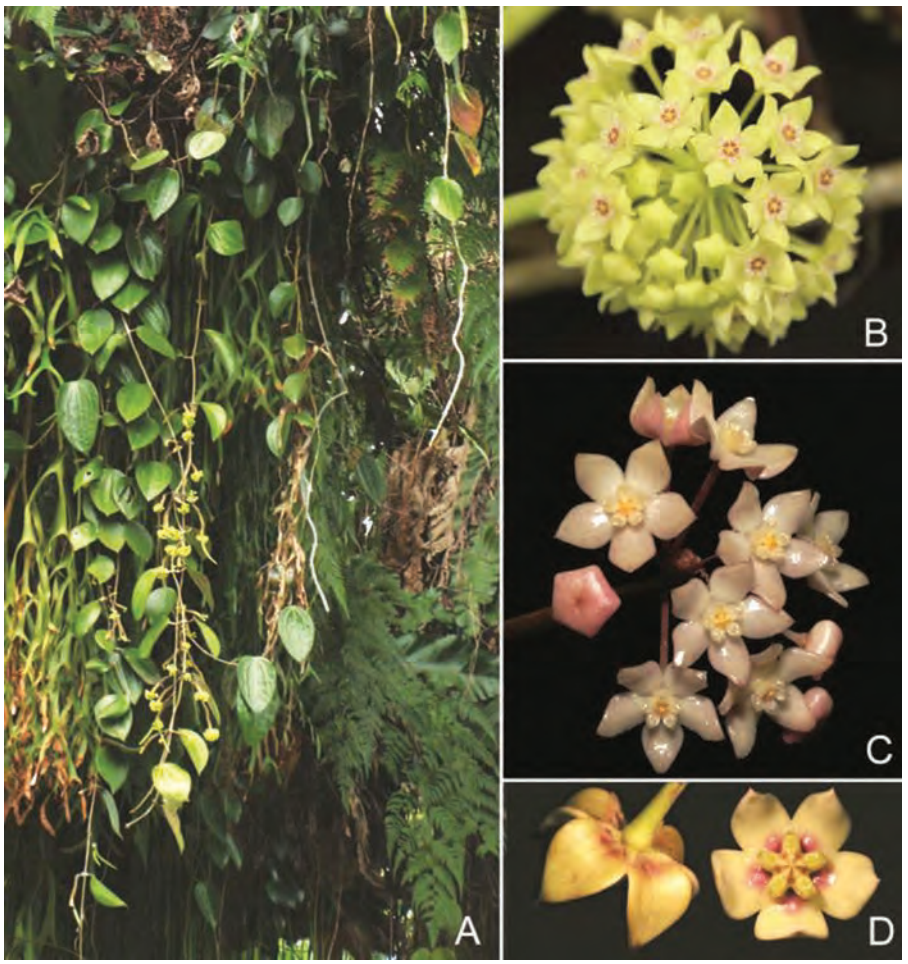
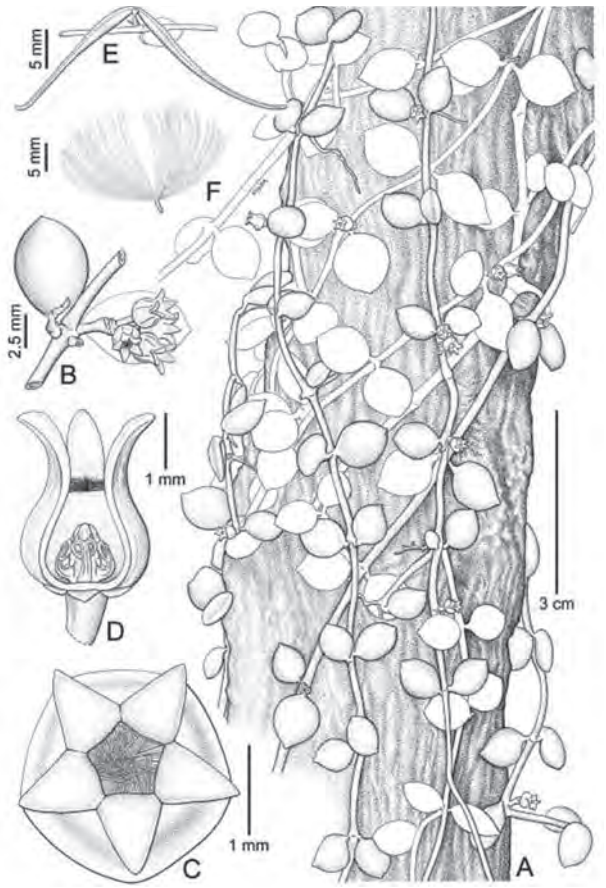


Plate of *Hoya latifolia* (A–C) & *Hoya obtusifolia* (D) in the Apocynaceae.
(Photo credit: Michele Rodda)

***Dischidia nummularia* in the Apocyanceae showing the overall habit and close-ups of the flower and fruit.**
(Drawn by Loh Xiang Yun)



able to complete the account up to the standard we expect of our *Flora of Singapore*.

The effort to publish three volumes at the same time was quite formidable but we wanted to launch the *Flora* with a tangible demonstration of what we were planning for the entire series. From now on we shall publish one volume at a time as the content for each becomes ready. It is likely that the production of volumes will increase towards the later part of the next seven or eight years, but in 2020/2021 we plan to complete the bryophyte volume (the mosses, liverworts and hornworts), the volume with the gymnosperms and so-called basal dicots (the major families of which will be the Cinnamon family, the Nutmeg family, the Pepper family, and the Custard Apple family), and the volume with the Asterales (the Daisy family and its relatives), the Solanales (the Capsicum family and its relatives) and Lamiales (the Mint family and its relatives).

The *Flora of Singapore* can be purchased from the Gardens' shops or, for those purchasing from overseas, ordered directly from the Gardens' library. The content of the volumes already published is also freely available online through our website (www.sbg.org.sg). We plan to publish text-only family accounts online as each family is written and fully edited, pending final publication with photos and illustrations in book form and online when its volume is ready. In time, we also plan to have individual species pages made available through the Gardens' website.

The natural heritage of Singapore is for all Singaporeans and visitors to cherish and protect. The *Flora of Singapore* project will help us better understand our plant diversity and by doing so better enable us to value and conserve it.

David J. Middleton
Jana Leong-Škorničková
Herbarium

Stuart Lindsay
Native Plant Centre

Conserving an enigmatic aroid for Singapore

In early 2016 while conducting a survey at Bukit Timah Nature Reserve, a team from the Herbarium and the National Biodiversity Centre discovered a small colony of an aroid with rather unusual leaves – bullate (puckered) on the upper surface and rather glossy beneath. The plants had scrambled across the dimly lit forest floor and some had made their way up small trees to drape loosely over their branches. As it so happened, there was a flowering stem dangling from a tree within our reach, and we were able to collect a specimen to bring back to the Herbarium for identification. We also made a single stem cutting to pass to our colleagues in the Native Plant Centre so that they could try to cultivate the species.

With fertile material in hand, the team identified the species as *Scindapsus lucens* – a new record for Singapore, and the third *Scindapsus* species reported for this island. It was a rather surprising find that shows us that despite how well explored our forests in Singapore might be, there is always more to discover! Of the other two *Scindapsus* species found here, most of us are perhaps most familiar with *S. pictus*, also known as the Satin Pothos. This species is common in this part of the world and a popular ornamental that is readily available in most nurseries. The other species, *S. hederaceus*, has plain green leaves and is not common in cultivation.

Our newly recorded species, *Scindapsus lucens*, is somewhat of an enigma. It was first described in 1994 from a plant cultivated in the Munich Botanical Garden. It was also being grown at Kew Gardens at that time, but no one had reportedly seen the species in the wild and its exact distribution was unknown. It was almost 15 years later, in 2010, that wild populations of this species were discovered – in Sumatra and Peninsular Malaysia. In Singapore, only two small populations have been recorded so far, including the Bukit Timah population that was found in 2016. Little is known about the species' phenology and how it is dispersed. In Singapore, flowering has only been observed in one

***Scindapsus lucens* in Bukit Timah Nature Reserve. This is one of only two small populations of this species known in Singapore.** *(Photo credit: Lua Hock Keong)*

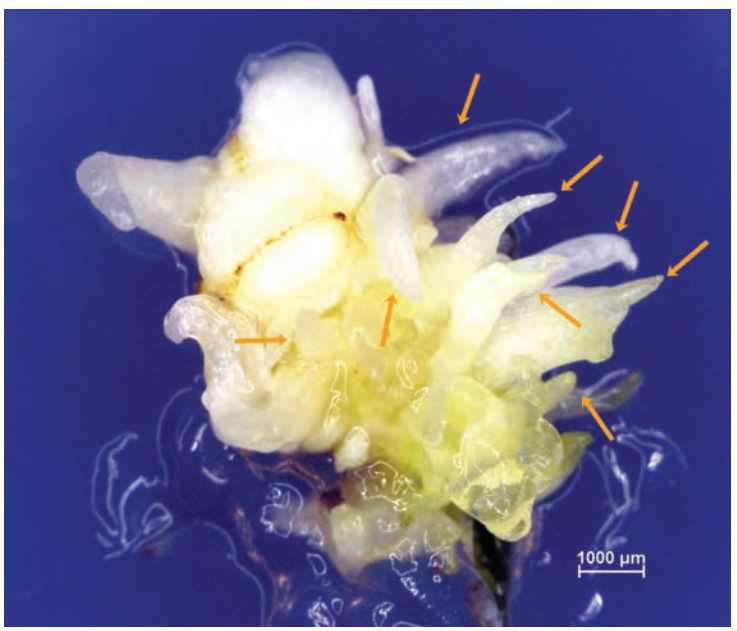
***Scindapsus lucens* with a cone-like inflorescence; the spathe, or petal-like structure, has already been shed. Its leaves are green on the under surface.** *(Photo credit: Lua Hock Keong)*

***Scindapus pictus*, or the Satin Pothos, another of our native *Scindapsus* that is similar to *S. lucens*. The two species are easily distinguished as the leaves of *S. pictus* are dotted with greyish silver specks or blotches, while those of *S. lucens* are plain green and bullate.** *(Photo credit: Lily Chen)*

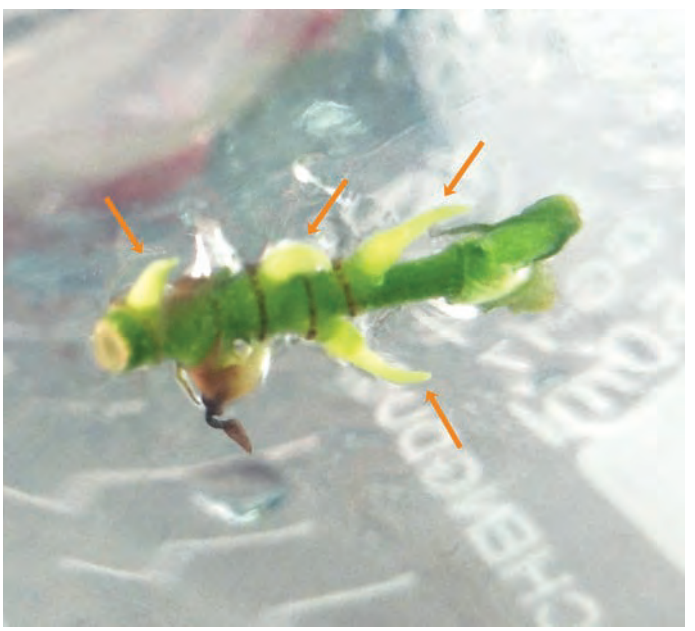
location thus far, and no fruiting has been observed.

It has been mentioned in literature that *Scindapsus lucens* has great ornamental potential due to its rather small size and attractive foliage, and that the best way to protect wild populations from horticultural demand would be to generate plants en-masse for the market via micropropagation. Given the rarity of the species in Singapore and that our small and localised populations do not appear to readily produce fruit, mass propagating this species by tissue culture would likely be highly effective for its conservation. To further protect our wild populations and share this highly attractive plant with Singapore's gardeners, propagated plants could also be introduced to our local horticulture scene.

Staff from the Gardens' Micropropagation Lab and Herbarium teamed up to look into producing *in-vitro* cultures of *Scindapsus lucens*. We experimented with using different types of culture media and parts of the plant. We found that nodal explants cultured on MS (Murashige & Skoog) medium produced new shoots more readily



Multiple shoots (indicated by the orange arrows) on a callus initiated using leaf tissue. In our experiments, tissue culture using leaves tended to produce more shoots than tissue from stems, but they took much longer to regenerate. *(Photo credit: Koh Teng Seah)*



Subcultures of stem sections produced shoots from multiple nodes (indicated by the orange arrows) when grown in phytohormone treated media. In phytohormone free media, sections of the stems tended to produce only one shoot; the rest of the nodes remained inactive. *(Photo credit: Koh Teng Seah)*

Plantlets of *Scindapsus lucens* generated *in-vitro*; these were about 5 to 6 cm tall at the time and ready to be de-flasked for acclimatisation and planting in conventional media. *(Photo credit: Chin Li Li)*

***Scindapsus lucens* being propagated and cared for in the Native Plant Centre. The Micropropagation Lab intends to produce at least 300 more plantlets from material collected from both of the wild populations in Singapore.** *(Photo credit: Cherish Yong)*

than cultures grown from unopened leaves, although the leaf tissue cultures tended to produce more shoots. In fact, it took five months for new shoots to emerge in our leaf cultures, compared to only three weeks for the nodal tissue to do so. Cultures from leaves have to undergo callus development prior to shoot regeneration, and thus it was not a surprise that they took longer. We were, however, able to increase the number of shoots produced by the faster-generating nodal tissue by supplementing the MS medium with synthetic cytokinin and auxin compounds, which are phytohormones.

Although our nodal cultures were quick to develop shoots, subsequent growth was slow, taking another four to five months before they lengthened. Overall, it has taken us between six months and a year to produce *in-vitro* cultures that can be used for sub-culturing. The lab is currently working on methods to speed up development and growth, and by the end of 2020, we are hoping to produce at least 300 plantlets that can be sent to the Native Plant Centre for planting into our nature reserves, parks and gardens.

Scindapsus lucens is comparatively easy to cultivate. Our colleagues in the Native Plant Centre who have been growing it since 2016 have found that it performs well under 50% shade and in a slightly acidic soil medium that drains moderately well. Unlike some other aroids which have highly attractive juvenile leaves but rather drab looking adult leaves, *S. lucens* produces leaves with one attractive form throughout its life. It is an ideal subject for indoor gardens and green walls in partially shaded areas.

Koh Teng Seah
Chin Li Li
Micropropagation Lab

Cherish Yong
Native Plant Centre

Lily Chen
Ho Boon Chuan
Herbarium

Lua Hock Keong
National Biodiversity Centre

The characteristic 'faces' of *Canarium*

The Burseraceae is currently represented by about 19 genera and 775 species, although these numbers will likely change in the future owing to ongoing taxonomic and phylogenetic studies. The Burseraceae are typically medium to large-sized trees, rarely shrubs. Members of the family are not only ecologically important, often being a major component of the canopy layer in tropical forests and a food source for animals, but also economically important. All species in the family produce an aromatic resin which can be extracted and made into candles and incense. In particular, *Boswellia carteri* (Frankincense) and *Commiphora abyssinica* (Myrrh) are well known and sought after for making incense, which is used in religious ceremonies and Chinese medicine, among other things. Many species from the genus *Canarium* are cultivated for their fleshy fruits and edible seeds, which are generally eaten after some processing. This article will introduce interesting aspects of the fruits and seeds of the genus, as well as some notable species.

Canarium species have ovoid to oblong, sometimes triangular in cross-section, drupe-like fruits with a fleshy outer layer (the pericarp) and a hard stone (the pyrene). The pericarp of the fruits is edible but often processed or cooked prior to consumption. The pyrene contains three cells, but one or two of them are often slightly or almost entirely reduced and never develop into seeds. The mature seeds have fleshy and much folded seed leaves (cotyledons) which are edible as well. When the pyrene is cross-sectioned, the number of seeds and reduced cells are visible and they often look like adorable, funny, or sometimes horrified faces. The characters of the pyrenes and their cross-sections appear to be rather consistent within each currently recognised taxon. As both the flesh and seeds of these plants may be eaten, it is no surprise that many species have been cultivated for that purpose.

One cultivated *Canarium* species familiar to us would be *C. album*. Commonly known as Chinese or Green Olive, it is unrelated to *Olea europaea*, the European Olive from the Oleaceae. The flesh of the fruits of the Chinese Olive are often dried, preserved and flavoured with liquorice to make a snack called 甘草橄榄 (*gān cǎo gǎn lǎn*) in Chinese. The flesh is also sometimes dyed red or green and eaten as a snack during Chinese New Year. Usually sweet and crunchy, it is quite a treat for children and adults alike.

A portrait of *Canarium* spp. showing their different 'faces'. The leftmost cross-sectioned pyrenes with two developing seeds and one highly reduced cell, forming 'faces' resembling chipmunks, are of an unidentified *Canarium* sp., and the cross-sectioned pyrene at the top is an abnormality of *Canarium latistipulatum* subsp. *mitus*. *(Photo credit: Adi Haliq)*

Canarium odontophyllum, an endemic of Borneo, is known as Dabai in Sarawak or Kembayau in Brunei and Sabah. Fruits of this species are highly prized in that region for their flesh. They first have to be soaked in hot water to soften and cook before eating. The texture of the cooked flesh is a little grainy and the earthy taste is an acquired one.

(Left) *Canarium odontophyllum* fruits in a local market in Brunei, and (right) a cross-sectioned pyrene with one mature seed and two reduced cells. *(Photo credit: Cerlin Ng)*

Canarium latistipulatum subsp. *mitus* is a subspecies found in Brunei and locally known as Mitus. This subspecies is widely cultivated in some areas for its seeds that have a crunchy cabbage-like texture and pleasant nutty taste. However, because of the hard stony pyrene, it can sometimes be a challenge to get at the seeds.

(Left) Cross-sectioned pyrenes of *Canarium latistipulatum* subsp. *mitus* with one large seed (removed) and two reduced cells, forming a 'face' with a big mouth and slit-like eyes, and (right) a close-up of a seed.
(Photo credit: Seah Wei Wei)

Canarium vulgare, also known by its common name Java Almond, is more often cultivated for ornamental purposes rather than consumption, although like the other *Canarium* species mentioned here, its fruits are edible. Its seeds are sometimes used as a substitute for almonds, especially after roasting. Individuals of the species can grow up to 45 m tall and develop buttress or prop-like roots which makes them highly attractive. There is a row of trees of this species, one of which is a Heritage Tree, planted along a driveway that used to lead to the now-demolished Tyersall House. This area is now a part of the Keppel Discovery Wetlands in the Learning Forest at the Tyersall-Gallop Core, and visitors may admire these trees near the Canarium Pond.

(Left) Cross-sectioned pyrenes of *Canarium vulgare* with two mature seeds (most removed) and one reduced cell, forming 'faces' with long eyes and an upturned mouth, very much like characters from a Tim Burton animated movie, and (right) a close-up of a seed. *(Photo credit: Seah Wei Wei)*

Lastly, *Canarium pilosum* is a species native to Singapore. It is a small to medium-sized tree that can grow to 27 m tall, with small fruits up to 3 cm long and 1.5 cm wide. Its seeds are harvested in the wild but the species is not known to be commercially cultivated for that purpose. This species can be found in the forests of Bukit Timah Nature Reserve and the Central Catchment Nature Reserve, as well as in the Gardens' Rain Forest.

Cross-sectioned pyrenes of *Canarium pilosum* showing one mature seed and two reduced cells, forming rather sad looking 'faces'. *(Photo credit: Adi Haliq)*

A packet of liquorice flavoured Green Olives, also known as 甘草榄, most likely produced using the fruits of *Canarium album*.
(Photo credit: Seah Wei Wei)

Beautiful and interesting both inside and out, certainly there is a lot more to learn about the fruits and seeds of *Canarium* and their various 'faces'. Amusingly, I.H. Burkill, second director of the Gardens (from 1912 to 1925) and a specialist in economic botany, wrote in his famed *A dictionary of the economic products of the Malay Peninsula* regarding *Canarium rufum* (now reduced to a subspecies of *Canarium littorale*) that although there is little worth in the fruits of the taxon because of their hard pyrene and small seed size, "people with nothing to do pick them up and amuse themselves by cracking the shell and eating the kernel." We enjoyed reading Burkill's observation, as we expect that this is probably how the discoveries of edible and delicious wild fruits and seeds of *Canarium* and many other genera, as well as the methods for processing them, were made.

Seah Wei Wei
Serena Lee
Herbarium

The Seed Dispersal Garden

The Seed Dispersal Garden, along with the adjoining Seed Bank, was officially opened on 13 July 2019 by Mr Desmond Lee, Singapore's Minister for Social and Family Development and Second Minister for National Development. Together with Mr Kenneth Er, CEO of the National Parks Board, Minister Desmond Lee planted a Double Coconut (*Lodoicea maldivica*) in the Seed Dispersal Garden. This palm is renowned for producing the largest and heaviest seed in the world.

The aim of the Seed Dispersal Garden is to complement the Seed Bank and highlight the various ways that flowering plants have evolved to disperse their seeds. The roughly 150 species of plants on display here are grouped according to their method of dispersal. In nature, seeds can be dispersed in many different ways, such as by animals present in the environment, abiotic means such as wind or water, or by self-dispersal.

Most flowering plants begin their lives as a seed. Within the seed is an embryo, which typically has a cotyledon (if a monocot) or two cotyledons (if a dicot) that provide food for the plant after the seed germinates. The seed generally has a seed coat or 'testa' for protection against the weather and/or water, and may also help it to survive passage through the digestive tract of an animal if eaten. Dispersal is important for plants as not only does it prevent competition for nutrients and space between the mother plant and its offspring, it also allows plants to colonise wider areas, thereby increasing the chances of the species' survival.

A path through the Seed Dispersal Garden brings visitors through four different zones, each representing a different habitat type in which the respective method of dispersal is common. The Self Dispersal Zone recreates a secondary forest type habitat, and the plants found in this part of the garden have seedpods that dehisce when mature to release the seeds inside. The Wind Dispersal Zone features a dry grassland habitat, with grasses, orchids and deciduous trees that produce seeds that are dispersed by the wind. On display in the Water Dispersal Zone is a sandy beach type habitat with plants that rely on water to disperse their seeds, while the Animal Dispersal Zone represents a rainforest setting with plants that produce showy, colourful fruits for attracting animals. In each of these zones, a sculpture by Mr Chua Boon Kee illustrates the seeds of one of the plants featured in the respective zone.

The Seed Dispersal Garden with the Seed Bank in the background. These new features are accessible from the Red Brick Path in the Bukit Timah Core, or from the Summit canteen at NUS. *(Photo credit: Jerome Koh)*

(Clockwise from top left) The sculptures in the Seed Dispersal Garden feature the Javan Cucumber (*Alsomitra macrocarpa*) in the Wind Dispersal Zone; the Saga Daun Tajam (*Adenanthera malayana*) in the Self Dispersal Zone; the Green Coffee Tree (*Canthiumera robusta*), Queen Coralbead (*Coculus orbiculatus*) and Broad-leaf Bramble (*Rubus moluccanus*) in the Animal Dispersal Zone; and the Sea Pong-pong (*Cerbera manghas*) in the Water Dispersal Zone. *(Photo credits: Jerome Koh)*

Self Dispersal (Autochory) Zone

Visitors to this part of the Seed Dispersal Garden will find autochorous plants like the Saga Daun Tajam (*Adenanthera malayana*), a canopy tree found in primary and secondary rainforests in Singapore, Peninsular Malaysia, Sumatra, Borneo and Thailand. Its seedpods may grow up to 15 cm long. As they mature, they twist spirally and eventually fall to the floor where they split open to reveal glossy, bi-coloured red and black seeds inside. Some plants have evolved multiple dispersal methods, and the Saga Daun Tajam is an example of this. Not only are its seeds self-dispersed, they may be transported further away from the parent plant by birds. The seeds are surrounded by a hard seed coat that enables them to pass through the gut of these animals intact.

(Left) The seedpod of a Saga Daun Tajam which has split open to release the bicoloured red and black seeds contained inside. *(Photo credit: Jerome Koh)*
(Right) The seedpods develop from catkins that are made up of many individual flowers that turn from white to yellow when mature. *(Photo credit: Zaki Jamil)*

(Left) The ripe fruit of the Sea Pong-pong. The red exocarp disintegrates to reveal a fibrous mesocarp which allows it to float in the sea. Inside is a woody, waterproof endocarp that protects the seed during prolonged periods in the water.
(Right) The fruit develops from a flower that is white with a brilliant red throat.
(Photo credits: Jerome Koh)

Water Dispersal (Hydrochory) Zone

Here, visitors will find the Sea Pong-pong (*Cerbera manghas*) among the hydrochorous species on display. The fruits of this tree have an outer covering that turns from green to red when mature. This covering disintegrates to reveal a thick and fibrous layer that helps the seed stay afloat, and a waterproof seed coat prevents saltwater from destroying the seed's contents. These adaptations enable long-distance flotation, and facilitate the establishment of the Sea Pong-pong along waterways in coastal forests and back mangroves. Also found in this zone is the Sea Purslane (*Sesuvium portulacastrum*), a native creeper whose fruits are dispersed by water and deposited in crevices on beaches. There, the seeds germinate and the stolons quickly spread to form a carpet over the sand bed.

Wind Dispersal (Anemochory) Zone

Found in the Wind Dispersal Zone, the Critically Endangered Tandok-tandok (*Strophanthus caudatus*) produces seeds with a tuft of hair that catches the wind and acts as a parachute. Another interesting example here is the Banjutan (*Hopea ferruginea*); also Critically Endangered, like other dipterocarps it has winged seeds that propel down from the canopy onto the forest floor like helicopters. Other anemochorous plants in this part of the garden have seeds with papery wings that enable them to glide in the wind. An example is the Javan Cucumber (*Alsomitra macrocarpa*), with seeds that are masters of aerodynamics. This climber produces a football-sized fruit called a pepo, which contains hundreds of tightly packed winged seeds known as samaras – at only 1 mm thick, each samara is so light that it can glide in the wind for hundreds of metres.

(Left) The juvenile leaves of the Javan Cucumber. (Right) Shown here on display at the Seed Bank, this climber's huge fruits contain hundreds of samaras that glide in the wind. *(Photo credits: Jolene Lim)*

Animal Dispersal (Zoochory) Zone

Mammals, birds, reptiles and even insects are important in maintaining regional diversity and gene flow through seed dispersal. Some zoochorous plants produce fleshy or brightly coloured fruits with indigestible seeds, while others have hooks or hairs that cling onto passing animals. An example of the latter is the Rumput Lilit Kain (*Centotheca lappacea*), a Critically Endangered native grass found in the forest margins of Singapore and on display in the Animal Dispersal Zone.

(Left) Habit of the Rumput Lilit Kain in cultivation in the Seed Dispersal Garden. (Above) An infructescence clinging onto fabric, displaying how easily it can be transported by animals (and people). *(Photo credits: Jolene Lim)*

Also found in this part of the garden are the Broad-leaf Bramble (*Rubus moluccanus*), a native wild raspberry that produces showy red berries, and the Queen Coralbead (*Cocculus orbiculatus*), a climber with grape-like fruits that turn from green to blue as they mature.

(Left) The bright red berries of the Broad-leaf Bramble attract birds and mammals to consume them and help to disperse the seeds. *(Photo credit: Jerome Koh)* **(Above) The grape-like fruits of the Queen Coralbead which look appetising to birds and humans alike!** *(Photo credit: Jolene Lim)*

As the world's natural ecosystems are increasingly lost to urbanisation and degraded through anthropogenic activities, the Gardens' Seed Dispersal Garden and Seed Bank aim to conserve threatened plant species by preserving their genetic diversity. We also hope that they will help to raise awareness on the wonders and diversity of plant dispersal methods, and foster greater interest in their study for plant conservation.

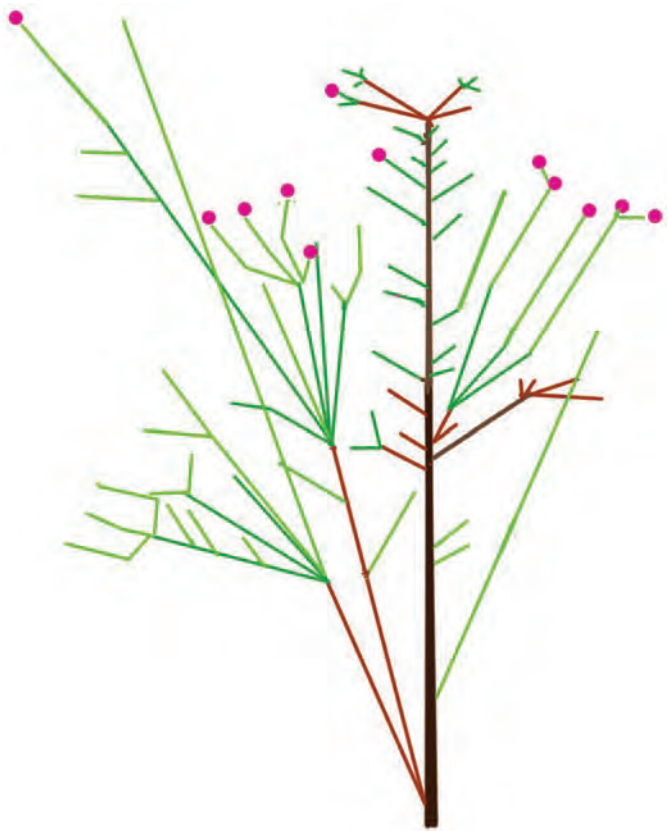
Jolene Lim
Jerome Koh
Horticulture and Operations

Living versus herbarium collections for research

In the last issue of *Gardenwise*, David Middleton extolled the virtues of herbarium collections and preserved specimens for botanical research, especially that relating to the taxonomy (identification and classification) of plants, including their geographical range and conservation status (volume 53, pages 28–30). While an herbarium is an essential part of any botanic garden that intends to do taxonomic research, gardens are, of course, the home of living plants and here I would like to examine how the living can be exploited for research in ways that preserved herbarium collections cannot.

One obvious limitation of an herbarium specimen, however well preserved and documented (labelled), is that it is dead. Anyone who studies the taxonomy of plants will tell you that the majority of species show a degree of variation, whether within a discrete population or over their geographical range. The cause of this variation can be twofold: genetic or phenotypic. Genetic variation is important because it causes real and inheritable differences between individuals and populations, whereas phenotypic variation is that induced by the environment in which the plant is found. In the herbarium it can be very difficult if not impossible to distinguish these two causes of variation, but when plants from different places and habitats are brought together and cultivated under uniform conditions it soon becomes possible to eliminate phenotypic variation from the equation.

In my eight years at the Singapore Botanic Gardens, I have been able to study a genus of cacti (my specialist interest) as living plants. I will use this experience to illustrate the range of advantages that the living have over the 'dead'. While I have been growing and studying cacti much of my career (I could say nearly all of my life), the majority of plants from this family cannot be grown satisfactorily outdoors in Singapore's climate, because their physiology is not adapted to the high night-time temperatures experienced in our lowland equatorial warm-ocean-buffered situation. *Pereskia* (including the segregate *Leuenbergeria*) however, being a genus of cacti with well-developed leaves using conventional C3 metabolism, loves Singapore's climate and will grow here at a speed that no other cactus can match.



Growth architecture of *Pereskia* (*Leuenbergeria*) *quisqueyana*, showing the occurrence of apical branching (the different colours represent successive growth periods over three years). *(Image credit: Daniela Zappi from drawings by author)*

One of the aspects of plant morphology and behaviour which cannot be deduced in the herbarium is the developmental sequence from seedling to adult, as well as phenological differences, meaning variation in the timing of when individual specimens begin to grow, flower, go to rest, etc. For example, two species can appear very similar as adult plants, but if their seedling and juvenile stages are studied, marked differences in morphology and behaviour can be detected. Such differences are very difficult to notice in the field when collecting herbarium material as the botanist is rarely able to spend enough time in habitat or to return to a site repeatedly at different times of the year as the seasons change.

In Singapore, I have grown and studied a variety of *Pereskia* species including endangered species from the *P.* PORTULACIFOLIA group of four dioecious species endemic to the Greater Antilles (dioecious meaning that male and female flowers are borne on separate plants). Two of these I have grown from seed to maturity and have been able to study their development as well as compare them with living plants of the other two species in the group. These belong to the subgenus *Leuenbergera*, which is

(Left) *Pereskia* (*Leuenbergeria*) *marcanoi* seedling with densely arranged leaves, the youngest of which are green. (Right) In comparison, *Pereskia* (*Leuenbergeria*) *quisqueyana* has less densely arranged leaves that are reddish orange when young.

Detached massive tuberous roots of *Pereskia* (*Leuenbergeria*) *quisqueyana*.

probably worthy of recognition as a genus in its own right, as *Leuenbergeria*. I have also grown various other members of *Leuenbergeria* and have discovered that their developmental patterns have much in common, but are different from those of *Pereskia* in the strict sense. Studied as herbarium specimens and even in habitat as mature individuals, these differences would be quite difficult to detect. The Leuenbergerias, at least when young, mainly branch from the apex of existing stems, whereas the true Pereskias branch quite randomly and mostly by means of lateral, not apical shoots. The material that can be accommodated on a standard size herbarium sheet is unlikely to show these differences.

Returning to the *P.* PORTULACIFOLIA group, the two endangered species I grew from seed are *Pereskia quisqueyana* and *P. marcanoi*. At maturity these two have rather similar leaves and flowers, the latter being quite fleshy so difficult to interpret once preserved, even if kept in liquid preservative rather than pressed and dried. In life, however, you cannot fail to see how different they are. Developmentally, the former species has a tall, slender unbranched primary stem, whose newest leaves get larger as it grows and when very young are orange-red tinged. *P. marcanoi* on the other hand has a very stout primary stem, which soon branches, bearing rather large leaves, which are green from the start, but as the stem elongates the newer leaves are smaller than those of the earlier seedling stage. The larger leaves of the seedling stage are also more densely arranged than in all the other species, the opposing spirals when viewed from above being eight and five, as opposed to five and three (these conform as in most plants to the Fibonacci series). Then there are the seldom-collected parts of the plant, such as the roots, which in *P. quisqueyana* are massively tuberous, but much less so in *P. marcanoi*. The flowers of the two species would look superficially very similar in preserved material, but again differ markedly when observed as live material. Those of the former are a shell pink and have short but distinct, slender stalks (pedicels), whereas those of the latter are more magenta in colour and almost lack a well-defined stalk, which if present is much thicker.

(Left) The flower of *Pereskia* (*Leuenbergeria*) *quisqueyana* is shell pink with a slender stalk. In this image, the flower is being visited by a Meloponine (stingless) bee to collect pollen. (Right) In comparison, the flower of *P.* (*Leuenbergeria*) *marcanoi* is magenta.

Trunk of a *Pereskia* (*Leuenbergeria*) *quisqueyana* specimen that produces leaves seasonally from the old areoles.

Fruits of *Pereskia* (*Leuenbergeria*) *portulacifolia*, with seeds destined for banking.

Differences between species are expected to be more obvious, but what about differences between genetically distinct individuals of the same species? In the case of *Pereskia quisqueyana*, I raised two seedlings, both of which proved to be male when they eventually flowered. Compared over five years, growing under identical conditions side by side, these two proved to be remarkably different. One regularly came into growth weeks before the other and bore seasonally deciduous leaves from the spine clusters (areoles) each growing period, whereas the other never developed such leaves, in other words, its leaves were only those produced from the stem tips during extension growth. This not only tells us that this Critically Endangered species is inherently variable, but that despite its very small wild population, it is still evidently genetically diverse, which is very good news for such a highly threatened plant.

In terms of the value of living plants for *ex situ* conservation purposes, my male and female plants of *Pereskia portulacifolia* have been 'farmed' for seeds. By regular cross-pollination, I have produced more than 2,500 seeds of the species over the past year for deposition in a seed bank to ensure this plant does not go extinct.

But these are just a few of the advantages that living specimens have over dead ones. Besides the points noted already, it has been possible to use living root tips for counting the number of chromosomes in *Pereskia quisqueyana*, confirming that it has the same number as other species (courtesy of my colleague Matti Niissalo). Another opportunity has been to study the behaviour of insect pollinators. While this can also be done in habitat, it is more easily facilitated over the long periods of observation that a cultivated specimen affords. And while mentioning insects, one can also observe whether they want to eat your plants! Thus, I have discovered that the related *P. bleo* is not attacked by any insect, a property in part shared by *P. quisqueyana*, which is, however, eaten by grasshoppers. Insects certainly attack other species of the genus in my garden, suggesting that the aforementioned pair may have some insect-repellent chemistry that could be worthy of investigation by the phytochemist.

Observing living plants with developing fruits can also be instructive in terms of deducing which vectors might disperse the fruit and seeds in nature. Mature fruits of *Pereskia portulacifolia* fall from the plant when still green and slowly ripen on the ground, suggesting that whatever might like to eat them for their juicy flesh is a ground-dwelling creature. The fruits of *P. bleo*, however, ripen on the plant before falling and are a very curious shape, like an inverted cone. Reading about the species in the botanical literature I discovered that, bizarrely for a cactus, it often grows near water. So, I tested ripe fruits in fresh and saltwater and found that they float for weeks with the flat base of the cone uppermost acting like a sail and the pointed end downwards like the keel of a boat. Applying a gentle breeze, they travel along quite quickly in the water, possibly suggesting a means by which the genus was able to colonise the Caribbean islands from the Tropical American mainland way back in time.

Hopefully these notes help demonstrate why living collections are so important for research in the botanic garden.

Nigel P. Taylor
Former Group Director

All images by Dr Nigel P. Taylor, unless otherwise indicated

Herbarium collections – part 2

In the last 'Taxonomy Corner' we looked at the collection and preservation of herbarium specimens and their use in botanical research. Singapore is one of the best-collected countries in the world when you measure the number of herbarium specimens per unit area. All of the countries around Singapore have very much lower collection densities, in some cases orders of magnitude lower. In this issue of *Gardenwise*, we shall look at what these differing collection densities across Southeast Asia mean for our understanding of plant diversity in the region.

The current estimate of the world's total number of vascular plant species (i.e., all species of clubmosses and their relatives, ferns, conifers and their relatives, and flowering plants) is around 350,000. In the last 30 years, however, published estimates have ranged from 250,000 species to 422,000 species. Whatever the true figure, we know that the spread of those species across the earth is not even, with very high diversity in the wet tropics of the world and very low diversity in the deserts and arctic regions of the world. We know this because for centuries botanists have been collecting plants and cataloguing and describing them. Even though we may still be unsure of the total numbers of species in the world, there is a high degree of consensus on where the plant diversity is concentrated.

It is self-evident to any botanist who has travelled that the plant diversity of the wet tropics is considerably higher than say northern Europe. For example, as noted in *Gardenwise* 49 (August 2017), the plant diversity of Singapore is much higher than that of the United Kingdom even though the UK is more than 300 times larger. Both Singapore and the UK have active communities of botanists and, consequently, long histories of collecting plants and depositing those collections in herbaria. In 2014 it was estimated that the collection density in Singapore was 5,721 collections per 100 km^2. That of the UK was estimated in the year 2000 at 1,720 collections per 100 km^2. It will undoubtedly now be slightly higher in the UK but starting from what is already a high level. With both countries being very well collected, we can be fairly confident that when we compare the plant diversities of the two countries, we really are comparing reasonably accurate figures. Hence, when we say there are more species of plants in Singapore than in the UK, we can

Aung Thame of the Singapore Botanic Gardens collecting in Vietnam. *(Photo credit: Dr Jana Leong-Škorničková)*

be fairly sure that this statement is true and not an artefact caused by incomparable data.

When we compare Singapore and the UK, however, we are rather comparing chalk and cheese, so different is the plant diversity of the two countries. What happens when we compare the diversity of Singapore to that of our neighbouring countries? We know that almost all of the plant species found in Singapore are also found in Peninsular Malaysia. The collection density of Peninsular Malaysia is estimated to be about 200 collections per 100 km^2, almost 30 times lower than that of Singapore. Malaysia has a very active botanical community but the country is much larger than Singapore with a wide variety of habitats, challenging terrains to collect in, and many more species. In Peninsular Malaysia, almost 200 new species have been described in the last 10 years and many new records and rediscoveries are being found. One can only begin to imagine the treasures that Malaysian botanists will continue to find as the collection density of Malaysia increases to anything approaching the collection density for Singapore.

The collection density for Laos is estimated at only 10 collections per 100 km^2, that of Cambodia only 16 collections per 100 km^2, and that of Vietnam about 46 collections per 100 km^2. Between these three countries, there is a wide range of climates, elevations and habitats, potentially supporting a vast array of plant species with influences from the Himalayas to the northwest, China to the northeast, Thailand to the west, and Malesia to the south and east. More than 600 new species have been described from this region in the last 10 years, including many new genera.

We can see from the large numbers of new species being described from Peninsular Malaysia, Cambodia, Laos and Vietnam that when a collection programme is started in a region with a low collection density, accompanied by the necessary taxonomic research, then the potential for new discoveries is very high. One would expect that as the collection density increases, then the potential for new discoveries with further collecting would decrease. Two questions arise: 1. at what collection density could we expect to have accounted for all of the plant diversity of a region, and 2. given that this ideal may be some time in the future, what are the implications for falling short of this ideal?

To address question 1, let us return to Singapore. With a collection density about 30 to 500 times greater than our neighbouring countries, would attaining a collection density similar to Singapore mean that all of the plant diversity would be accounted for in the rest of the region? In a nutshell, no, for two reasons. Firstly, collecting alone is only part of the story. It is estimated there are more than 30,000 undescribed species in the herbaria of the world that have already been collected and await study and publication. There are simply too few botanists to do this. If there were huge numbers of new collections from the whole of Southeast Asia, large numbers of botanists would be required to study and name the material. We would not know if we had reached a plateau of new discoveries until all of the previously collected material had been studied and that will take time. Secondly, the experience of Singapore is that even a collection density of 5,721 collections per 100 km^2 has not fully accounted for all of the plant diversity

Koh Sin Lan and Ali Ibrahim of the Gardens collecting in Singapore. *(Photo credit: Joseph Lai)*

Lim Weihao of the Gardens collecting in Brunei. *(Photo credit: Low Yee Wen)*

of the country! In the last 10 years, 20 new species that occur in Singapore have been described. Most of these are also found in Peninsular Malaysia and many of the new species were described after new research on older collections resulted in revised species concepts. But some of these new species were described from new collections made only in recent years. In addition, around 100 new species records have been found and about 140 species that were thought to be nationally extinct have been rediscovered. A recent survey of the plant diversity of Bukit Timah Nature Reserve resulted in the discovery of dozens of species that were previously not known to occur there, including some that were not even known to occur in Singapore. We know that the very high collection density in Singapore is still not enough to have accounted for all of the plant diversity in the country but we do not yet know what the ideal collection density for a tropical country would be. Another factor to consider is that the average collection density for a country does not account for very different collection densities in different parts of a country. It has been found that in Thailand, for example, a disproportionally large number of the collections made in the country came from a handful of high mountains and that across large stretches of the landscape there were almost no collections at all.

What about question 2? We can see that nowhere in Southeast Asia, including Singapore, has there been enough collecting to account for all of the plant diversity found in each country, although in Singapore new discoveries make up a very small percentage of new collections. The shortfall in our understanding of total species diversity is closely bound to the collection density – the fewer the collections, the greater the likelihood that new collections will lead to new species, new records and a better understanding of the distribution of known species. The implications of this can be quite profound. With deforestation, expansion of agricultural land, mining, urbanisation and climate change, in countries with low collection density there is a high chance that species will be lost forever before they were ever collected for the first time. Conservation policies are set by national authorities based on many and varied parameters but one of which is usually based on baseline biodiversity data for the country and parts of it. If species were never collected and described, we shall never know that they went extinct due to land use changes or climate change. These species never become part of the baseline data. In Singapore we can closely monitor our rare and threatened species and establish protocols for their careful management because our high collection density means that we have a reasonable idea of what we have and what each species' conservation needs are, notwithstanding the fact that new discoveries continue to be made here. In other parts of Southeast Asia, there are likely to be hundreds, perhaps even thousands, of species that are as yet undescribed or unrecorded. Many of these will not yet have been collected because they occur in very low numbers and/or have very restricted distributions and these are precisely the species that could be most at threat of extinction. Most species are distributed across national boundaries but differing collection densities and consequent understandings of plant diversity and distribution in different national territories could hamper effective conservation planning. The botanic gardens, universities and other research institutions across Southeast Asia are very aware of these issues and are working to increase collection densities, often in collaboration with the Singapore Botanic Gardens and each other. The question is, can we work quickly and collaboratively enough to gather the data that is needed to fully understand the plant diversity of the entire region before we lose any more without knowing it is even lost?

David J. Middleton
Herbarium

Publications by Gardens' staff in 2019

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Thomas, D.C., Xue, B., Chaowasku, T. & Saunders, R.M.K. (2019). *Historical biogeography and diversification of Asian-Pacific Annonaceae* [Talk and abstract]. 11th Flora Malesiana Symposium, Universiti Brunei Darussalam, Brunei, 30 June to 5 July 2019.

Wong, K.M. (2019). *Ancient enduring clones, wild relatives, and mutants: The interface of complex origins, selection, genetics, and systematics* [Keynote lecture]. Provectus Plantae: International Conference on Exploring the Scope of Plant Genetic Resources, University of Kerala, Thiruvananthapuram, Kerala, India, 22 May 2019.

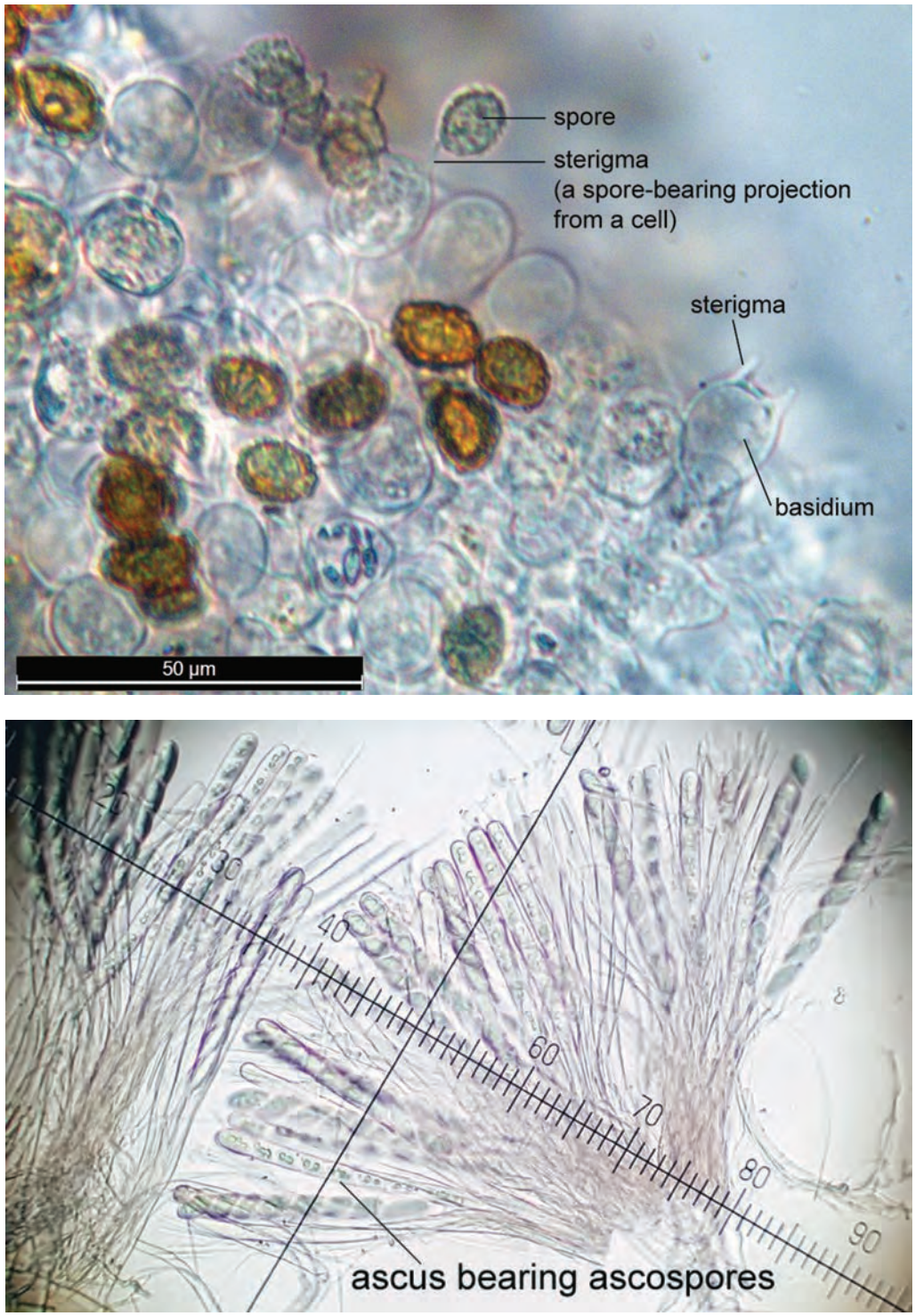
Xue, B., Tan, Y.-H., **Thomas, D.C.**, Chaowasku, T., Hou, X.-L. & Saunders, R.M.K. (2019). *A new Annonaceae genus,* Wuodendron, *provides support for a post-boreotropical origin of the Asian-Neotropical disjunction in the tribe Miliuseae* [Talk and abstract]. 11th Flora Malesiana Symposium, 30 June to 5 July 2019. Universiti Brunei Darussalam, Brunei.

Cups-o-Fungi

What are cup fungi? Well, like the gasteromycetes or 'stomach fungi' previously covered in *Gardenwise* (see volume 51, page 29), the fruiting bodies of cup fungi have the shape of cups, goblets or saucers. Cup-shaped fungi come from a number of families, but not all members within any of these families produce cup-shaped fruiting bodies. They also differ in other ways from all of the other fungi that have been covered so far in 'From the Earth'.

Cup fungi come from the order Pezizales (phylum Ascomycota) and their spores are borne on the inner surface of the cups. The cup shape generally serves to concentrate raindrops, which disperse the spores as they splash out of the cup. The slightly curved structure of the cups enables wind currents to blow the spores out in a different manner than in most forms found in the phylum Basidiomycota which includes the agarics (gilled fungi) and boletes (fleshy fungi with pores). There are many other differences between these two divisions of fungi – the ascomycetes and the basidiomycetes. In the former, the sexual spores (ascospores) develop in sacs (asci) while in the latter, the spores are borne on a basidium. The asci can be operculate (with a lid at the tip) or inoperculate (without a lid at the tip).

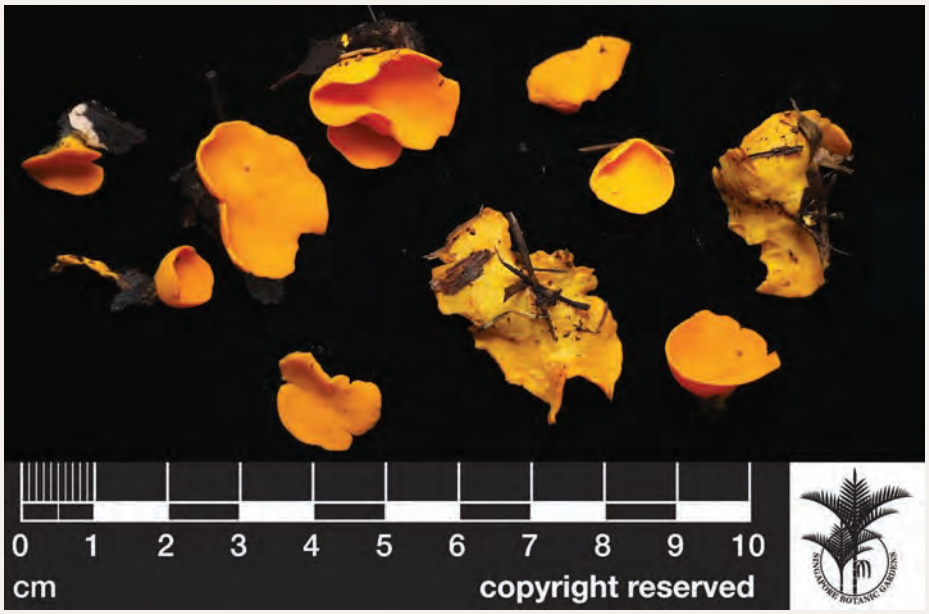
Highlighted in this article are some of the cup fungi that can be found in Singapore.



The fertile layer of a basidiomycete and an ascomycete (top and bottom, respectively), under a light microscope.

Orange Peel Fungus (*Aleuria* sp., Pyronemataceae)

This fungus looks like an orange peel lying on the ground, especially after the Chinese New Year season. It has a sessile fruiting body, meaning it does not have a stalk, and grows in clusters on the ground, often in clayey soils. *Aleuria* are yellowish orange in colour and slightly paler on the underside of the cup. The genus is now restricted to species with reticulated spores.



A collection of Orange Peel Fungi, *Aleuria* sp. Unfortunately, these specimens did not have any matured spores or paraphyses that would enable us to identify them to the species level.

Spores of *Aleuria aurantia*, identified in the UK.

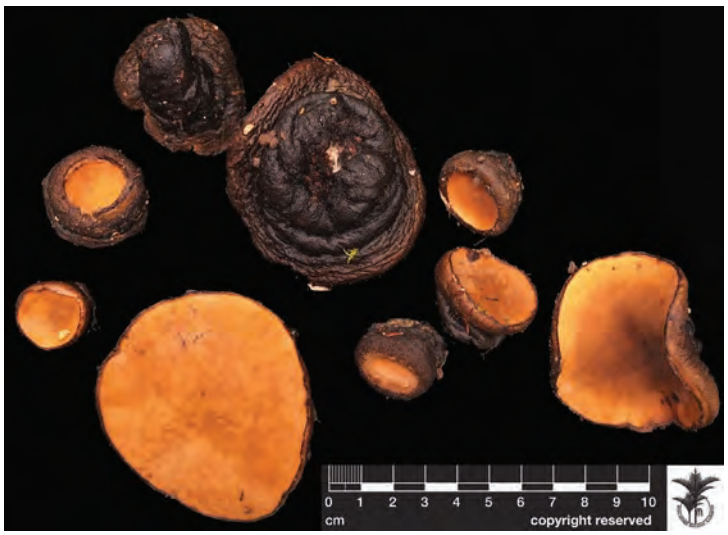
Eyelash Fungus (*Scutellinia scutellata*, Pyronemataceae)

The cups of this fungus look like tiny orange dots (up to about 1 cm across) with eyelashes. They grow in small groups and have been found on rotting wood, coconut husks and in other damp places. The important characters for identification in this genus are the length of the 'eyelashes' and if these are rooting (or not), features of the spores and the overall size of the fruiting body.

The Eyelash Fungus, *Scutellinia scutellata*.

Peanut-butter Cup Fungus (*Trichaleurina javanica*, Pyronemataceae)

Previously known as *Galiella*, the tropical species in this genus, including the Peanut-butter Cup Fungus, have reverted to the genus *Trichaleurina* due to recent taxonomic revisions. The Peanut-butter Cup Fungus can be identified by the colour of the hymenium (the fertile layer on the fruiting body), and the size and shape of the spores, asci and paraphyses (sterile hair-like cells on the hymenium).



The Peanut-butter Cup Fungus, *Trichaleurina javanica*.

The Peanut-butter Cup Fungus on a fallen branch.

Venus' Wine Cup and the Bristly Tropical Cup (*Cookeina speciosa* and *C. tricholoma*, Sarcoscyphaceae)

Thus far, there seems to be only two species of *Cookeina* found in Singapore. *Cookeina* have a lovely stalked cup-shaped fruiting body that varies from yellowish to pink or reddish. This colour tends to fade upon drying. The fruiting body itself is thin and flexible. The two species are easily distinguishable as the fruiting bodies of *C. tricholoma* have long white hairs, while those of *C. speciosa* do not. When looking at similar fungi of the same genus from other countries, the asci, spores and paraphyses are all important characters to consider in order to make a correct identification.

The Venus' Wine Cup, *Cookeina speciosa*.

The Bristly Tropical Cup, *Cookeina tricholoma*, (left) at Gunung Mulu National Park, Sarawak, and (right) in Singapore. *(Photo credit, right: Paul Leong)*

Serena Lee
Herbarium

All photos by Serena Lee, unless otherwise stated

Gardenwise · Volume 54 · February 2020

Confusing common names of edibles

In botany and horticulture, we refer to plants by their scientific names. These conform to international codes of nomenclature and are accepted and used worldwide for specific plants, but are usually in Latin and can be difficult for some to remember or even pronounce. Common names, on the other hand, are easy to remember but can lead to confusion as one name may refer to many different plants and many names can refer to a single plant. This article features a few of the edible plants found in Singapore that are easily confused because of their common names.

Plectranthus amboinicus

Plectranthus amboinicus is a fleshy, herbaceous plant that is frequently mistaken for Mint (*Mentha* species and varieties). This is understandable given that it is a close relative and commonly referred to as both Mexican Mint and Po Ho, the latter meaning 'mint' in various dialects of Chinese. There are a range of other common names used for it, including Cuban Oregano, Indian Borage and Spanish Thyme, likely further confusing people about its identity.

In Singapore, this plant is widely grown for both medicinal and culinary uses. It is best known as a treatment for cough, and is also used in cooking as a substitute for Oregano (*Origanum vulgare*).

***Plectranthus amboinicus* is a common medicinal and culinary plant that is frequently mistaken for Mint in Singapore. It is easily propagated via stem-cuttings.**

Talinum species

Talinum fruticosum is an herbaceous plant commonly cultivated in community and home gardens in Singapore. Sometimes called the Waterleaf or Suriname Purslane, it is better known locally as Earth Ginseng, which is a direct translation of its Chinese name, Tu Ren Shen. The plant has a swollen storage root that bears some resemblance to the root of the real Ginseng (*Panax* species). It has folkloric medicinal uses and its young, tender leaves are eaten as a leafy vegetable. The leaves should be cooked thoroughly before consumption however to remove oxalate and cyanogenic glucosides.

Best known locally as Earth Ginseng, *Talinum fruticosum* produces small, attractive pink flowers. It needs to be grown in a medium that drains well.

This plant is sometimes confused with *Talinum paniculatum*. This related species is distinguishable by its much smaller pink flowers, which are numerous and borne on a many-branched inflorescence.

(Left) Brazilian Spinach or Sissoo Spinach is an herbaceous plant with curled green leaves. (Right) The *Alternanthera* cultivar with red leaves is known locally as Thai Watercress or Wild Watercress. Both of these plants can be used as a low, edible border plant in local vegetable gardens, and can grow well in areas with wet soil.

Alternanthera species and cultivars

Plants from the genus *Alternanthera* often feature colourful leaves and are planted as ornamentals to add a pop of colour to outdoor landscapes. Locally, the foliage of some *Alternanthera* are eaten as leafy vegetables or used as medicinal herbs, particularly *A. sissoo* hort. This is a recent introduction to Singapore and commonly called Brazilian Spinach or Sissoo Spinach. Two other examples are cultivars of *Alternanthera ficoidea*. The reverted, green version of 'White Carpet' is sometimes called Finnish Spinach, and a different cultivar with red leaves has been recently named by local urban farmers as Thai Watercress or Wild Watercress. Despite their common names, none of these plants are related to Spinach (*Spinacea oleracea*, a distant relative also in the Amaranth family, Amaranthaceae) or Watercress (*Nasturtium officinale*, from the Cabbage family, Brassicaceae).

The young leaves of the three plants mentioned above are edible but should be cooked thoroughly by boiling or steaming before eating. This will reduce the amount of calcium oxalate in the leaves. In susceptible individuals, too much oxalate in the diet can lead to the development of kidney stones.

Eupatorium capillifolium

When chopped up, the fine, feathery leaves of *Eupatorium capillifolium* look like those of Dill (*Anethum graveolens*) and have been used similarly to flavour fish dishes. Despite this, the two plants are not related – Dill is a member of the Carrot family (Apiaceae) while *Eupatorium capillifolium* is in the Daisy family (Asteraceae).

***Eupatorium capillifolium* has fine, feathery leaves that look like those of Dill, but the plant is taller, woodier, and more branched in comparison to Dill. Its foliage makes it a popular candidate for a landscape that calls for a plant with finely textured leaves.**

For readers who are familiar with the culinary uses of Dill, it grows as a small, herbaceous plant with bluish green feathery leaves that rise from the base. In contrast, *Eupatorium capillifolium* grows as a tall, erect shrub that gets woody with age. Known by the common name of Dogfennel or more generally called fake dill, this plant contains alkaloids and should not be used for flavouring food as it has been reported to cause liver damage in cattle.

Wilson Wong
Jurong Lake Gardens

All photos by Dr Wilson Wong

Fascinating Creatures of the Singapore Botanic Gardens for preschoolers

Hidden within our urban metropolis are ecosystems rich in fascinating biodiversity. The Singapore Botanic Gardens is one such area and a popular destination for primary and secondary schools to bring their students on learning journeys. However, there are still a good number of preschools yet to visit the Gardens, and so the Education team wanted to make it easy for them and bring the Gardens to these schools instead!

Children of PCS Yishun Childcare wearing props created by Kay Yee. *(Photo credit: Jessica Chan)*

Since April 2019, we have been conducting an interactive sharing session called the 'Fascinating Creatures of the Singapore Botanic Gardens' at preschools across Singapore. So far, we have reached out to 713 children from 14 different schools. Through roleplay and creative expression, we encourage the children to develop an awareness of plants and animals and an appreciation of how they coexist in different habitats. Wearing masks of different birds, mammals, amphibians and reptiles, the children are encouraged to imitate the calls of various animals and act out their foraging habits.

The 'Fascinating Creatures of the Singapore Botanic Gardens' programme was inspired by the Ministry of Education's Nurturing Early Learners Framework, which focuses on nurturing children's curiosity about the world, encouraging active learning through experiencing and experimenting, and fostering competence so that children develop their thinking and reasoning skills. With this framework in mind, the Education team wished to develop a programme to harness the innate curiosity and vibrant energy of young children towards the natural world. Through many collaborative brainstorming sessions, we trialled several possible storylines as a team and even conducted the programme for children of NParks' staff. By observing their enthusiastic and spontaneous reactions to the content, what started out as a storytelling and scripted drama quickly evolved into a child-led interactive session. The flexible nature of this interactive programme allows facilitators to adjust the content and sharing experience according to the learning abilities of the children and the questions they ask.

Hui Min teaching children about the social behaviour of termites at Glow and Grow @ Pasir Ris 21. *(Photo credit: Steffi Loe)*

As we continue sharing about the Gardens' biodiversity with children around Singapore, it is our hope that they will grow up to become adults who will value and appreciate the natural world around them.

Tan Hui Min
Steffi Loe
Education Branch

A burst of fragrances under the sun

After a prolonged hot season and low rainfall, the month of November welcomed the arrival of inter-monsoonal conditions that triggered many plants in the Gardens to burst into flower. Besides providing an explosion of colour, some of these flowers released amazing fragrances to delight our visitors. Highlighted here are *Vatica pauciflora* and *Magnolia figo*, two of the many plants in bloom during this period.

Vatica pauciflora

A number of *Vatica* species are planted around the Gardens, and a large concentration of *V. pauciflora* trees can be found lining the road down to the Fernery and Plant House. In full bloom, the trees along this avenue were covered in clusters of delicate, creamy white flowers. Before noticing the flowers, however, visitors walking nearby would have caught their sweet, soft fragrance, which carries a good distance in the wind.

Vatica pauciflora is in the Dipterocarpaceae, a family consisting of 17 genera and more than 500 species of tropical lowland rainforest trees. Its generic epithet, *Vatica*, is derived from the Latin *vates* or *vatis*, meaning 'prophet' or 'soothsayer'. Strangely, considering the profusion of blooms it produces, the specific epithet means 'few-flowered'. *V. pauciflora* is native to Indonesia (Sumatra), Malaysia, Singapore, Thailand and Vietnam.

This species is usually found in lowland dipterocarp forests near swamps and streams, and is a component of freshwater swamp forests. It is commonly known in Malaysia and Singapore as Resak Laru, Resak Paya or Resak Ayer, in Indonesia as Resak Padang, Resak Rawa or Resak Rawang, in Thailand as Sak, Klusi or Sak Nam, and in Vietnam as Táu It Hoa. The name Resak Laru refers to the *laru* that is obtained from its bark. *Laru* is used as a natural preservative and an inhibitor of the fermentation process in the production of the alcoholic beverage known as toddy. *Laru* can be obtained from other plant sources as well, including other species of *Vatica*, clove leaves, guava leaves, limes, and mangosteen peels. Different oligomers have been isolated from *Vatica pauciflora*, and these reportedly have anti-inflammatory, anti-oxidation and anti-cancer properties.

***Vatica pauciflora* in the Gardens heavily covered with inflorescences.**

Close-up of the sweetly scented flowers of *Vatica pauciflora*.

The *Vatica pauciflora* trees in the Gardens were planted around 10 years ago and have yet to reach their potential height of 30 m. The stems of this species exude a sticky resin if injured, and the leaves are alternate, simple, obovate in shape and

The large wingless fruits of *Vatica pauciflora*.

The compact shrubby Banana Shrub located near the Ethnobotany Centre.

The lovely magnolia-like flower of the Banana Shrub.

have a glossy, dark green surface. The inflorescences are many-branched and bear numerous perfect flowers (with both male and female reproductive parts) with five green sepals and five creamy white petals. The petals are delicate and fall off easily in a strong wind or in the rain, resulting in a carpet of petals strewn on the ground beneath the tree. Although dipterocarps normally have winged fruits, those of *Vatica pauciflora* are wingless. They are about 3 cm long and wide, brownish in colour and contain a single globose seed each.

Vatica pauciflora is not commonly cultivated as an ornamental, but it is harvested in the region for its hard, somewhat durable timber. Its heartwood is yellowish when fresh and turns light to deep red-brown when exposed to the air. The timber is used locally for house posts, making boats and in light construction. *V. pauciflora* is considered Critically Endangered in Singapore, and has been assessed globally as Vulnerable. Its population is declining due to changes in land use for agriculture and timber harvesting activities. Therefore, *ex situ* collections of this species should continue to be made and it should also be conserved *in situ* through expanded protection of its habitat.

Magnolia figo

Unlike *Vatica pauciflora*, this shrubby plant's fragrance does not stray far from its source. The flowers are equally fragrant, however, with an intense banana-like, fruity chewing gum scent that is emitted toward the late afternoon. In the Gardens, *Magnolia figo* can be found gracing the flower beds at the rear entrance of the Ethnobotany Centre in the Bukit Timah Core.

Originally described by the Portuguese missionary and naturalist João de Loureiro as *Liriodendron figo*, this species was later reclassified as *Michelia figo* by the German botanist Kurt Polycarp Joachim Sprengel. In 2006, a cladistics analysis of the genus *Michelia* led to renaming the plant as *Magnolia figo*. Its generic epithet, *Magnolia*, was named in honour of the French botanist Pierre Magnol (1638–1715). Magnol was an innovator of botanical classification, and the first to publish the concept of plant families based on morphological characteristics. Its specific epithet, *figo*, is Latin for 'attach' or 'fasten down', or Italian for 'fig tree', a probable reference to the plant's fig-like leaves. *Magnolia figo* belongs to the Chempaka family, Magnoliaceae, and is native to southern China.

This plant commonly goes by the name of Banana Shrub due to the banana-like fragrance of its flowers. There are a number of other vernacular names for it as well, including the Port Wine Magnolia, Pisang-pisang and Chempaka Ambon. The Banana Shrub can be described as a large woody shrub or small compact tree that can reach up to 5 m in height and width, but the crown will grow more openly if planted in shady conditions. The young twigs, petioles and buds are densely covered in brown hairs. The small magnolia-like flowers are about 4 cm across with six thick, waxy, creamy white tepals that are tinged purplish red at the centre. The fruit is around 2 to 3.5 cm in length and ovoid to globose in shape with a short sharp beak at the tip.

The Banana Shrub is cultivated as an ornamental and usually propagated by softwood cuttings. It is slow growing and suitable as a hedge for screening or creating borders. The plant can also be trained into a standard shrub or multi-stemmed tree. It prefers growing in fertile, acidic to neutral, well-drained soils with abundant organic matter.

If you catch the sweet ripe scent of bananas on your next visit to the Ethnobotany Centre, instead of looking for an actual banana, cast your eyes toward the shrub known as *Magnolia figo* instead.

Nura Abdul Karim
Research and Conservation

All photos by Dr Nura Abdul Karim

An exhibition on the ethnobotany of the Jackfruit tree family

This ethnobotanical exhibition on the Jackfruit tree family (Moraceae) is currently being held on the second floor of the Gardens' Centre for Ethnobotany. Beyond the commonly known Jackfruit, the exhibition showcases some of the other members of the family that are also used as a source of food, material and medicine by people in Singapore and other parts of the region.

The Jackfruit (*Artocarpus heteropyllus*), or *nangka* in Malay, produces the world's largest tree-fruit. Some of the jackfruits sold in Singapore's markets weigh more than 50 kg. This tree is widely planted throughout the tropics, and is thought to have originated from southern India and brought to Southeast Asia in the 6th century CE. There is a widely held opinion that the Jackfruit takes its name from the botanist William Jack, but more likely its name has a different origin. According to some sources, the English name of the fruit, jack, is derived from the Portuguese *jacca*, which itself is derived from the Malayalam (a southern Indian language) word *chakka*. The assimilation of this name into European languages occurred in the 17th century, when Europeans came across the tree in Kerala, India.

A jackfruit (*Artocarpus heteropyllus*) at the Geylang Serai Market in Singapore.
(Photo credit: S.K. Ganesan)

Chempedak fruit (*Artocarpus integer*) at the Geylang Serai Market in Singapore.
(Photo credit: S.K. Ganesan)

Fruit of the Tarap (*Artocarpus odoratissimus*) in Ranau District, Sabah.
(Photo credit: S.K. Ganesan)

Besides the Jackfruit, the exhibition highlights two other species for their delicious fruit – the Chempedak (*Artocarpus integer*) and the Tarap (*Artocarpus odoratissimus*). The fruit of the Chempedak is often available in local markets in Singapore, but the Tarap is endemic to Borneo and its fruit is only found in markets there. Another relative with a similar common name, the Terap (*Artocarpus elasticus*) is processed by indigenous people in Borneo to make bark cloth, which in turn can be woven with other materials (such as rattan) to make floor mats. An example of such a mat, made by members of the Bidayuh community from Borneo, is on display at the Centre for Ethnobotany. The exhibition

An Oriental Pied Hornbill feeding on the fleshy white fruit of a Terap (*Artocarpus elasticus*) in the Gardens. *(Photo credit: Paul Leong)*

Breadfruit (*Artocarpus altilis*) at the Gadong Night Market in Brunei Darussalam. *(Photo credit: S.K. Ganesan)*

also touches on the folk taxonomy of *Artocarpus* in Sarawak, as well as the epic story of how the Breadfruit (*Artocarpus altilis*) was introduced from the Old World to the New World. We are grateful to Dr Elliot Gardner from the Morton Arboretum and Dr Nyree Zerega from Northwestern University and the Chicago Botanic Garden for their contributions to these respective topics for the exhibition.

Our exhibition has coincided with the recent fruiting of several relatives of the Jackfruit planted in the Gardens. For example, the Keledang (*Artocarpus lanceifolius*) and Tempunai (*Artocarpus rigidus*), both of which have sweet tasting fruit, and the Tampang (*Artocarpus nitidus* subsp. *griffithii*), whose fruit tastes like lime. To our delight, a fruiting Terap tree attracted Oriental Pied Hornbills, which we were able to photograph.

The Keladan (*Artocarpus lanceifolius*) fruiting in the Gardens. *(Photo credit: S.K. Ganesan)*

The 'Ethnobotany of the Jackfruit Tree Family' exhibition will be on at the Centre for Ethnobotany until June 2020.

Fruits of the Tempunai (*Artocarpus rigidus*), taken in the Gardens. *(Photo credit: S.K. Ganesan)*

Fruit and leaves of the Tampang (*Artocarpus nitidus* subsp. *griffithii*), collected from the Gardens. *(Photo credit: S.K. Ganesan)*

A section of a Tampang (*Artocarpus nitidus* subsp. *griffithii*) fruit, collected in the Gardens. *(Photo credit: S.K. Ganesan)*

The Centre is open daily from 9am until 6pm, except for the last Wednesday of each month. Admission is free, so do stop by your next visit to the Gardens.

S.K. Ganesan
Herbarium

The 7th Southeast Asia Botanic Gardens Network Conference

Participants of the 7th SEABG Network Conference. *(Photo courtesy of QSBG)*

The beautiful Queen Sirikit Botanic Garden (QSBG) in Chiang Mai, Thailand, was the venue for the 7th Southeast Asia Botanic Gardens (SEABG) Network Conference. The Conference was held from 5 to 9 August and co-organised by Botanic Gardens Conservation International and QSBG. Over 70 individuals from 16 Asian countries attended this year's conference, and several of the participants gave oral presentations highlighting their conservation work and/or general introductions to their institutions. Besides the Singapore Botanic Gardens, which has been a member of the SEABG network since its founding in 2004, the institutions represented at the conference included the Makiling Botanic Gardens (Philippines), Bogor Botanic Gardens (Indonesia), Mount Kinabalu Botanical Garden (East Malaysia) and the Tsukuba Botanical Garden (Japan).

Participants engrossed in discussion during a workshop session.

During the conference, the SEABG network members reviewed the activities of the network under the four-step action plan developed at the previous SEABG Network Conference held in 2017. As part of the review of the action plan, the attendees discussed at length and agreed upon some possible actions to be undertaken by the

network going forward. These included improving and extending informal communication channels between the network members, developing and providing specialist technical training, increasing the members' understanding of and contributions towards achieving the targets of the Global Strategy for Plant Conservation, increasing Red Listing activities for more of Southeast Asia's flora, and reaching out to other botanical networks through invitations to conferences and training sessions. The network members also worked towards developing an up-to-date action plan with a focus on the objectives of the SEABG as stated in the Working Practice document that was developed in 2015 and amended during the previous conference in 2017.

The conference also incorporated a capacity-building workshop entitled 'The Role of Botanic Gardens in *In Situ* Species Recovery'. The workshop involved presentations, a group practical and a discussion session led by international experts from the Institute for Conservation Research (San Diego Zoo, USA), the Blue Mountains Botanic Garden (Mount Tomah, Australia) and the Kunming Botanical Garden (Chinese Academy of Sciences, China). A session on the conservation of tree genetic resources and presentations on ongoing regional and international initiatives were made by Dr Riina Jalonen (Asia Pacific Forest Genetic Resources Information System Project, Biodiversity International), Dr Joeri Strijk (Alliance for Conservation Tree Genomics) and Dr Murphy Westwood (Global Conservation Consortium for Oak, The Morton Arboretum).

Participants took a break from the indoor activities by touring QSBG's Natural Science Museum, Glasshouse Complex and Limestone Plant House. A field trip to Doi Suthep-Pui National Park was also organised, including a hike up the Doi Pui Nature Trail and a visit to the Forest Restoration Research Unit of Chiang Mai University and the Doi Suthep temple.

A glimpse of the QSBG Limestone Plant House, which houses an exceptional collection of rare and difficult to cultivate limestone flora from Thailand.

The strikingly beautiful flowers of *Agapetes megacarpa* (Ericaceae), an endangered shrub from Thailand. This species is thriving well in the Limestone Plant House of QSBG.

At the close of the conference, it was announced that the 8th SEABG Network Conference will be hosted by the Makiling Botanic Gardens in the Philippines in 2021.

Nura Abdul Karim
Research and Conservation

All photos by Dr Nura Abdul Karim unless otherwise stated

Talking plant conservation in the city of the Giant Pandas

The World Forum on the Global Strategy for Plant Conservation (GSPC) was held in Dujiangyan, Sichuan Province, China from 28 to 30 October 2019. It was organised by the China Wild Plant Conservation Association (CWPCA), along with the Global Partnership for Plant Conservation (GPPC), Botanic Gardens Conservation International (BGCI), International Union for Conservation of Nature (IUCN), Biodiversity Committee, Chinese Academy of Sciences, China (BC-CAS), and Society of Entrepreneurs and Ecology (SEE) Foundation.

Participants at the World Forum on the Global Strategy for Plant Conservation.

The GSPC was first adopted by the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) in 2002, and included a set of targets to be achieved by 2010. Updates were later made to these targets for the period 2011–2020. The aims of the October 2019 World Forum were to review the successes, perspectives and challenges of various countries with implementing the GSPC over the last 10 years, and to prepare for the upcoming 15th Meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP15) that will be held in Kunming, China in 2020. The upcoming CBD COP15 will establish the strategic plan for biodiversity conservation targets for the period 2021–2030.

A declaration in support of having a post-2020 GSPC was agreed upon during a special session of the Forum. The Dujiangyan declaration, which had been drafted following discussions with BGCI, IUCN, GPPC, BC-CAS and CWPCA, and incorporated suggestions and amendments from the international participants during the forum, has since been amended and will be circulated at the upcoming 23rd Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) in Montreal. The SBSTTA is an intergovernmental scientific advisory body that provides the COP and its other subsidiary bodies with timely advice relating to the CBD. Also during the meeting, the gardens represented at the Forum, including the Singapore Botanic Gardens, agreed that achieving a higher level of plant conservation to meet the GSPC targets (past and future) will require the involvement of all stakeholders. This includes public, private and government sectors worldwide.

The forum participants also had the opportunity to visit the Conservation and Research Center for Giant Pandas at the Dujiangyan Base in Chengdu. The Center is dedicated to panda conservation and research, disease prevention and control, rescue of pandas from the wild, and international cooperation and public science education about pandas. According to China's State Forestry and Grassland Administration, there are currently about 1,864 pandas in the wild, two-thirds of which live within 67 dedicated nature reserves. The population is up from 1,114 pandas in the 1970s, thanks to intensive breeding programmes at research centres such as the one in Dujiangyan. China has practiced the concept of 'panda diplomacy' as a sign of goodwill with other countries since the 7th century, and today there are over 50 pandas on loan and living in 18 different countries. This includes Kai Kai and Jai Jai, two adorable Giant Pandas on loan from Sichuan to the Singapore Wildlife Reserves for a 10-year period.

A panda at rest after a heavy breakfast of bamboo shoots and stems at the China Conservation and Research Center for the Giant Pandas, Dujiangyan Base, Chengdu.

Nura Abdul Karim
Research and Conservation

All photos by Dr Nura Abdul Karim

Getting to know gingers: Zingiberales Workshop at the Dr Cecilia Koo Botanic Conservation Center

From 24 to 27 June 2019, the Dr Cecilia Koo Botanic Conservation Center (KBCC), in partnership with Botanic Gardens Conservation International (BGCI), held a workshop aimed at equipping new garden curators and young researchers with fundamental knowledge about the order Zingiberales. The workshop was attended by 16 participants from various countries in Southeast Asia. The accommodation and lecture room were located within the same building on the lush grounds of KBCC, which allowed us to work, eat, sleep and interact non-stop during the four-day-long workshop.

Dr Chia-Wei Li, a Taiwanese biologist and former director of the National Museum of Natural Science, began the workshop with an introduction to KBCC and a tour of its facilities. Located in Pingtung County in southern Taiwan, KBCC is a non-governmental organisation that works toward the conservation of tropical and sub-tropical plants in Taiwan. The brainchild of Dr Li, KBCC was supported by Ms Cecilia Koo Yan, who offered 5 hectares of farmland for the initial construction of the tropical plant conservation centre. KBCC's facilities have since grown to include 17 large plant nurseries and two controlled-environment greenhouses. Besides conserving plants, KBCC also plays a part in research and education by collaborating with scientists from botanic gardens and research and academic institutions worldwide, and on the first day of the workshop, signed a Memorandum-of-Understanding (MoU) with the Singapore Botanic Gardens.

Over the following days of the workshop, Dr Jana Leong-Škorničková, a Principal Researcher from the Singapore Botanic Gardens, delivered six informative presentations that covered the diversity, morphology, taxonomy and horticulture of the order Zingiberales. Special attention was paid to its largest family, the Zingiberaceae, which is best known for Ginger (*Zingiber officinale*), Turmeric (*Curcuma longa*), Cardamom (*Elettaria cardamomum*) and Galangal (*Alpinia galanga*). She also shared about conservation efforts and practical experiences from work done in Singapore to maintain healthy populations of native species such as *Etlingera maingayi*, *Globba leucantha*, *Hornstedtia conica*, *Sundamomum hastilabium* and *Zingiber singapurense*. Another talk was given by Mr Tran Huu Dang of the Southern Institute of Ecology, Vietnam Academy of Science and Technology. Mr Tran spoke about the ethonobotany of gingers in Vietnam, including the different species used for food, medicine and religious purposes. Dr Pei-Chun Liao from the National Taiwan Normal University also gave a presentation, entitled 'Using molecular markers to study the speciation of two endemic ginger species *Zingiber kawagoii* and

Participants on a tour around KBCC's plant nurseries.

Zingiberaceae collection in one of KBCC's plant nurseries.

(Left) Dr Jana Leong-Škorničková presenting on the genus *Hedychium*, and (right) showing methods of dissecting floral parts of *Kaempferia elegans*.

Mr Zeke Chen from KBCC demonstrating how to plant a *Hedychium* during an interactive session on horticultural management.
(Photo credit: Jana Leong-Škorničková)

Mr Tran Huu Dang of the Southern Institute of Ecology, Vietnam Academy of Science and Technology, demonstrating how to create dried herbarium specimens.

Zingiber shuanlongensis'. His talk was followed by a practical exercise on methods used to design molecular markers.

Several other practical hands-on sessions were held over the course of the workshop. For example, we learned to dissect and study the floral parts of various genera and how to collect and photo-document plants in the field. This included pressing herbarium specimens and setting up field air dryers, but also more delicate tasks like collecting and processing leaf tissues for future DNA work. KBCC's Zingiberales collection manager, Mr Zeke Chen, assisted by other KBCC staff, ran an interactive session on the horticultural management of the living collections in KBCC and shared useful tips on preparing planting media, repotting root-bound plants and managing pest and diseases. Each day ended with an opportunity for the participants to introduce their institutions and share about their job scopes and research interests.

It was an intensive yet fruitful four days that allowed all of us to further our knowledge about the order Zingiberales. Moreover, the workshop provided an excellent opportunity for networking, which may facilitate plant exchanges and future collaborations with other institutions in the future.

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All photos by Lim Qing Sarah, unless otherwise indicated

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(Left) *Papilionanda* Ibrahim Mohamed Solih-Fazna Ahmed, named after His Excellency Ibrahim Mohamed Solih, President of the Republic of Maldives, and Mdm Fazna Ahmed during their visit on 1 July 2019. (Right) *Papilionanda* Nikol Pashinyan-Anna Hakobyan, named after His Excellency Nikol Pashinyan, Prime Minister of the Republic of Armenia, and Mdm Anna Hakobyan during their visit on 9 July 2019.

H.E. Shaikh Dr Abdulla Bin Ahmed Al Khalifa, Undersecretary for International Affairs, Ministry of Foreign Affairs of the Kingdom of Bahrain, and **H.H. Mdm Shaikha Najla**

Ms Aisyah Munirah, Universiti Kebangsaan Malaysia, Malaysia

Mr Andrew Barr, Chief Minister of the Australian Capital Territory, and delegation

Dr Axel Poulson, Royal Botanic Garden Edinburgh, United Kingdom

Dr Brigitta Duyfjes, Naturalis Biodiversity Center, Leiden, The Netherlands

Dr Caroline Pannell, University of Oxford, United Kingdom

Mr Chia-Hao Chang, National Sun Yat-sen University, Taiwan

Dr Daniele Cicuzza, Universiti Brunei Darussalam

Prof. David Mabberley, University of Oxford, United Kingdom

Delegation from the City Council of Jambi, Sumatra, Indonesia

Ms Eyen Khoo, Sabah Forestry Department, Malaysia

Mr Himesh Jayasinghe, Royal Botanic Gardens, Peradeniya, Sri Lanka

Mr Hyo-jun Kim and delegation from Seoul Grand Park, Gyeonggi-do, Korea

H.E. Ibrahim Mohamed Solih, President of the Republic of Maldives, and **Mdm Fazna Ahmed**, Maldives

H.E. István Jakab, Deputy Speaker of the Hungarian Parliament, **H.E. Dr István Szerdahelyi**, Ambassador of Singapore to Hungary, **H.E. Ms Ng Shin Ein**, Non-Resident Ambassador of Singapore to Hungary, and delegation

Ms Jennifer S. Danila, University of Santo Tomas, The Philippines

Dr Jennifer DeMuria, Smithsonian Institution, United States of America

Prof. Jeremy Bruhl, N.C.W. Beadle Herbarium, Australia

Ms Jing-Xia Liu, Kunming Institute of Botany, China

Mr Jorge Buenaventura, **Ms Lots Topacio** and **Ms Jaja Bibar**, La Salle Botanical Gardens, Philippines

Dr Jun Wen, Smithsonian Institution, United States of America

Ms Lan Nyee Fan, University of Malaya, Malaysia

Dr Ngo Kang Min, Nanyang Technological University, Singapore

H.E. Nikol Pashinyan, Prime Minister of the Republic of Armenia, and **Mdm Anna Hakobyan**, Armenia

Mdm Nor Ezzawanis A.T., Forest Research Institute Malaysia

Ms Nur Syazwana, Universiti Kebangsaan Malaysia

Dr Nyree Zerega, Northwestern University, United States of America

H.E. Mr Patrick Bourne, Ambassador of Ireland to Singapore

Mr Patrick Courtney and **Mrs Michelle Courtney**, Kings Park and Botanic Garden, Australia

Dr Paul Smith, Secretary General, Botanic Gardens Conservation International

Dr Ruth Kiew, Forest Research Institute Malaysia

Dr Shih-Hui Liu, National Sun Yat-sen University, Taiwan

Mr Shinichiro Ito, **Mr Noriyasu Satou**, **Mr Takashi Maeda** and **Mr Takuya Kawakami**, Miyakoh Botanic Garden Aoshima, and **Mr Hidemi Setonaga**, **Mr Takahiko Kai**, **Mr Makoto Nishimoto** and **Mr Ko Odote**, Miyazaki Prefecture Land Development Department, Japan

Mr Shuai Liao, The Morton Arboretum, United States of America

Y.B. Mr Soon Lip Chee, **Mr Tuan Haji Mohamed Akbar bin Mustapha**, **Ms Barathi a/p Suppiah** and **Mr Muhammad Farezudin Shah**, City Council of Penang Island, Malaysia

Dr Sri Rahayu, Bogor Botanic Gardens, Indonesia

Dr W.J.F. McDonald, Queensland Herbarium, Australia

Dr Willem de Wilde, Naturalis Biodiversity Center, The Netherlands

Mr Wu Hong and **Mr Xu Linfeng**, Shanghai Botanical Garden, China

Mr Yang Lei, **Mr Zhong Yongwen**, **Mr Cai Shuchuan** and **Ms Kang Jie**, Shenzhen Municipality, and **Mr Zou Yuanjun**, Fairy Lake Botanical Garden, China

Mr Yusuke Arai, Deputy Chief of Mission, Embassy of Japan in Singapore

Mr Zu-Chang Xu, Kunming Institute of Botany, China

The old Bonsai House

In nature, some trees that grow in rocky crevices on high mountains can live for decades or more yet remain dwarfed throughout their lifetime. Often gnarled and twisted, their weather-beaten appearance captures our interest and awe just as it caught the imagination of the ancient Chinese who first developed the practice of bonsai. This culture was adopted in Japan and has a long history there as well. In 1985, the Gardens built a Bonsai House to showcase this beautiful living art form, the works of which are often the result of years of patience and horticultural skill.

Situated on Lawn X, the octagonal shaped Bonsai House had an airy and sunny ambience. It displayed both graphic artwork and a living collection of bonsai. In the graphic section, a series of panels traced the origin and depicted various styles of bonsai. The living collection incorporated tropical species to encourage visitors to use native plants for creating local bonsai. In total, 118 bonsai specimens were showcased in various styles, about a third of which were subtropical or tropical species. Featured in the collection were specimens of *Leptospermum flavescens*, *Baeckea frutescens* and native *Syzygium* species that had been trained from seedlings. Members of the public gave positive and interesting feedback about the display. Teachers who brought their students to the Bonsai House were equally pleased with the aesthetic and educational content found there.

(Top) The Bonsai Garden in 2009, and (bottom) in 2019.

The Bonsai House eventually closed to make way for the National Orchid Garden, which opened in 1995. The bonsai collection was moved to our nursery until 2005, when a new Bonsai Garden was developed at its present site on Lawn O (shown above).

Christina Soh
Library

Ali Ibrahim
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